WK DICKSON
community infrastructure consultants

City of Rocky Mount
Maple Creek Tributary #2 Drainage Basin Study

November 2012

CITY OF ROCKY MOUNT

MAPLE CREEK TRIBUTARY #2 DRAINAGE BASIN STUDY

WKD # 20110202.00.RA

November 2012

Prepared for

City of Rocky Mount
P.O. Box 1180
Rocky Mount, NC 27802

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11-15-12

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The City of Rocky Mount selected WK Dickson to complete a drainage basin study for the Maple Creek Tributary #2 watershed. The goals of this study include: (1) evaluate the watershed to identify existing flooding and erosion problems, (2) identify capital improvements required to upgrade existing drainage systems to meet City Design Standards, and (3) identify capital improvement projects that will, to the maximum extent practicable, mitigate the frequency and severity of flooding for citizens.

The enclosed drainage basin study consists of an Existing Conditions Analysis, collection of citizen input, City Design Standard Analysis, Alternative Analysis, and conclusions and recommendations.

Existing Conditions Analysis

An Existing Conditions Analysis was conducted in order to evaluate the existing hydrologic and hydraulic characteristics of the Maple Creek Tributary #2 watershed. The analysis was conducted to determine the performance of four culvert crossings along the primary channel as well as selected secondary open and closed systems throughout the basin (See Figure ES-1).

Citizen input, GIS inventory data, survey, and field work findings were all used to develop the existing conditions model. Curve numbers (CN) and time of concentration (T_c) values associated with existing conditions were determined by using aerial photography, existing land use classifications, and State LiDAR contour data. Flow reduction provided by attenuation areas that occur behind culvert crossings, through channel sections, and at other low lying areas within the basin were considered for this analysis.

At select locations where flooding has been reported approximate high water mark elevations and flooding characteristics were documented. This information was then compared with modeling results in order to validate the findings of the Existing Conditions Analysis. The Existing Conditions Analysis confirmed some flooding problems submitted by citizens and revealed that several of the primary and secondary systems' components do not meet the City of Rocky Mount's design standards and may cause flooding. More information about the Existing Conditions Analysis can be found in Section 2 of this report.

City Design Standard Analysis

The City Design Standard Analysis was completed to determine the improvements required to upgrade the deficient systems to meet the City of Rocky Mount's development requirements. The proposed improvements described in Section 3 of the report show what would be required if these systems were to be built new at the time of the study.

For the City Design Standard Analysis, the watershed was considered fully built-out to its zoned land uses. CN and Tc were updated to reflect future conditions and were used to calculate future condition flows for the 50- and 100-year storms. City development standards require that all new development must control peak flows generated by the 1-, 2-, and 25-year storm event to a value equal to or less than pre-development flows. Because this requirement will affect future development within the basin, the existing flows calculated for the 1-, 2-, and 25-year storms were considered equal to the future conditions flows. A combination of the existing 1-, 2-, and 25- year existing flows and the future 50- and 100- year flows were used for the City Design Standard Analysis.

The attenuation areas considered in the Existing Conditions Analysis were excluded from the City Design Standard Analysis. This exclusion was made because the City does not currently own or plan to acquire the property where existing attenuation occurs. This approach provides a conservative flow estimate by not including the flow reduction that may be provided by these areas.

Analysis results for the four major culvert crossings along the primary channel as well as the secondary system identified at South Halifax Road and Kingswood Drive are presented in Section 3. Due to extensive impacts to surrounding properties, the low number of structural flooding problems reported by citizens, and the projected increase in flooding along the lower reaches of the subject tributary associated with system-wide culvert upsizing, alternatives identified in this section of the report are not recommended. More information about the City Design Standard Analysis may be found in Section 3 of this document.

Alternative Analysis

None of the improvements identified in the City Design Standard Analysis are recommended for implementation. Consequently, an Alternative Analysis was completed to identify other improvements that may be more practical to implement. Many possible alternatives were discussed with City staff as a result of the basin study and each was ranked in priority based on impact to public safety and potential to improve existing flooding problems. Additionally, alternatives were ranked by taking into account desired level of service, anticipated permitting, physical feasibility, anticipated easement needs, property acquisition, and the estimated cost versus the projected benefits provided.

For the Alternative Analysis, the watershed was considered fully built-out to its zoned land uses. Based on this assumption, the hydrologic and hydraulic parameters, including runoff curve numbers, time of concentration, and land cover, remain consistent with the City Design Standard Analysis.

Findings and Recommendations

A summary of the findings and recommendations for both the primary and secondary drainage systems analyzed for the Maple Creek Tributary #2 Drainage Basin Study are shown below.

Primary System

Michael Scott Drive

Description: Double 8′ x 8′ Reinforced Concrete Box Culvert (RCBC)
Existing Conditions: Good Condition, 100-year Level of Service (LOS)
City Design Standard: Add 72″ Reinforced Concrete Pipe (RCP) to meet 25-year LOS
Recommended Alternative/Improvement: None

Woodstock Road

Description: Double 7′ x 4.5′ Corrugated Metal Pipe (CMP)
Existing Conditions: Poor Condition, 2-year LOS
City Design Standard: Replace with Triple 10′x7′ RCBC, 50-year LOS
Recommended Alternative/Improvement: Alternative #2, replace with double 10′ x 6′ RCBC as soon as possible

Ketch Point Drive
Description: Double 9′ x 4′ RCBC
Existing Conditions: Good Condition, 2-year LOS, no reports of flooding
City Design Standard: Replace with Quad 12′ x 7′ RCBC for 25-year LOS
Recommended Alternative/Improvement: None

East Rail Road
Description: 48″ RCP
Existing Conditions: Good Condition, 2-year LOS, no reports of flooding
City Design Standard: Add Double 72″ RCP for 100-year LOS
Recommended Alternative/Improvement: None

Secondary System

South Halifax Road
Description: 42″ CMP and 42″ RCP
Existing Conditions: Fair Condition, 2-year LOS
City Design Standard: Double 10′x6′ RCBC, 50-year LOS
Recommended Alternative/Improvement: Additional study required

Kingswood Drive
Description: 42″ CMP and open channel
Existing Conditions: Fair Condition, 2-year LOS
City Design Standard: Replace Double 10′ x 6′ RCBC, 50-year LOS
Recommended Alternative/Improvement: Additional study required

Recommended Primary System Improvements

Based on study findings and conversation with City staff four alternatives where selected to be presented in Section 4 of this study. Of these four, *Alternative #2 Woodstock Road Culvert Replacement without Upstream Detention* has been selected as the top priority for this basin and is recommended for immediate implementation (See Figure ES-2). The estimated project costs for Alternative #2 are $408,790. For a complete breakdown of the costs, see Appendix K.

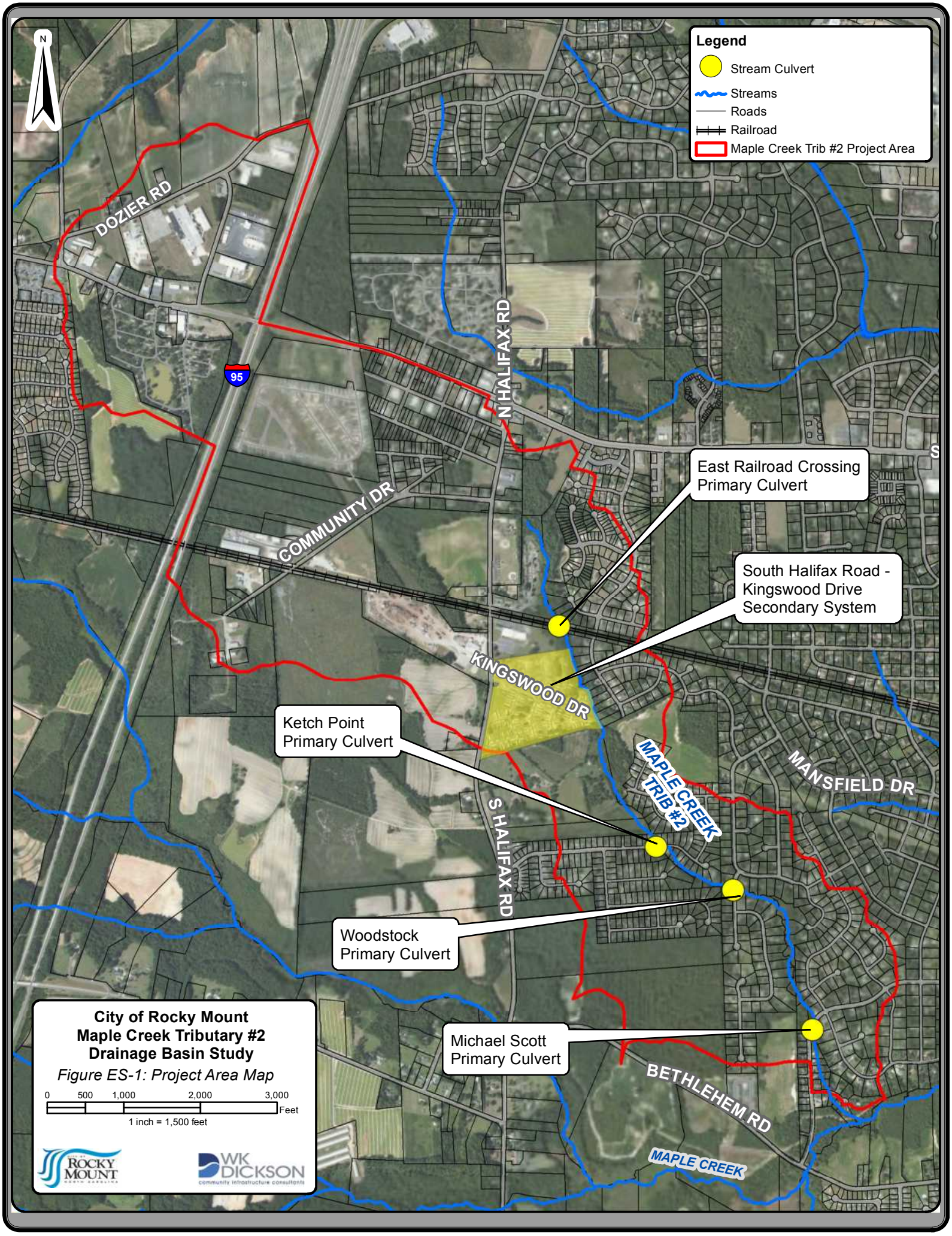
Recommended Secondary System Improvements

Flooding problems at the South Halifax Road Culvert should be considered a high priority for the City. *Alternative #3 South Halifax Road & Kingswood Drive Improvements* highlights one possible improvement for this flood prone area. It includes a bypass system that will collect and reroute storm flows around the South Halifax Crossing and the Kingswood Drive community (See Figure ES-3). Additional survey and analysis is required to validate the feasibility and effectiveness of this alternative. The estimated project costs for Alternative #3 are $3,712,580. For a complete breakdown of the costs, see Appendix K.

The culverts at South Halifax Road as well as the drainage system immediately downstream along Kingswood Drive are undersized. Rocky Mount Recyclers, located directly upstream of this culvert crossing reported a high frequency of structural flooding, partially due to back water from the South Halifax culverts. When flooding occurs at this location, it creates a public safety hazard to motorist traveling along South Halifax Road, employees of Rocky Mount Recyclers, and the hundreds of residents located along Kingswood Drive.

Because of the unique nature of this flooding problem and the large number of citizens affected, it is recommended that additional study be completed to identify the most effective, cost efficient and beneficial solution. The cost benefit per capita for a capital improvement project designed to address the flooding at South Halifax Road and Kingswood Drive is exceptionally high and should be considered favorable by City staff.

A project that will effectively address the South Halifax Road and Kingswood Drive flooding issues will provide potential for economic, public safety, water quality, and flood control benefits. Improvement projects of this type may qualify for State and Federal grant funding. It is recommended that City staff pursue further development and implementation of an effective solution for this location as soon as possible.


N
Legend
Stream Culvert
Streams
Roads
Railroad
Maple Creek Trib #2 Project Area
DOZIER RD
95
N HALIFAX RD
COMMUNITY DR
East Railroad Crossing
Primary Culvert
South Halifax Road -
Kingswood Drive
Secondary System
KINGSWOOD DR
Ketch Point
Primary Culvert
MAPLE CREEK
TRIB #2
MANSFIELD DR
S HALIFAX RD
Woodstock
Primary Culvert
Michael Scott
Primary Culvert
BETHLEHEM RD
MAPLE CREEK
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure ES-1: Project Area Map
0
500
1,000
2,000
3,000
Feet
1 inch = 1,500 feet
ROCKY MOUNT
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Proposed Double
10' x 6' RCBCs
Remove Existing
Double 7' x 4.5' CMP
GLOUCESTER RD
WOODSTOCK RD
NETHERWOOD RD
3908
3904
3900
3840
3833
104
100
3901
3905
3909
3913
3844
3501
3905
3900
3904
3908
3912
4000
3928
3924
3904
4004
3920
5001
5005
5009
4032
3908
4000
5000
5004
5008
4004
4036
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure ES-2: Woodstock Road
Proposed Culvert Improvements
Recommended Alternative
0
50
100
200
Feet
1 inch = 100 feet
ROCKY MOUNT
WK DICKSON
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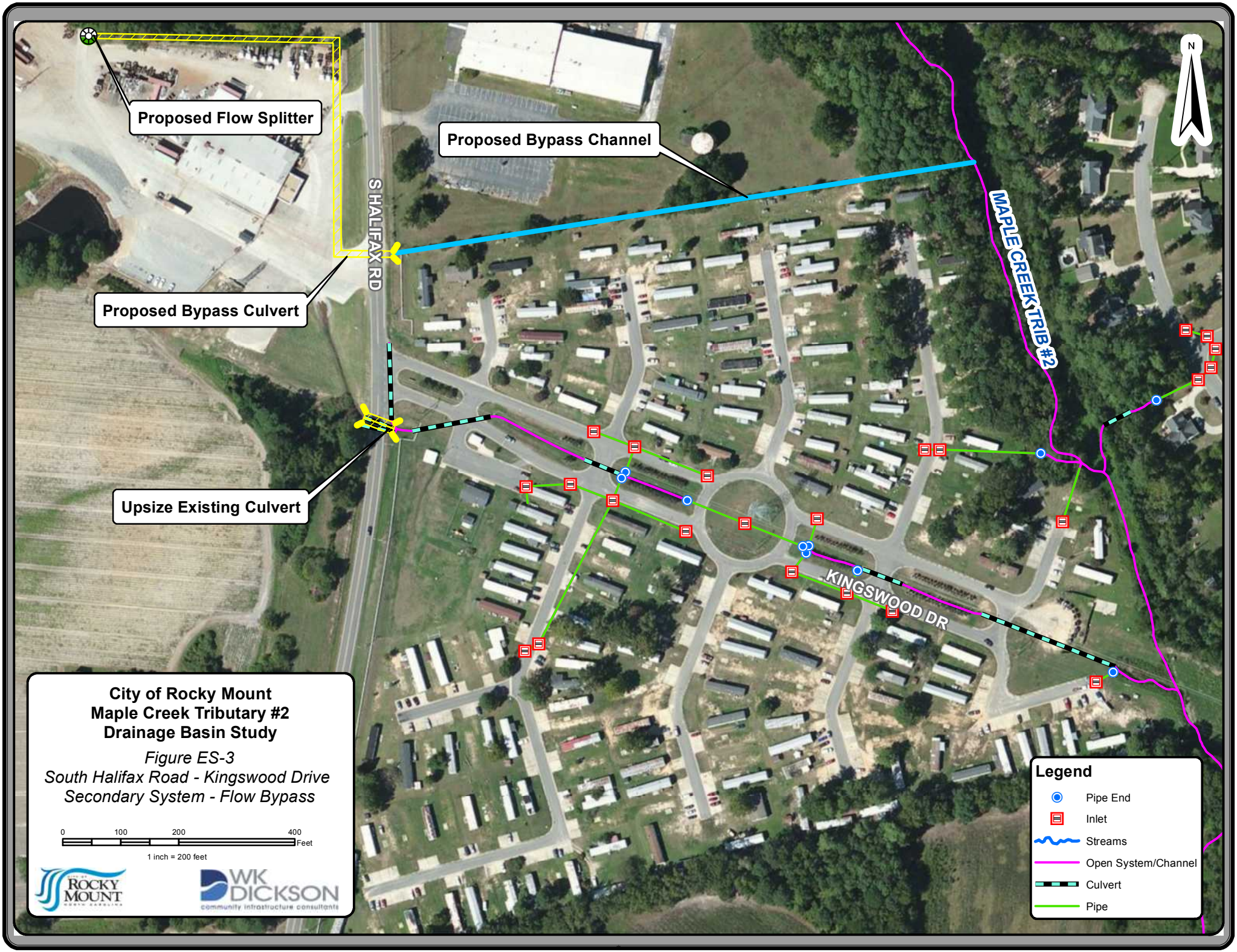
Legend
Pipe End
Manhole
Inlet
Open System/Channel
Culvert
Pipe


Proposed Flow Splitter
Proposed Bypass Channel
Proposed Bypass Culvert
Upsize Existing Culvert
S HALIFAX RD
MAPLE CREEK TRIB #2
KINGSWOOD DR
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure ES-3
South Halifax Road - Kingswood Drive
Secondary System - Flow Bypass
0
100
200
400
Feet
1 inch = 200 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Legend
Pipe End
Inlet
Streams
Open System/Channel
Culvert
Pipe

Project Description

The City of Rocky Mount has selected WK Dickson to evaluate the Maple Creek Tributary #2 watershed for existing flooding and erosion problems, as well as to recommend improvements for addressing identified issues. A vicinity map of the watershed is shown as Figure 1-1.

This report was prepared for the City of Rocky Mount as part of the Maple Creek Tributary #2 Drainage Basin Study. The study includes an evaluation of Maple Creek Tributary #2 from its confluence with Maple Creek at the downstream end of the study to approximately 500 feet downstream of South Halifax Road, as well as drainage systems that drain to Maple Creek Tributary #2. For the purposes of this report, Maple Creek Tributary #2 will be referred to as the primary system and the drainage systems that drain to it will be referred to as secondary systems.

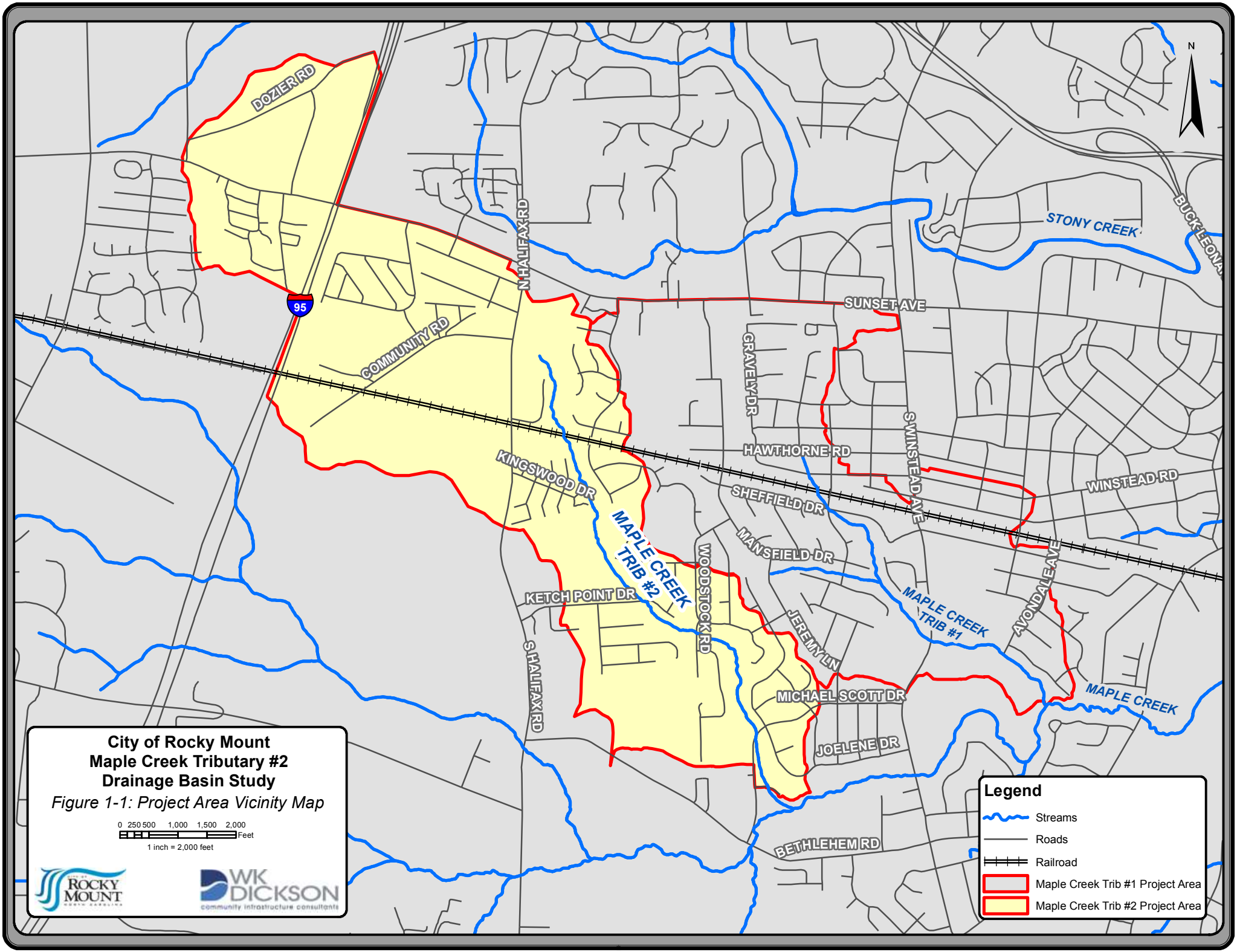
A project area map that shows the watershed and the drainage system evaluated in this study is included as Figure 1-2. Analysis was limited to the following:

- Primary System – Maple Creek Tributary #2
    - Michael Scott Drive Culvert
    - Woodstock Road Culvert
    - Ketch Point Drive Culvert
    - East Railroad Crossing Culvert
- Secondary System
    - South Halifax Road
    - Kingswood Drive

The simulation of the rainfall-runoff process and recommendations in this report were analyzed with the U.S. Army Corps of Engineers (USACE) HEC-HMS and HEC-RAS models based on Natural Resources Conservation Service (NRCS) methodologies. The HEC-RAS program was utilized for the open channel systems (including roadway culverts) and was the primary model used in this report since the majority of the analysis involves open channel. Hydraflow Storm Sewers 2011, an extension of AutoCAD Civil 3D, was used to evaluate the hydraulic capacity of closed systems. A detailed description of the hydrologic and hydraulic analyses can be found in Appendices A and B, respectively.

Watershed Characteristics

The Maple Creek Tributary #2 watershed is situated in the southwestern part of the City of Rocky Mount. As shown in Figure 1-1, Maple Creek Tributary #2 flows into Maple Creek, which is a tributary of the Tar River. The project area is approximately 1,070 acres (1.7 square miles) between its upstream boundary near Dozier Road and downstream boundary near Joelene Drive and Bethlehem Road. The existing land use in the watershed is composed mostly of residential, industrial, and agricultural. Soils within the watershed are predominately NRCS hydrologic soil groups B and C. More detailed information about the land use and soils in the Maple Creek Tributary #2 watershed is contained in Appendix C.


City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 1-1: Project Area Vicinity Map
0 250 500 1,000 1,500 2,000 Feet
1 inch = 2,000 feet
ROCKY MOUNT
WK DICKSON
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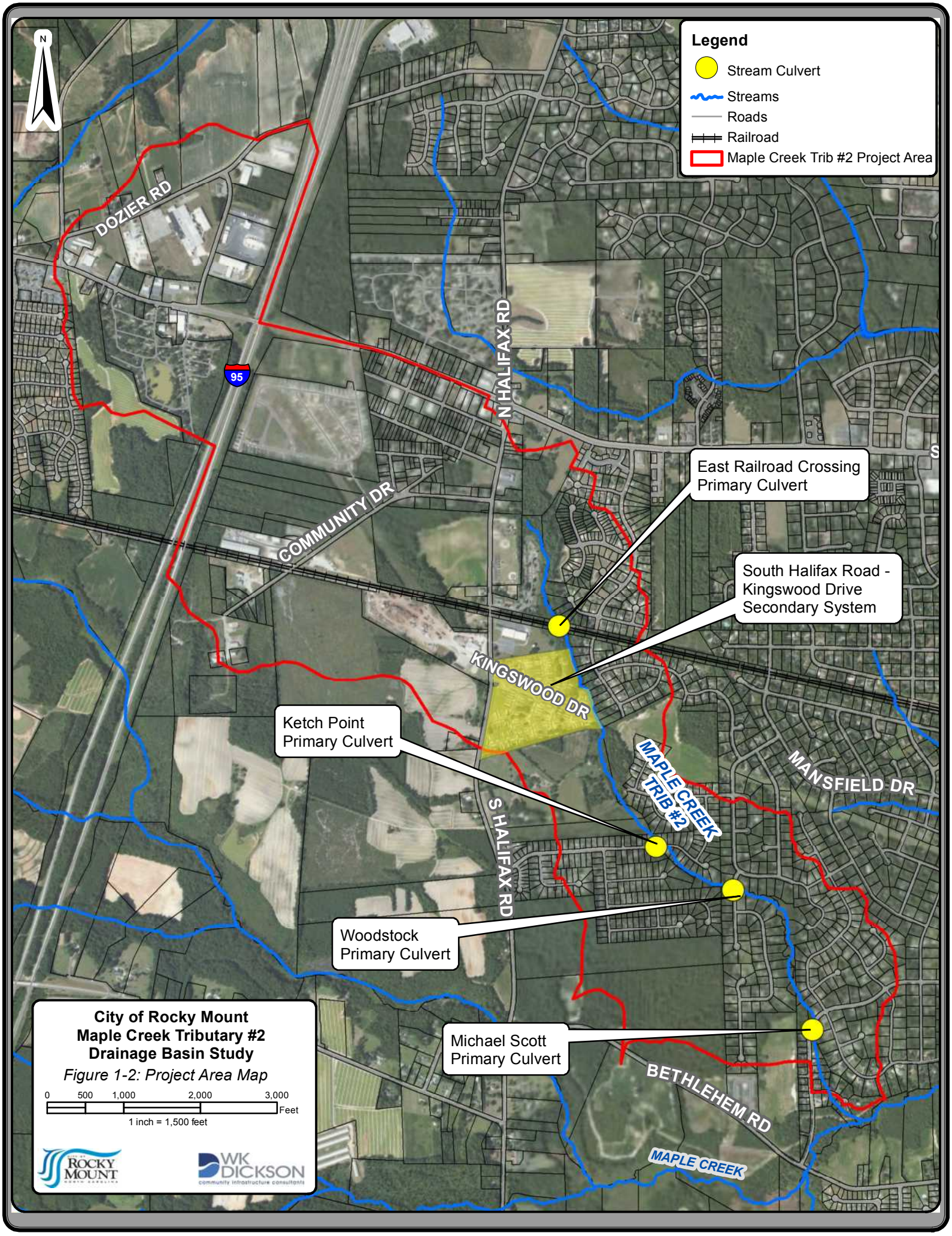
N
DOZIER RD
95
COMMUNITY RD
N HALIFAX RD
S HALIFAX RD
KINGSWOOD DR
KETCH POINT DR
MAPLE CREEK TRIB #2
WOODSTOCK RD
GRAVELY DR
SUNSET AVE
HAWTHORNE RD
SHEFFIELD DR
MANSFIELD DR
JEREMY LN
MICHAEL SCOTT DR
JOELENE DR
BETHLEHEM RD
S WINSTEAD AVE
WINSTEAD RD
AVONDALE AVE
MAPLE CREEK TRIB #1
MAPLE CREEK
STONY CREEK
BUCK LEONA
Legend
Streams
Roads
Railroad
Maple Creek Trib #1 Project Area
Maple Creek Trib #2 Project Area


N
Legend
Stream Culvert
Streams
Roads
Railroad
Maple Creek Trib #2 Project Area
DOZIER RD
95
N HALIFAX RD
COMMUNITY DR
East Railroad Crossing
Primary Culvert
South Halifax Road -
Kingswood Drive
Secondary System
KINGSWOOD DR
Ketch Point
Primary Culvert
MAPLE CREEK
TRIB #2
MANSFIELD DR
S HALIFAX RD
Woodstock
Primary Culvert
Michael Scott
Primary Culvert
BETHLEHEM RD
MAPLE CREEK
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 1-2: Project Area Map
0
500
1,000
2,000
3,000
Feet
1 inch = 1,500 feet
ROCKY MOUNT
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History of Drainage Problems

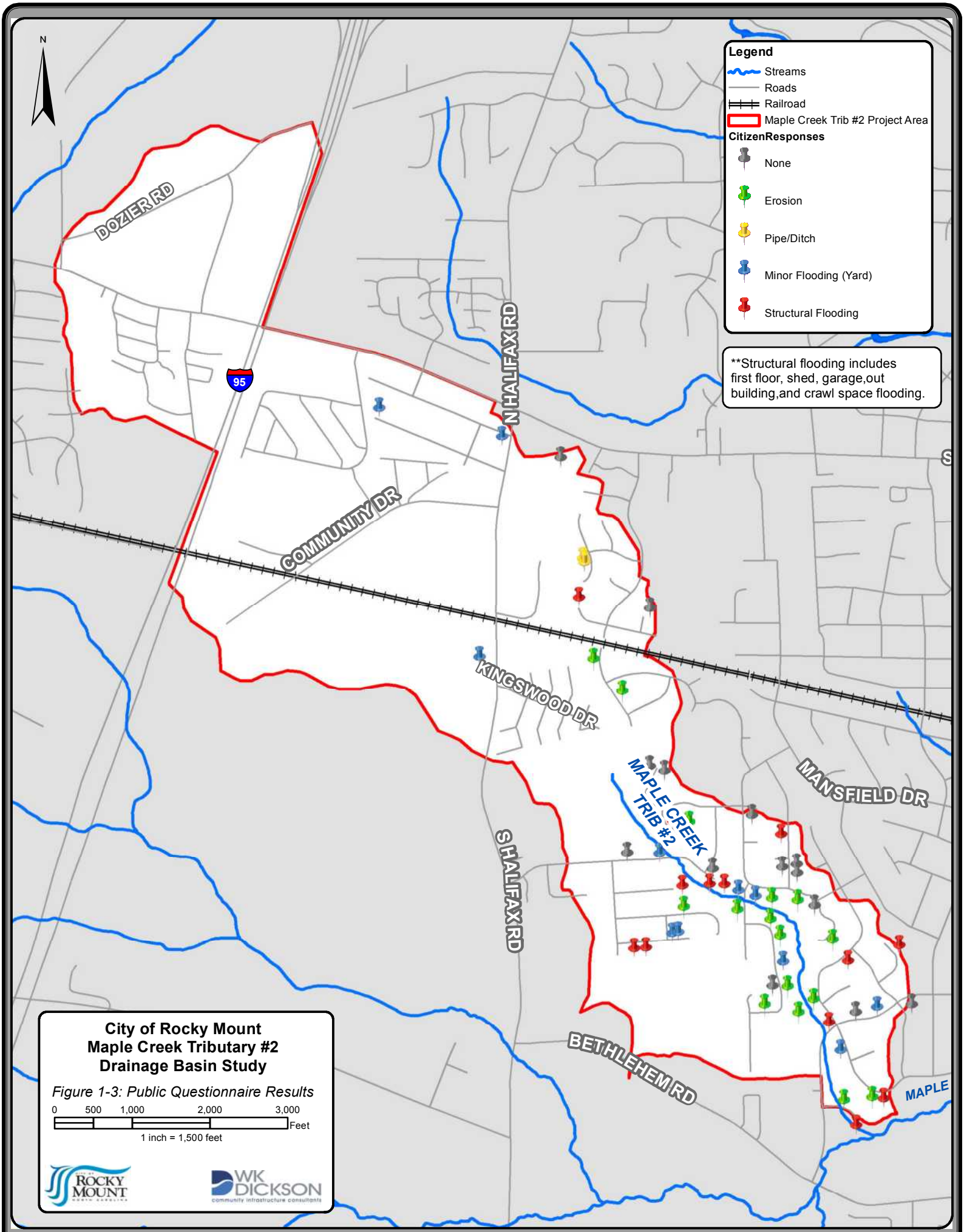
Drainage problems in the Maple Creek Tributary #2 watershed consist of yard, structural, crawl space, HVAC, and roadway flooding. A list of drainage problems in the watershed was compiled from feedback provided by property owners through emails, phone calls, as well as questionnaires and at public meetings held in March and September 2012. The questionnaires were mailed out in February 2012 and included questions regarding the frequency, location, and severity of flooding. Approximately sixty (60) questionnaires were completed by residents. Over fifty percent of the complaints were related to flooding and standing water, while forty percent were related to erosion. Questionnaire results were georeferenced and are shown in Figure 1-3. A copy of the questionnaire and tabular questionnaire results are included in Appendix D.

Additional feedback was obtained during several field visits through on-site interviews with residents. City staff further supplemented the list by providing information previously collected from property owners in the watershed. This information was solicited to help obtain high water marks for both extreme flood events and smaller more frequent heavy rain storms. This data was used as another check and validation tool to confirm that the modeling results were reasonable.

Stormwater Guidelines & Design Requirements

Stormwater design requirements were obtained from the City of Rocky Mount Stormwater Design Manual dated December 2006. They are consistent with those practices found in the North Carolina Department of Transportation (NCDOT) storm water manual entitled "Guidelines for Drainage Studies and Hydraulic Design" dated 1999. The following design standards and criteria were used to evaluate the performance of the existing drainage system and road crossings in this study:

- Residential Local and Collector Roadways – 25-year design storm with 1 foot of freeboard;
- Commercial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard;
- Industrial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard;
- Minor and Major Arterial Roadways – 50-year design storm with 0.5 foot of freeboard; and
- HW/D (the ratio of headwater depth to culvert depth) <1.2.


N
Legend
Streams
Roads
Railroad
Maple Creek Trib #2 Project Area
CitizenResponses
None
Erosion
Pipe/Ditch
Minor Flooding (Yard)
Structural Flooding
**Structural flooding includes first floor, shed, garage,out building,and crawl space flooding.
DOZIER RD
95
N HALIFAX RD
COMMUNITY DR
KINGSWOOD DR
MAPLE CREEK TRIB #2
MANSFIELD DR
S HALIFAX RD
BETHLEHEM RD
MAPLE
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 1-3: Public Questionnaire Results
0 500 1,000 2,000 3,000 Feet
1 inch = 1,500 feet
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Summary

An Existing Conditions Analysis was conducted in order to evaluate the existing hydrologic and hydraulic characteristics of the Maple Creek Tributary #2 watershed. This analysis was conducted to determine the performance of four culvert crossings along the primary channel as well as selected secondary open and closed systems throughout the basin (See Figure 1-2).

Citizen input, GIS inventory data, survey and field work findings were all used to develop the existing conditions model. Curve numbers (CN) and time of concentration (T_c) values associated with existing conditions were determined by using aerial photography, existing land use classifications, and State LiDAR contour data. Peak flows were developed for the 2-, 10-, 25-, 50-, and 100-year storm events. The existing conditions flows took into account existing attenuation areas within the basin. Flow reduction provided by attenuation areas was considered upstream of the four culvert crossings as well as two areas located in Sub-basins 1B and 3 (see watershed map in Appendix C). These additional attenuation areas were included based on field visits, public input, and a review of the topographic data. At select locations where flooding has been reported approximate high water mark elevations and flooding characteristics were documented. This information was then compared with modeling results in order to validate the findings of the Existing Condition Analysis. Detailed descriptions of the model parameters and assumptions can be found in Appendices A and B.

Existing conditions flows used for this analysis are summarized below in Table 2-1. A map showing the HEC-HMS node locations is included in Appendix H with the HEC-HMS output.

Table 2-1: Existing Flows from HEC-HMS

HEC-HMS Node	Road Name / Location	Storm Event				
		2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
Railroad East	Railroad Culvert	133	168	251	321	387
Junct-04	Intersection of Maple Creek Tributary #2 and Kingswood Drive	426	619	735	826	944
Junct-07	Between Hampton Drive and Ketch Point Drive	432	631	752	847	963
Ketch	Ketch Point Drive	436	639	759	852	973
Woodstock	Woodstock Road	441	649	766	868	996
Michael	Michael Scott Drive	470	720	885	1,026	1,184

Primary System

The primary drainage system being evaluated is composed of over 10,000 linear feet of open channel and culverts crossings at Michael Scott Drive, Woodstock Road, Ketch Point Drive, and the East Railroad Crossing. A description of the existing culvert crossings is provided in the following table:

Table 2-2: Existing Culvert Crossings – Primary System

Location	Culvert Size and Material*	Length (feet)	Required Level of Service (years)	Actual Level of Service (years)
Michael Scott Drive	Double 8′ x 8′ RCBC	96	25	100
Woodstock Road	Double 7′ x 4.5′ Elliptical CMP	50	25**	2
Ketch Point Drive	Double 9′ x 4′ RCBC	59	25	2
East Railroad Crossing	48″ RCP	35	100	2

*RCBC–Reinforced Concrete Box Culvert; RCP–Reinforced Concrete Pipe; CMP–Corrugated Metal Pipe
**This is a limited access road and is the only emergency evacuation route for over sixty (60) private residents; therefore it is recommended that a 50-year level of service be provided.

One railroad and three roadway culvert crossings were analyzed for flooding potential in the Maple Creek Tributary #2 Drainage Basin Study. All crossings analyzed in this study are listed in Table 2-3 along with their minimum top-of-road elevations and the 2-, 10-, 25-, 50- and 100-year flood elevations at the crossing for existing conditions.

Table 2-3: Hydraulic Performance for Existing Conditions

Location	Minimum Elevation at Top of Road (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)				
		2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
BOLD PRINT INDICATES ROADWAY OVERTOPPING						
Michael Scott Drive	110.94	106.21	107.41	108.20	108.86	109.59
Woodstock Road	115.20	114.49	**115.62**	**115.80**	**115.98**	**116.12**
Ketch Point Drive	117.31	116.82	**117.68**	**117.94**	**118.10**	**118.25**
East Railroad Crossing	134.83	133.80	**135.08**	**135.39**	**135.56**	**135.66**

*All elevations in this report are referenced to the North American Vertical Datum of 1988 (NAVD 1988).

As shown in Table 2-3, Michael Scott Drive is the only roadway culvert meeting the City of Rocky Mount's required design criteria for a residential collector roadway. Each of the other crossings overtops during a 10-year storm event and is thereby not meeting their required level of service. A complete sufficiency evaluation for each culvert crossing is included in Appendix E.

Secondary System

There are thousands of linear feet of secondary drainage systems located throughout the Maple Creek Tributary #2 watershed. This study was limited to just those systems discharging directly to Maple Creek Tributary #2. Additionally, only 1,000 feet of closed system and 1,000 feet of open system such as swales and roadside ditches were included in the scope of this analysis.

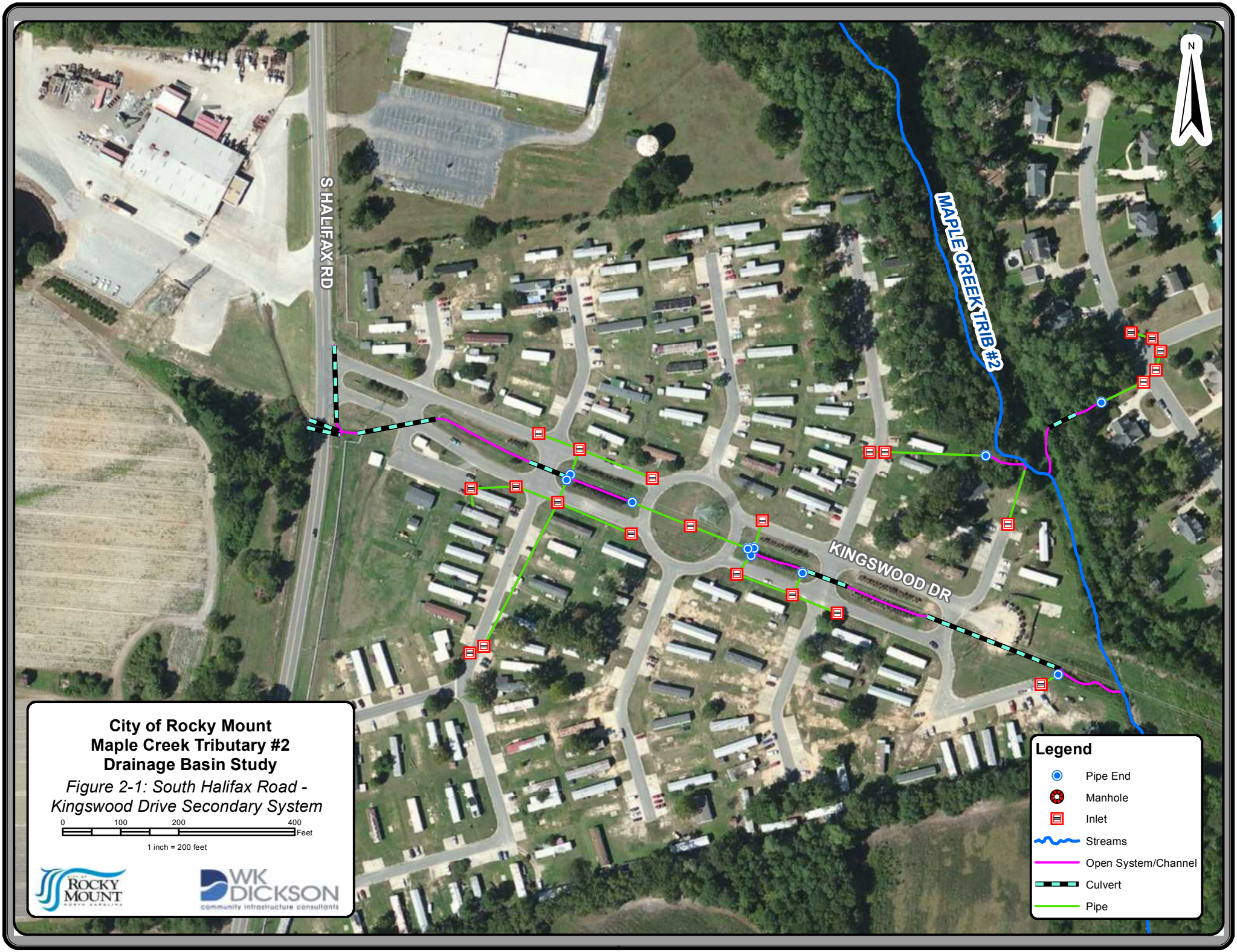
Due to the unknown extent of analysis required for the secondary systems in the watershed, a two-step process was used to evaluate these systems. The first step focused on screening and eliminating the majority of the open and closed secondary systems where no major drainage issues exist. This screening was based on feedback from residents, WK Dickson's field observations, and known drainage complaints provided by the City. Following this screening, numerous systems were identified as being undersized. The various systems were then ranked based on the frequency and severity of flooding events. Those systems with the highest priority ranking were then reviewed through the second step of analysis, which included detailed flow estimation and hydraulic grade line analysis. Through this process, the existing level of surface was determined.

The South Halifax Road culvert and Kingswood Drive drainage system were selected for more detailed analysis. The South Halifax Road culvert consists of one 42″ RCP and one 42″ CMP, both approximately 60 feet in length and the Kingswood Drive system consists of approximately 450 feet of open channel and 1,000 feet of closed pipe (See Figure 2-1). The hydrologic analysis for this system was completed using the rational method and Hydraflow Storm Sewers software. Detailed descriptions of the model parameters and assumptions can be found in Appendix B.

The culverts at South Halifax Road are undersized and this road overtops frequently which contributes to flooding of the Kingswood Drive system located directly downstream. This system's deficiency contributes to a serious public safety hazard for motorist traveling on South Halifax Road and residents of the Kingswood Mobile Park. Citizen input indicates that fatal car accidents have occurred on South Halifax Road due to flooding and residents near Kingswood Drive in some cases must be rescued by boat.

Analysis results show that the South Halifax Road culvert is overtopping in smaller storm events as reported by City residents and business owners. Limited survey of this system was completed to supplement the existing City's stormwater inventory data as needed to complete the modeling. Because the South Halifax Road culvert and Kingswood Drive system serve as a combined system they were evaluated based on the most stringent applicable design requirement. South Halifax Road (State Road #1544) is a secondary North Carolina Department of Transportation (NCDOT) roadway. Roadways of this classification require a 25-year level of service by NCDOT. South Halifax Road is also classified as minor arterial by the City of Rocky Mount which requires a 50-year level of service.

The combined South Halfiax Road and Kingswood Drive system was evaluated for the 50-year design storm. Currently, this system is severely undersized and does not meet the required City design standards. Analysis results show that this combined secondary system passes only the 2-year storm event. Hydraulic analysis input and output for this system is included in Appendix F.


S HALIFAX RD
MAPLE CREEK TRIB #2
KINGSWOOD DR
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 2-1: South Halifax Road - Kingswood Drive Secondary System
0
100
200
400
Feet
1 inch = 200 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Legend
Pipe End
Manhole
Inlet
Streams
Open System/Channel
Culvert
Pipe

Manhole Elevations Analysis

As part of this study sanitary sewer manholes located inside the 100-year existing conditions floodplain were surveyed and analyzed to determine if their rim elevations were above the floodplain. Forty (40) manholes were evaluated. Out of the forty (40) manholes evaluated, seventeen (17) were determined to be below the 100-year existing conditions floodplain and eleven (11) were found to have less than the industry standard freeboard of two feet. A memorandum containing the methodology, results, and recommendations for the manhole elevation analysis was submitted to the City on August 14, 2012. A copy of this memorandum is included as part of Appendix G.

Stream Erosion

Citizen input collected during the study reported many cases of erosion along Maple Creek Tributary #2. The majority of these reports were at locations between the Woodstock Road crossing and the Michael Scott Drive crossing.

Certain amounts of soil and sediment transfer should be considered typical for a stream of this type. Over time as flow conditions within the basin and natural vegetation along the channel evolve, the sinuosity and alignment of a stream channel with change slowly over time. As the stream bank evolves with time, some geometric and vegetation changes to stable stream banks may appear to be signs of erosion.

Stream bank erosion occurs when the volume of water conveyed by a channel exceeds the channels capacity and/or the velocity of the flow exceeds the shear strength of the soil and ground cover located in and on the channel bank. The result of erosion can include loss of stream bank, incised stream beds, and increased water turbidity (cloudy appearance) and pollution. Erosion of this type will lead to reduced water quality. These conditions also results in the decline of stream habitation, and chemical and biological degradation inside the water body.

Numerous reports of stream bank erosion were collected with citizen input. Most of these reports were at locations along the tributary between Woodstock Road and Michael Scott Drive. Velocity values determined through hydraulic modeling associated with the 10-year 24-hour storm peak flows at these locations range from approximately two (2) to five (5) feet per second. Given the type of vegetation observed along the tributary, these velocity values are generally considered non-erosive.

As a result of the erosion reported by citizens and the stream conditions observed during this study, it is recommended that monitoring pins be installed at select locations along the tributary and monitoring be conducted for a period of 12 to 24 months. This monitoring period will provide helpful insight to potential erosion and, if required, will serve as supporting evidence of needed stream bank stabilization improvements. Monitoring and improvement efforts should give priority to areas directly adjacent to structures, fences or public utilities, where the risk and cost of erosion in the greatest.

Erosion is typically addressed with stream bank stabilization or stream restoration improvement methods. These methods are generally expensive to complete and require coordination with a larger number of stakeholders including private property owners and permitting agencies. Prior

to selecting an improvement alternative, erosion monitoring is recommended to better understand the rate of erosion occurring along Maple Creek Tributary #2.

Conclusion

The Existing Conditions Analysis confirmed flooding problems reported by citizens and revealed that several of the primary and secondary systems' components do not meet the City of Rocky Mount's design standards and may cause flooding. For more information regarding recommendations to meet City design standards and alleviate flooding, see Section 7 of this study. In response to the reported stream bank erosion, monitoring is recommended to determine what stabilization measures are appropriate for Maple Creek Tributary #2.

Summary

The City Design Standard Analysis was completed to determine the improvements required to upgrade the deficient systems to meet the City of Rocky Mount's development requirements. The proposed improvements described in this section of the study outline what would be required if these systems were to be built new at the time of the study.

For the City Design Standard Analysis, the watershed was considered fully built-out to its zoned land uses. CN and Tc values were updated to reflect future conditions and were used to calculate future condition flows for the 50- and 100-year storms. City development standards require that all new development must control peak flows generated by the 1-, 2-, and 25-year storm event to a value equal to or less than pre-development flows. Because this requirement will affect future development within the basin, the existing flows calculated for the 1-, 2-, and 25-year storms were considered equal to the future conditions flows. A combination of the existing 1-, 2-, and 25- year existing flows and the future 50- and 100- year flows were used for the City Design Standard Analysis.

The attenuation areas considered in the Existing Conditions Analysis were excluded from the City Design Standard Analysis. This exclusion was made because the City does not currently own or plan to acquire the property where existing attenuation occurs. This approach provides a conservative flow estimate by not including the flow reduction that may be provided by these areas. The future peak flows used for sizing the proposed culverts are summarized below in Table 3-1.

Table 3-1: Future Flows from HEC-HMS (City Design Standard)

HEC-HMS Node	Road Name / Location	Storm Event				
		2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
Railroad East	Railroad Culvert	213	347	431	513	574
Junct-04	Intersection of Maple Creek Tributary #2 and Kingswood Drive	380	635	799	1,217	1,360
Junct-07	Between Hampton Drive and Ketch Point Drive	416	701	885	1,317	1,475
Ketch	Ketch Point Drive	436	737	932	1,368	1,533
Woodstock	Woodstock Road	488	830	1,051	1,507	1,692
Michael	Michael Scott Drive	601	1,028	1,304	1,801	2,026

Primary System

The improvements presented in this section were identified through an iterative process of upsizing culverts, adjusting culvert and channel inverts, and discussions with City staff. The design objective for the Michael Scott Drive and Ketch Point Drive culvert crossings is to convey the 25-year peak flow through the roadway culverts with a minimum freeboard of 12 inches and an HW/D ratio of 1.2 or less. The recommended design objective for the Woodstock Road culvert crossing has been increased above the 25-year City design standard. This is recommended because Woodstock Road is a limited access road and is the only emergency evacuation route for over sixty residences. For the Woodstock Road culvert crossing, the recommended design objective is to convey the 50-year peak flow with a minimum freeboard of 6 inches and an HW/D ratio of 1.2 or less.

The City does not provide a standard that can be applied at the East Railroad culvert crossing. However, railroad culverts are typically designed to pass the 100-year storm event therefore, this was used as the standard. To meet the Division of Water Quality requirements, culverts were modeled as if the inverts were buried one foot below the existing channel bottom. In addition, it was decided that proposed culverts in this study shall have endwalls, and/or wingwalls to improve the hydraulic efficiency.

Micheal Scott Drive

The culvert at Michael Scott Drive is currently passing the 100-year existing conditions flood without overtopping. However, the increase between existing and future flows will cause this culvert to no longer meet the City's design standard. The following summarizes the design improvements required at Michael Scott Drive to pass the 25-year design storm with one foot of freeboard (See Figure 3-1):

- Install approximately 95 linear feet of 72″ RCP as floodplain culvert;
- Remove and replace downstream and upstream headwalls and wingwalls; and
- Perform necessary channel improvements to accommodate installation of larger culverts.

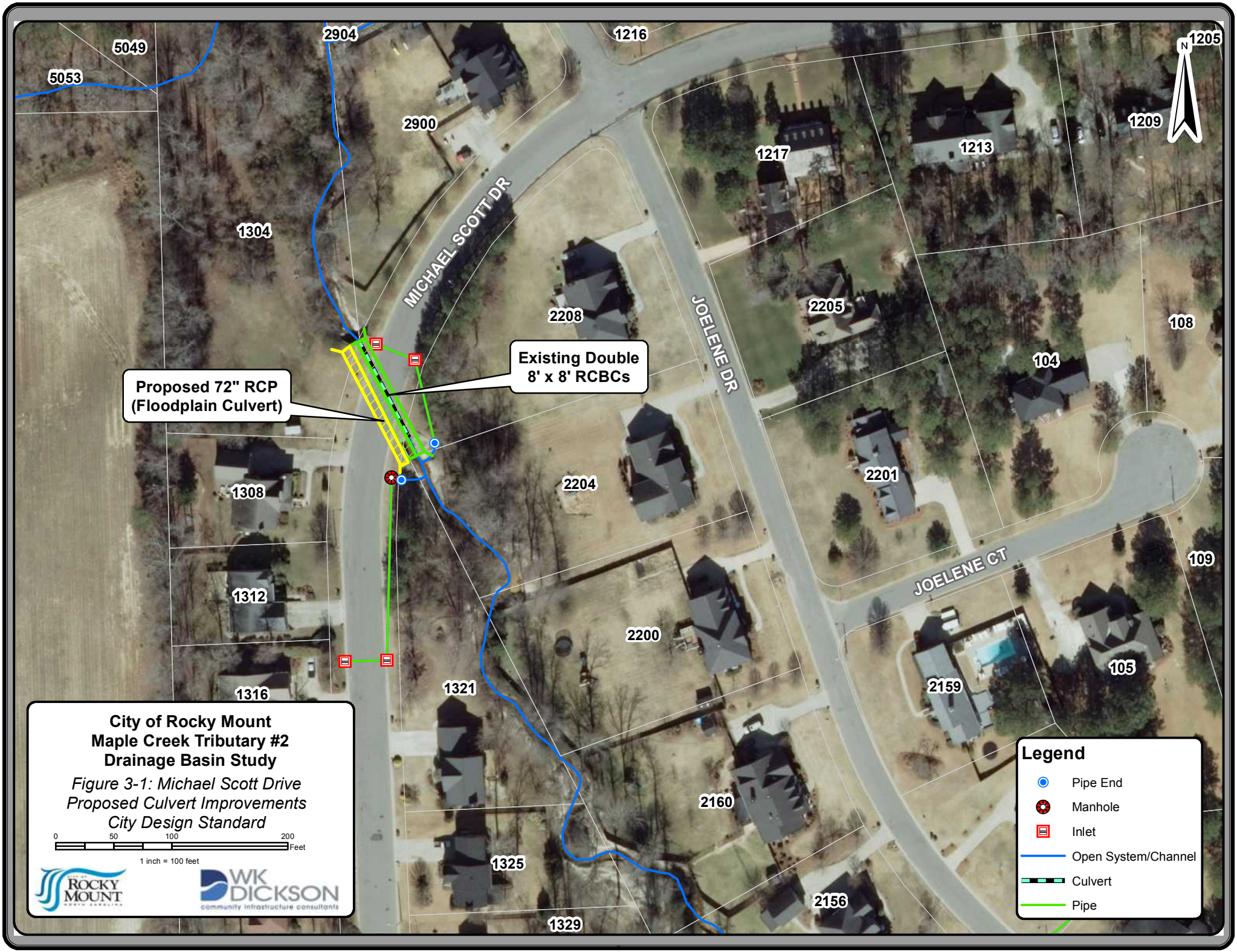
The estimated project costs are $101,980. HEC-RAS results for the City Design Analysis have been included in Appendix J.

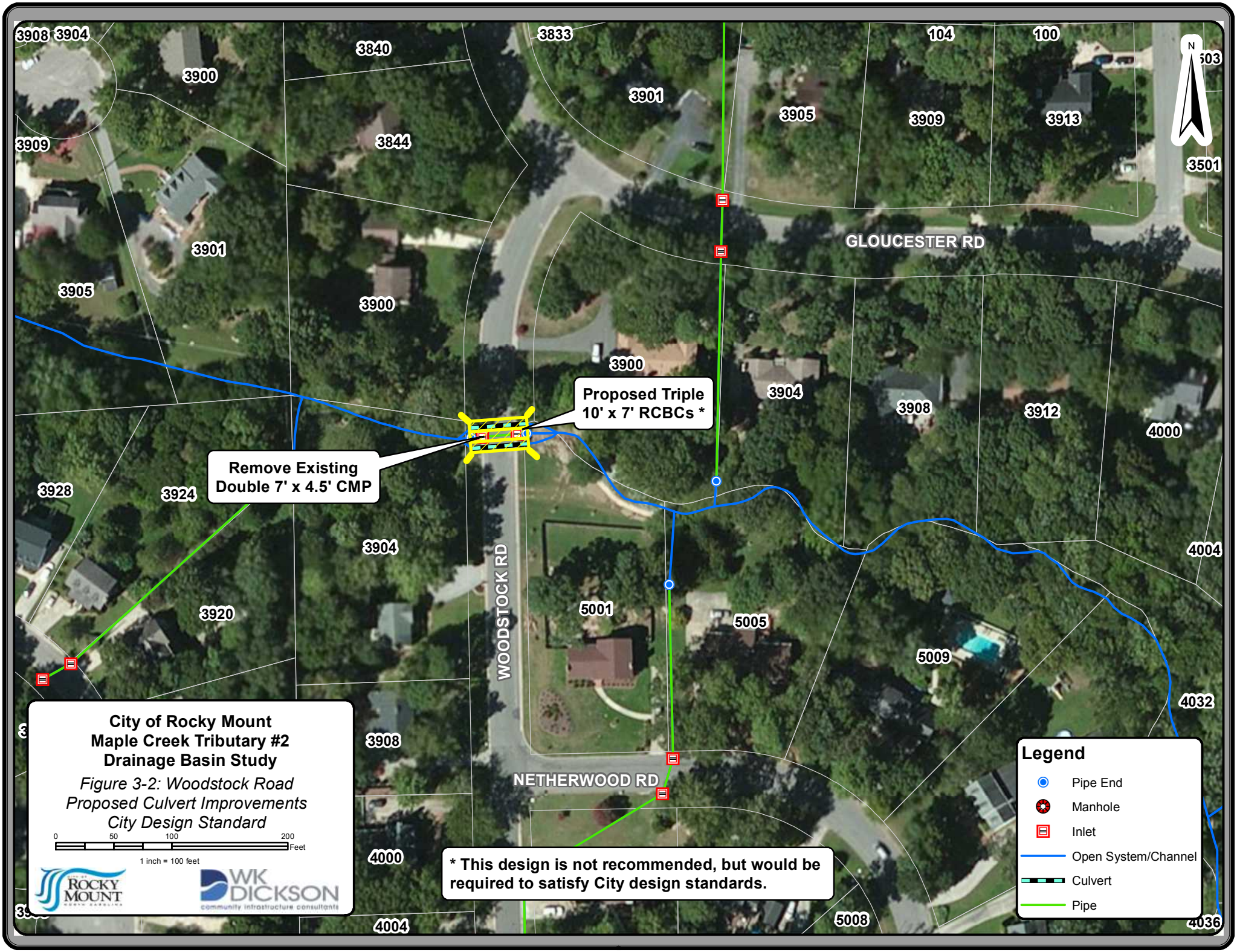
Woodstock Road

The culvert at Woodstock Road is undersized and does not meet a 10-year level of service in the existing conditions flood without overtopping. The increase in flows being considered for the City Design Standard Analysis causes the level of service to further decline. The following summarizes the design improvements necessary at Woodstock Road to pass the 50-year design storm (See Figure 3-2):

- Replace approximately 50 linear feet of double 7′ x 4.5′ CMP with triple 10′ x 7′ RCBCs or an equivalent three-sided bridge;
- Remove and replace downstream and upstream headwalls and wingwalls; and
- Perform necessary channel improvements to accommodate installation of larger culverts.

The estimated project costs for the RCBC option are $607,190. HEC-RAS results for the City Design Analysis have been included in Appendix J.


5049
5053
2904
1216
1205
2900
1209
1217
1213
1304
MICHAEL SCOTT DR
2208
JOELENE DR
2205
108
104
Existing Double
8' x 8' RCBCs
Proposed 72" RCP
(Floodplain Culvert)
1308
2204
2201
JOELENE CT
109
1312
2200
105
1316
1321
2159
2160
1325
2156
1329
N
Legend
Pipe End
Manhole
Inlet
Open System/Channel
Culvert
Pipe
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 3-1: Michael Scott Drive
Proposed Culvert Improvements
City Design Standard
0
50
100
200
Feet
1 inch = 100 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants


Proposed Triple
10' x 7' RCBCs *
Remove Existing
Double 7' x 4.5' CMP
GLOUCESTER RD
WOODSTOCK RD
NETHERWOOD RD
3908
3904
3900
3840
3833
104
100
3901
3905
3909
3913
3844
3501
3905
3900
3904
3908
3912
4000
3928
3924
3904
4004
3920
5001
5005
5009
4032
3908
4000
4004
5008
4036
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 3-2: Woodstock Road
Proposed Culvert Improvements
City Design Standard
0
50
100
200
Feet
1 inch = 100 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
* This design is not recommended, but would be required to satisfy City design standards.
Legend
Pipe End
Manhole
Inlet
Open System/Channel
Culvert
Pipe

Ketch Point Drive

The culvert at Ketch Point Drive is located approximately 1,200 feet upstream of Woodstock Road and similarly does not meet a 10-year level of service in the existing conditions flood without overtopping. Additionally, the increase in flows being considered for the City Design Standard Analysis causes the level of service to further decline. The following summarizes the design improvements required at Ketch Point Drive to pass the 25-year design storm (See Figure 3-3):

- Replace approximately 59 linear feet of double 9′ x 4′ RCBCs with quad 12′ x 7′ RCBCs or an equivalent three-sided bridge;
- Remove and replace downstream and upstream headwalls and wingwalls; and
- Perform necessary channel improvements to accommodate installation of larger culverts.

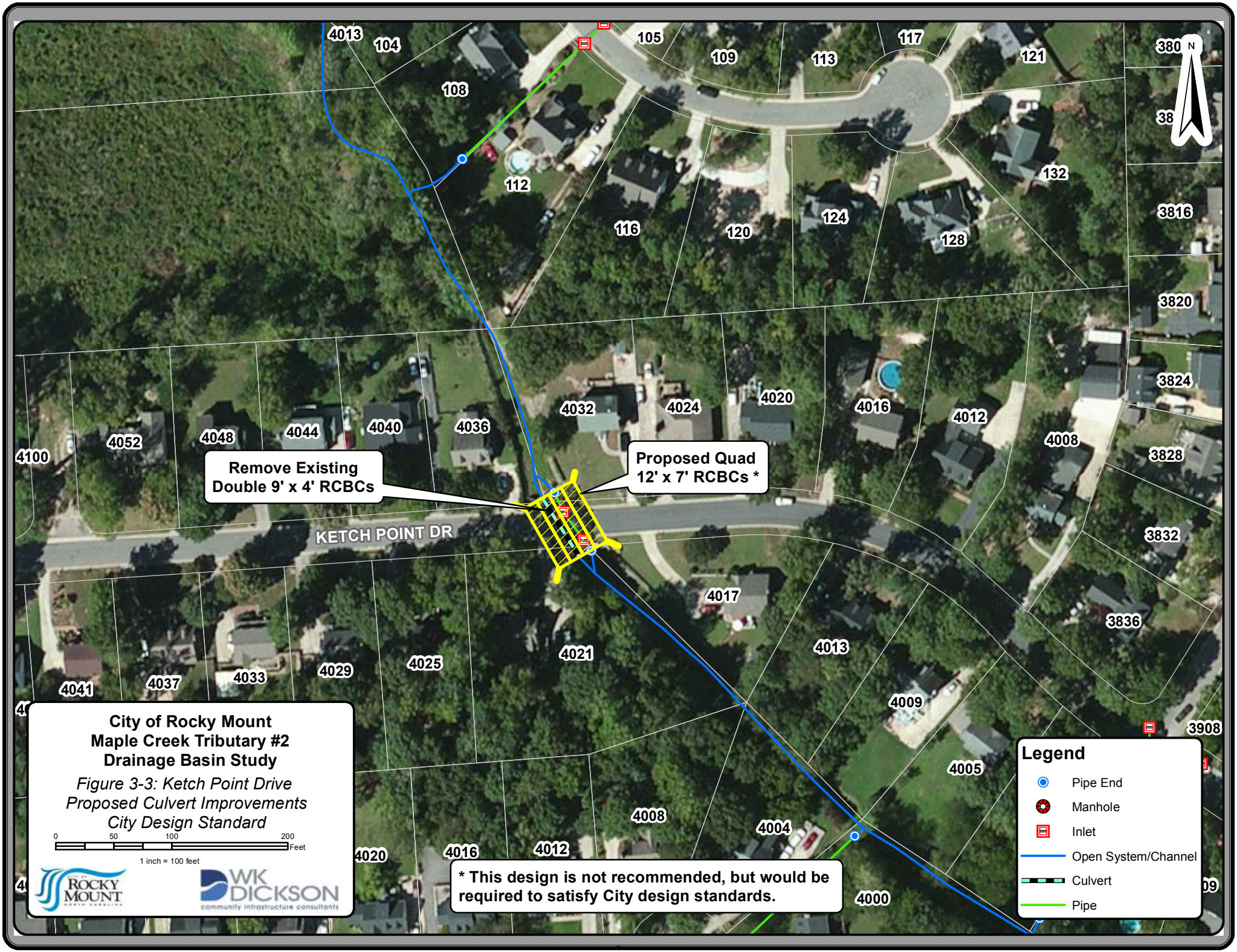
The estimated project costs for the RCBC option are $1,489,110. HEC-RAS results for the City Design Analysis have been included in Appendix J.

East Railroad Crossing

The culvert at the railroad crossing is currently passing the 2-year existing conditions flood without overtopping. The zoned development in the watershed will cause flows to increase by 70 percent at this crossing during the 25-year storm event. The increase in flows being considered for the City Design Standard Analysis causes the level of service to further decline. The following summarizes the design improvements required at the East Railroad Crossing to pass the 100-year design storm (See Figure 3-4):

- Install approximately 35 linear feet of double 72″ RCP as floodplain culverts;
- Perform necessary channel improvements to accommodate installation of the floodplain culverts.

The estimated project costs are $143,510. HEC-RAS results for the City Design Analysis have been included in Appendix J.



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study

Figure 3-3: Ketch Point Drive
Proposed Culvert Improvements
City Design Standard

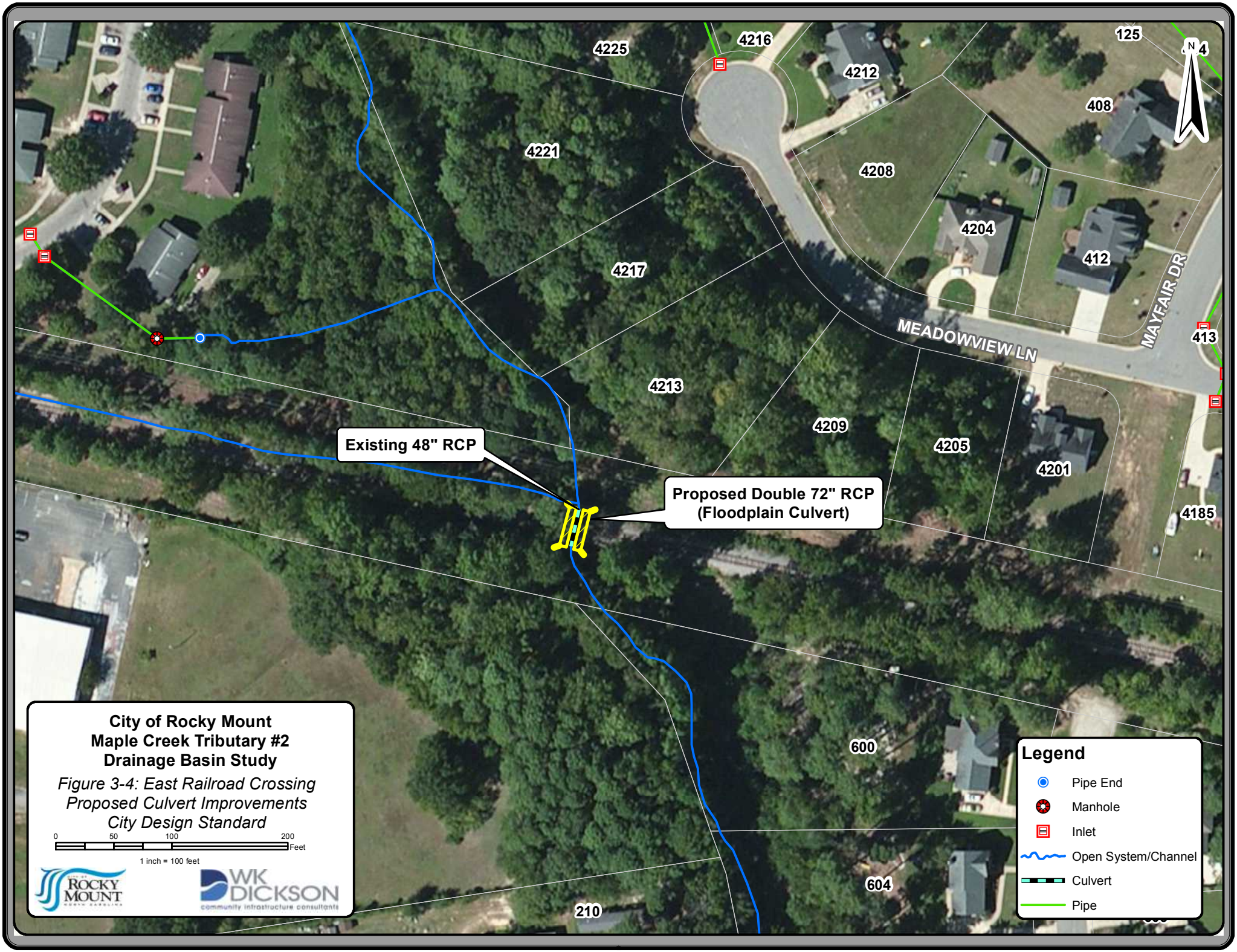

4225
4216
4212
125
4
408
4221
4208
4204
412
4217
MEADOWVIEW LN
MAYFAIR DR
413
4213
4209
4205
4201
4185
Existing 48" RCP
Proposed Double 72" RCP
(Floodplain Culvert)
600
604
210
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 3-4: East Railroad Crossing
Proposed Culvert Improvements
City Design Standard
0
50
100
200
Feet
1 inch = 100 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Legend
Pipe End
Manhole
Inlet
Open System/Channel
Culvert
Pipe

Table 3-2: Summary of Required Culvert Improvements – City Design Standard

Location	Roadway Classification	Provided Level of Service (years)	Existing Culvert Size and Material	Proposed Culvert Size and Material
Michael Scott Drive	Residential	25	Double 8′ x 8′ RCBC	72″ RCP (Floodplain Culvert)
Woodstock Road	Residential* (Limited Access)	50	Double 7′ x 4.5′ Elliptical CMP	Triple 10′ x 7′ RCBC
Ketch Point Drive	Residential	25	Double 9′ x 4′ RCBC	Quad 12′ x 7′ RCBC
East Railroad Crossing	N/A	100	48″ RCP	Double 72″ RCP (Floodplain Culverts)

*This is a limited access road and is the only emergency evacuation route for over sixty (60) private residents; therefore it is recommended that a 50-year level of service be provided.

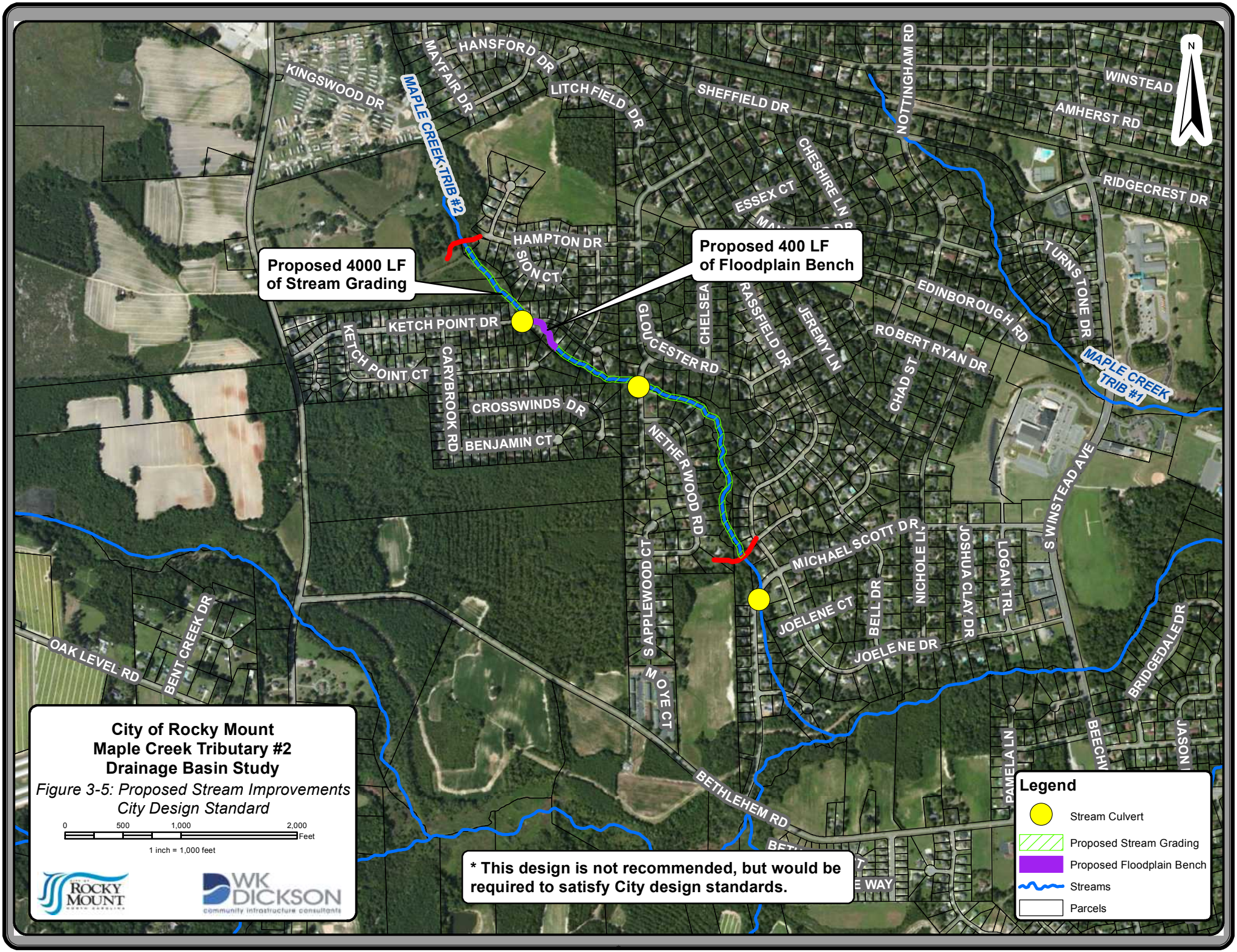
The above noted primary system improvements also require floodplain benching and stream grading in order to meet City Design Standards. Stream grading will increase the capacity of the primary stream channel by lowering the stream bed elevation and widening the stream bank width. In addition to this increase in the stream's capacity, floodplain benches are required to help store and convey the water associated with larger storms. Excavation of an engineered floodplain bench along the primary channel will increase the available area of storage and prevent structural flooding for residents adjacent to the primary channel. As shown on Figure 3-5, floodplain benching and stream grading considered in this analysis include one to two feet of stream bed excavation along 4000 linear feet of stream as well as 400 linear feet of flood plain benching ranging from 30 to 40 feet in width.

The estimated project costs for the various systems are outlined in the following table.

Table 3-3: Summary of Costs for Proposed Primary System Improvements–City Design Standard

Location	Estimated Construction Cost	Estimated Design Cost*	Estimated Total Cost
Michael Scott Drive	$84,980	$17,000	$101,980
Woodstock Road	$505,990	$101,200	$607,190
Ketch Point Drive	$1,145,470	$343,640	$1,489,110
East Railroad Crossing	$119,590	$23,920	$143,510
Floodplain Benching/ Stream Grading	$1,835,880	$2,150,760	$3,986,640

*Design, Survey, Easement Acquisition, Permitting, & Miscellaneous Administrative Costs. For a breakdown of the costs, see Appendix K.


Proposed 4000 LF of Stream Grading
Proposed 400 LF of Floodplain Bench
MAPLE CREEK TRIB #2
MAPLE CREEK TRIB #1
KINGSWOOD DR
MAYFAIR DR
HANSFORD DR
LITCHFIELD DR
SHEFFIELD DR
NOTTINGHAM RD
WINSTEAD
AMHERST RD
CHESHIRE LN
ESSEX CT
RIDGECREST DR
HAMPTON DR
SION CT
TURNSTONE DR
EDINBOROUGH RD
KETCH POINT DR
KETCH POINT CT
CARYBROOK RD
GLOUCESTER RD
CHELSEA
RASSFIELD DR
JEREMY LN
ROBERT RYAN DR
CHAD ST
CROSSWINDS DR
BENJAMIN CT
NETHERWOOD RD
S WINSTEAD AVE
MICHAEL SCOTT DR
NICHOLE LN
JOSHUA CLAY DR
LOGAN TRL
S APPLEWOOD CT
JOELENE CT
BELL DR
JOELENE DR
MOYE CT
OAK LEVEL RD
BENT CREEK DR
BRIDGEDALE DR
BEECH
JASON
PAMELA LN
BETHLEHEM RD
WAY
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 3-5: Proposed Stream Improvements
City Design Standard
0
500
1,000
2,000
Feet
1 inch = 1,000 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
* This design is not recommended, but would be required to satisfy City design standards.
Legend
Stream Culvert
Proposed Stream Grading
Proposed Floodplain Bench
Streams
Parcels

Secondary System

South Halifax Road Culvert and Kingswood Drive System

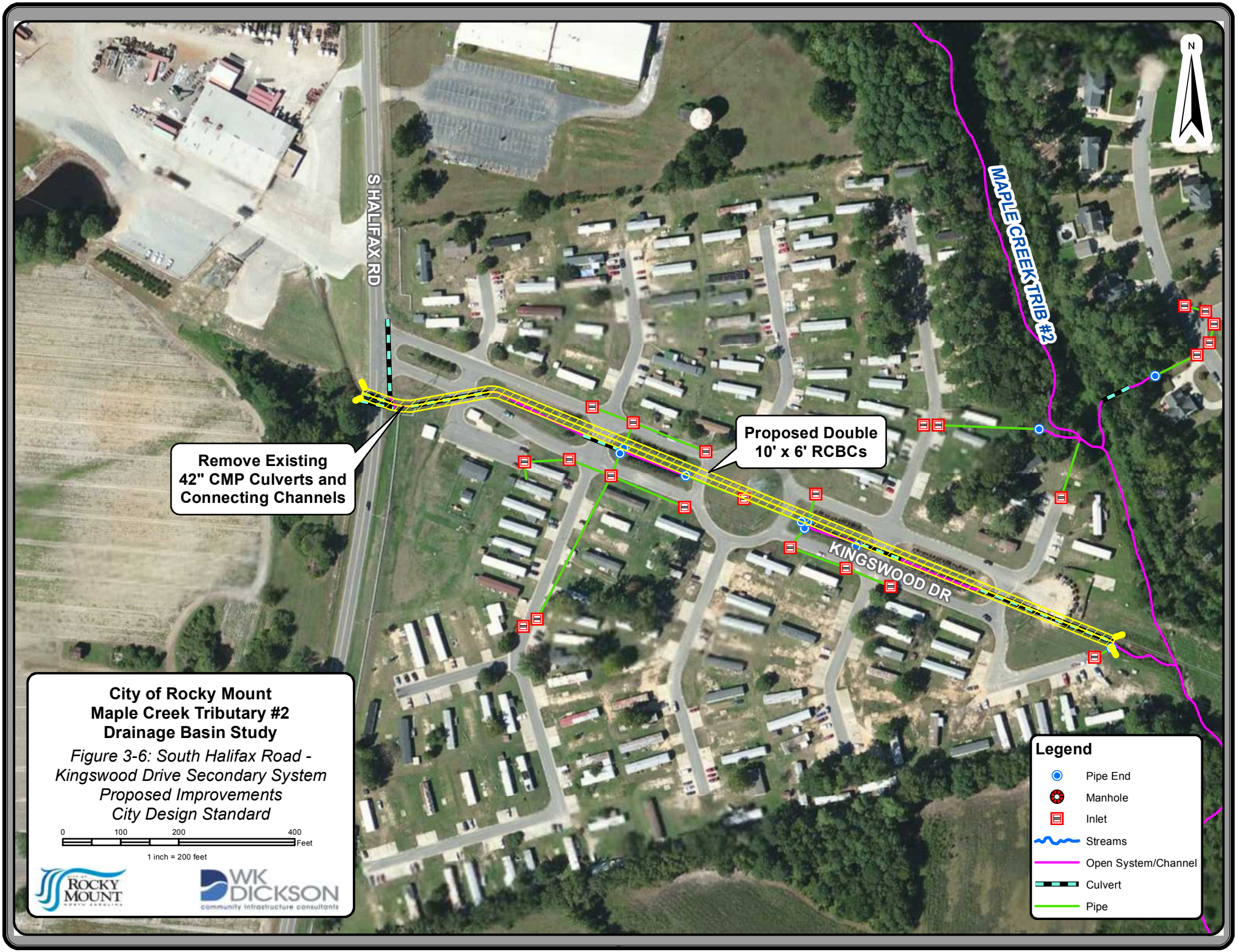
The City design standard for the South Halifax Road culvert crossing is to convey the 50-year peak flow through the roadway culverts with a minimum freeboard of 6 inches and an HW/D ratio of 1.2 or less. As previously mentioned, South Halifax Road is a secondary NCDOT road. The NCDOT design requirement for secondary roads is to convey the 25-year peak flow. It should be noted that the City design requirement (50-year) is more stringent than NCDOT requirement.

As a residential collector road, the Kingswood Drive system is required to provide a 25-year level of service. In order for both the South Halifax culvert and Kingswood Drive system to meet City design standards significant improvements must be implemented. The design alternative below proposes one pipe system extending from the upstream side of South Halifax Road through Kingswood Drive and discharging into the primary channel. The design improvements required to provide the 50-year level of service are as follows (See Figure 3-6):

- Replace existing 42″ RCP and CMP (South Halifax Road culverts) with 90 linear feet of double 10′ x 6′ RCBC ;
- Replace existing Kingswood Drive system consisting of open channel sections and 48″ CMP with approximately 1400 linear feet of double 10′ x 6′ RCBC;
- Install custom downstream and upstream headwalls; and
- Perform necessary grading and channel improvements to accommodate installation of larger culverts.

There are sections along Kingwood Drive that are currently concrete-lined open channel. As part of the City Design Standard, this will be converted to a closed system and the flow would be piped through the box culverts. Additionally, portions of South Halifax Road and Kingswood Drive would need to be raised several feet to meet the cover requirements and accommodate the height of the proposed RCBC.

Another constraint that would require extensive coordination is the existing high voltage utility transmission line that runs above the existing drainage system along Kingswood Drive. The alignment of the transmission line is essentially identical to that of the drainage system. Large excavation below or around these utility structures will require difficult coordination and foundation support. The total estimated project cost, not including required transmission line coordination is $8,099,980. For a complete breakdown of the costs, see Appendix K.


S HALIFAX RD
MAPLE CREEK TRIB #2
KINGSWOOD DR
N
Remove Existing 42" CMP Culverts and Connecting Channels
Proposed Double 10' x 6' RCBCs
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 3-6: South Halifax Road - Kingswood Drive Secondary System Proposed Improvements City Design Standard
0
100
200
400
Feet
1 inch = 200 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Legend
Pipe End
Manhole
Inlet
Streams
Open System/Channel
Culvert
Pipe

Conclusion

The culvert improvements presented as part of the City Design Standard Analysis will increase the level of service for the crossings at Woodstock Road, Ketch Point Drive, and the East Railroad Crossing in order to comply with current City design standards and regulations. However, these improvements will cause an increase in flows and water surface elevations experienced along Maple Creek Tributary #2 for locations downstream. Properties along the tributary between Woodstock Road and Michael Scott Drive are projected to see increases in water surface elevations by approximately one foot. These proposed improvements will likely create new flooding issues at residences that currently do not have flooding problems. Additionally, the improvements presented in this section for the primary system will require extensive stream grading, channel improvements, and floodplain benching that will be difficult to complete due to private property impacts and the required permitting (See Figure 3-5).

The proposed improvements to the secondary system including the South Halifax Road culvert and Kingswood Drive system identified in this section also include many challenges. There are a number of unique site constraints surrounding this system that must be addressed in order to implement an improvement of any kind. The replacement of the existing system in its entirely with twin RCBCs will increase flows and WSEL downstream and will be extremely expensive.

Based on the negative effects along Maple Creek Tributary #2 and on the watershed as a whole, none of the improvements identified in this section of the study are recommended for implementation. Instead, improvements outlined in the Alternative Analysis (Section 4) of this study are recommended for implementation.

Summary

Since none of the improvements identified in the City Design Standard Analysis are recommended for implementation, an Alternative Analysis was completed to identify other improvements that will be more practical to implement. Section 4 of the basin study presents design alternatives that have been developed to address collected public input, known infrastructure needs, and system deficiencies identified by this study. Many possible alternatives were found as a result of the basin study and each was prioritized based on impact to public safety and potential to improve existing flooding problems. Additionally, alternatives were ranked by taking into account desired level of service, anticipated permitting, physical feasibility, anticipated easement needs, property acquisition, and the estimated cost versus the projected benefits provided. Through discussions with City staff the following alternatives summarized in Table 4-1 have been selected to be considered for this study.

Table 4-1: Summary of Alternatives

Alt #	Name	Description	Alternative Objectives
1	Woodstock Road Culvert Replacement and Hampton Road Detention Area	• Replace existing culvert at Woodstock Road • Reconstruct previously breached detention area near Hampton Road	• Reduce flooding upstream of Woodstock Road • Replace failing culverts at Woodstock Road • Mitigate flow increase downstream of Woodstock Road due to culvert upsize with Hampton Road detention area
1A	Woodstock Road Culvert Replacement and Railroad West and Community Drive Detention Areas	• Replace existing culverts at Woodstock Road • Acquire properties upstream where detention is occurring	• Reduce flooding upstream of Woodstock Road • Replace failing culverts at Woodstock Road • Consider upstream detention to reduce flooding downstream and increase LOS at culvert crossings
2	Woodstock Road Culvert Replacement without Upstream Detention	• Replace existing culverts at Woodstock Road	• Reduce flooding upstream of Woodstock Road • Replace failing culverts at Woodstock Road
3	South Halifax Road and Kingwoods Drive Improvements	• Flow bypass culvert and channel	• Send flows that exceed capacity of existing system to a new bypass system

For the Alternative Analysis, the watershed was considered fully built-out to its zoned land uses. Based on this assumption, the hydrologic and hydraulic parameters, including runoff curve numbers, time of concentration, and land cover, remain consistent with the City Design Standard Analysis.

Primary System

Based on the poor existing condition and performance of the Woodstock Road culvert, the replacement of this culvert was identified early on in the study as a high priority. Given that the future culvert at this location will be larger and will covey more flow downstream, two alternatives were developed (Alternative #1 and #1A) to explore detention areas that may provide the needed flow reduction to mitigate the increased flows associated with the upsized culvert. Alternatives #1, #1A, and #2 all include the replacement of the existing Woodstock Road Culvert. Alternatives #1 and #1A each look at different detention areas to determine their respective flood reduction and level of service improving potential. Alternative #2 includes only the replacement of the Woodstock Road culvert without any upstream detention. As part of Alternative #2, a detailed analysis of its impacts to downstream properties was completed.

The peak flows used for sizing the proposed culverts in Alternative #1 are summarized below in Table 4-2. These flows were developed for Alternative #1 taking into account attenuation provided by the proposed detention area.

Table 4-2: Future Flows from HEC-HMS (Alternative #1)

HEC-HMS Node	Road Name / Location	Storm Event				
		2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
Railroad East	Railroad Culvert	213	347	431	513	574
Junct-04	Intersection of Maple Creek Tributary #2 and Kingswood Drive	476	785	983	1,217	1,360
Junct-07	Between Hampton Drive and Ketch Point Drive	432	735	920	1,136	1,269
Ketch	Ketch Point Drive	437	745	933	1,150	1,286
Woodstock	Woodstock Road	469	815	1,028	1,254	1,405
Michael	Michael Scott Drive	607	1,054	1,330	1,605	1,804

Alternative #1 Woodstock Road Culvert Replacement and Hampton Detention Area:

Alternative #1 includes improvements to the Woodstock Road culvert coupled with reconstruction of an upstream detention area located west of Hampton Road (referred to as Hampton Road detention area). As shown in Figure 4-1, the Woodstock Road culvert would be upsized to a double 10′ x 6′ RCBC. This alternative will provide a 10-year level of service for the Woodstock Road culvert crossing. Additionally, it will reduce the frequency and severity of flooding upstream of Woodstock Road. The recommended improvements will cause minimal downstream water surface elevation (WSEL) increases. The highest WSEL increases are associated with the 50- and 100-year storm and are projected to be as high as 25 inches upstream of Michael Scott Drive. Table 4-3 shows a comparison of the WSEL for the areas directly upstream and downstream of Woodstock Road for the existing conditions and Alternative #1 in the 10-year and 100-year design storms.

Table 4-3: WSEL Comparison Upstream and Downstream of Woodstock Road Culvert

	Existing Conditions WSEL (ft)		Alternative #1 WSEL (ft)	
Location	**10-Year**	**100-Year**	**10-Year**	**100-Year**
Approximately 160 feet U/S of Woodstock Road	115.73	116.29	114.76	116.26
Approximately 60 feet U/S of Woodstock Road	115.62	116.12	114.11	115.83
Approximately 140 feet D/S of Woodstock Road	111.77	112.68	112.23	113.73
Approximately 200 feet D/S of Woodstock Road	111.67	112.57	112.12	113.62

The following summarizes the design improvements proposed at Woodstock Road for Alternative #1. (See Figure 4-1):

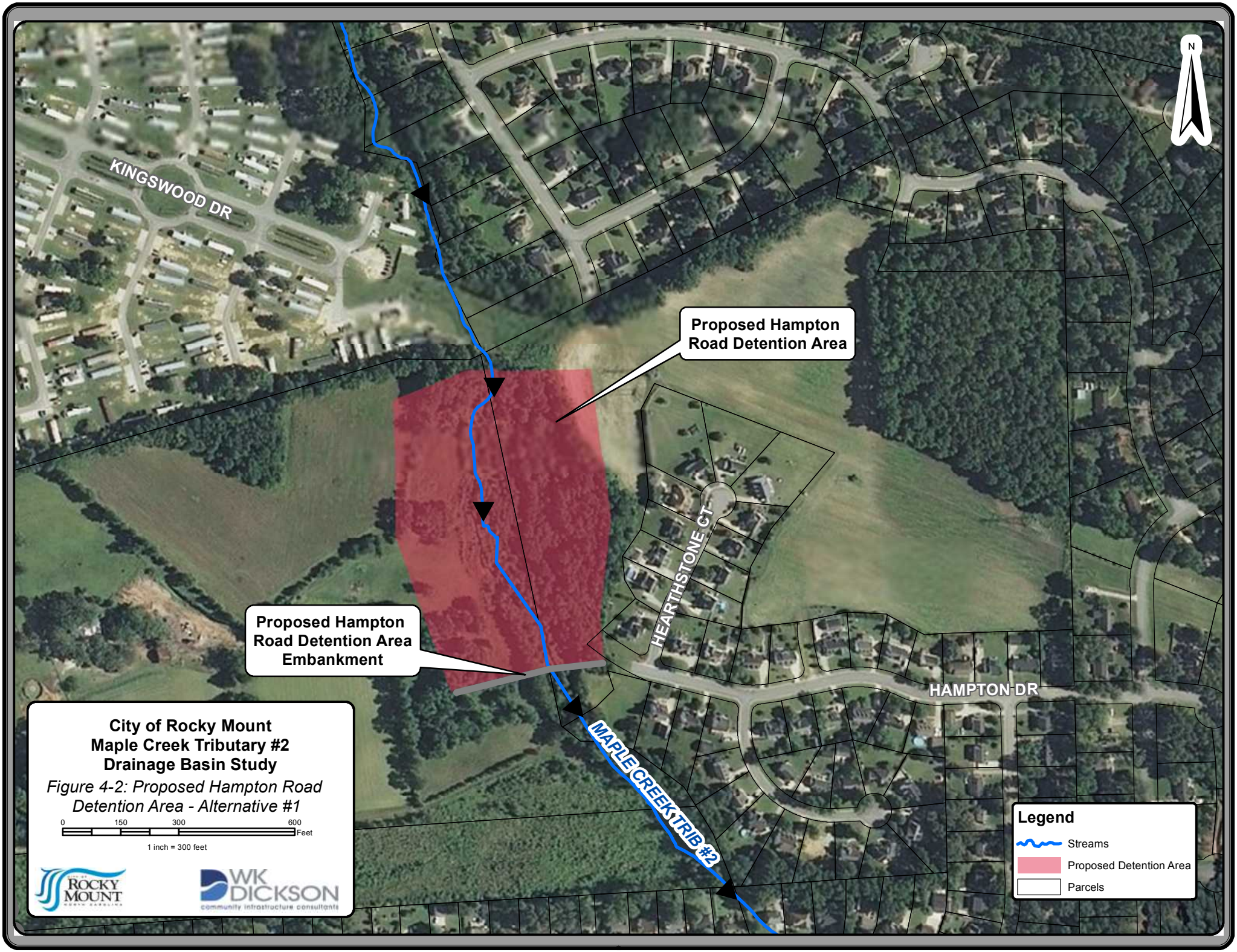
- Replace approximately 50 linear feet of double 7′ x 4.5′ CMP with double 10′ x 6′ RCBC;
- Remove and replace downstream and upstream headwalls and wingwalls; and
- Perform necessary channel improvements to accommodate installation of larger culverts.

Alternative #1 also proposes a detention area located adjacent to Hampton Road. Public input and historical mapping indicate that a pond was previously at this location. Within the last fifteen to twenty years, the dam for the pond was breached and never repaired. As part of this alternative, an embankment would be constructed to provide attenuation in the upstream area of the Maple Creek Tributary #2 watershed. The alignment of the embankment will follow the probable extension of Hampton Road. The embankment would allow the passage of base flow through a culvert and also provide storage for the 2-, 10-, 25-year storms thereby reducing peak flows associated with these events. The proposed location of the Hampton Road detention area is shown as Figure 4-2. It should be noted that property acquisitions and/or easements will be required to complete the construction of the Hampton Road detention area and embankment.

The Hampton Road detention area will provide a small amount of peak flow reduction in the primary system between Ketch Point Drive and Woodstock Road. For the 25-year storm, the peak flow will be reduced by less than five percent. The proposed Hampton Road detention area was evaluated using State LiDAR contours and limited modeling. Prior to the final design, more thorough information will be needed including detailed survey and soil analysis. Additional modeling will also be required to complete the design of the proposed detention area after the detailed survey and soils data is obtained.

The total estimated project costs for Alternative #1 are $733,180. For a completed breakdown of the costs, see Appendix K.


Proposed Double
10' x 6' RCBCs
Remove Existing
Double 7' x 4.5' CMP
GLOUCESTER RD
WOODSTOCK RD
NETHERWOOD RD
3908
3904
3900
3840
3833
104
100
3901
3905
3909
3913
3844
3501
3905
3900
3904
3908
3912
4000
3928
3924
3904
4004
3920
5001
5005
5009
4032
3908
4000
5000
5004
5008
4004
4036
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 4-1: Woodstock Road
Proposed Culvert Improvements
Alternatives #1, #1A, and #2
0
50
100
200
Feet
1 inch = 100 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Legend
Pipe End
Manhole
Inlet
Open System/Channel
Culvert
Pipe


KINGSWOOD DR
Proposed Hampton Road Detention Area
HEARTHSTONE CT
Proposed Hampton Road Detention Area Embankment
HAMPTON DR
MAPLE CREEK TRIB #2
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 4-2: Proposed Hampton Road Detention Area - Alternative #1
0
150
300
600
Feet
1 inch = 300 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Legend
Streams
Proposed Detention Area
Parcels

Alternative #1A Woodstock Road Culvert Replacement and Railroad West and Community Drive Detention Areas:
Alternative #1A includes upsizing of Woodstock Road to a double 10′ x 6′ RCBC and taking into account the two existing detention areas located upstream of South Halifax Road. The location of the Community Drive and Railroad West detention areas are shown in Figure 4-3.

Alternative #1A was modeled using a combination of existing and future flows as described above in the summary of this section. For the 1-, 10- and 25-year storm events, existing conditions flows were used reflecting on-site storm water detention requirements and future flows were used for the 50 and 100-year storm events. The flows used for Alternative #1A are summarized in Table 4-4.

Table 4-4: Flows from HEC-HMS (Alternative #1A)

HEC-HMS Node	Road Name / Location	Storm Event				
		2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
Railroad East	Railroad Culvert	213	347	431	513	574
Junct-04	Intersection of Maple Creek Tributary #2 and Kingswood Drive	377	622	770	904	1,000
Junct-07	Between Hampton Drive and Ketch Point Drive	414	692	867	1,017	1,129
Ketch	Ketch Point Drive	435	724	927	1,092	1,215
Woodstock	Woodstock Road	487	817	1,043	1,222	1,362
Michael	Michael Scott Drive	600	1,015	1,259	1,473	1,664

Under this alternative, Woodstock Road will achieve a 10-year level of service. The proposed improvements will result in a reduction in the frequency and severity of flooding upstream of Woodstock Road. However, the improvements will cause small downstream water surface elevation (WSEL) increases in the 2- and 10-year storms. These increases are much higher for the 25-, 50- and 100-year storms. The WSEL increases associated with these larger storms are projected to be as high as 23 inches upstream of Michael Scott Drive. By accounting for the attenuation near Community Drive and the Railroad West crossing, the flows are reduced by up 20 percent in those areas located between the Railroad East and Ketch Point Drive culvert crossings. Alternative #1A will not eliminate WSEL increases but they will be lower than those resulting from the Alternative #1.

The estimated project costs for Alternative #1A are $1,099,730. The project costs for Alternative #1A includes property acquisition fees for several parcels. The values assumed for these parcels are the current tax property value. For a complete breakdown of the costs, see Appendix K.

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Figure 4-3
Existing Upstream Detention Areas

Alternative #2 Woodstock Road Culvert Replacement without Upstream Detention:
Alternative #2 is the recommended alternative for the primary system. This alternative also includes the replacement of Woodstock Road culvert; however, it does not include any of the detention areas proposed in the previous alternatives. The peak flows used for sizing the proposed culvert in this alternative are the same as those used for the City Design Standard Analysis (See Table 3-1). The Woodstock Road culvert would be upsized to double 10′ x 6′ RCBC and will provide a 10-year level of service. This alternative comes very close to passing the 25-year design storm only overtopping slightly. The following summarizes the design improvements proposed at Woodstock Road (See Figure 4-1):

- Replace approximately 50 linear feet of double 7′ x 4.5′ CMP with double 10′ x 6′ RCBC;
- Remove and replace downstream and upstream headwalls and wingwalls; and
- Perform necessary channel improvements to accommodate installation of larger culverts.

This alternative will provide the same level of service as Alternatives #1 and #1A but, without the additional expense of developing upstream detention. The estimated project costs for Alternative #2 are $408,790. HEC-RAS results for Alternative #2 have been included in Appendix J.

Table 4-5: Summary of Hydraulic Performance for Alternative Analysis – Woodstock Road

Alternative	Proposed Culvert Size and Material	Provided Level of Service (years)	10-Year Freeboard (feet)	50-Year Freeboard (feet)	100-Year Freeboard (feet)
#1	Double 10′ x 6′ RCBC	10	1.09	-0.41*	-0.63*
#1A	Double 10′ x 6′ RCBC	10	1.08	-0.32*	-0.54*
#2	Double 10′ x 6′ RCBC	10	0.98	-0.75*	-0.99*

*Overtops the road.

Increasing the size of the culvert at Woodstock Road from double 7′ x 4.5′ CMP to double 10′ x 6′ RCBC will result in a reduction in the frequency and severity of flooding upstream of Woodstock Road. The improvements will cause minimum downstream WSEL increases in the 2- and 10-year storms and more measureable WSEL increases for the 25-, 50- and 100-year storms. The WSEL increases associated with these larger storms are projected to be as high as 30 inches at locations directly upstream of Michael Scott Drive. Because of the potential for this improvement to impact downstream properties, an evaluation was completed to determine the magnitude of these impacts.

Critical elevations such as finished floor, HVAC pad, crawl space, and garage finish floor were collected for properties located where WSEL increase was projected. Each of the selected properties was reviewed in detail to verify that the projected WSEL increase associated with the replacement of the Woodstock Road culvert will not create new or worsen existing structural flooding issues. A memorandum containing the results of this downstream analysis was submitted to the City on August 30, 2012. A copy of this memorandum is included as part of Appendix G.

Secondary System

Alternative #3 South Halifax Road & Kingswood Drive Improvements:
The area surrounding the South Halifax Road culvert has been reviewed extensively to determine a practical design recommendation that will improve the performance of the South Halifax Road culvert and the Kingswood Drive system such that the severity and frequency of flooding may be reduced. Solutions typically used to improve drainage systems and address flooding issues do not appear to be practical for this location due to the following constraints:

- The culvert is operating under inlet control and services a drainage area of approximately 300 acres. This condition produces higher than desired HW/D values when sizing for the 10-, 25-, and 50-year level of service.

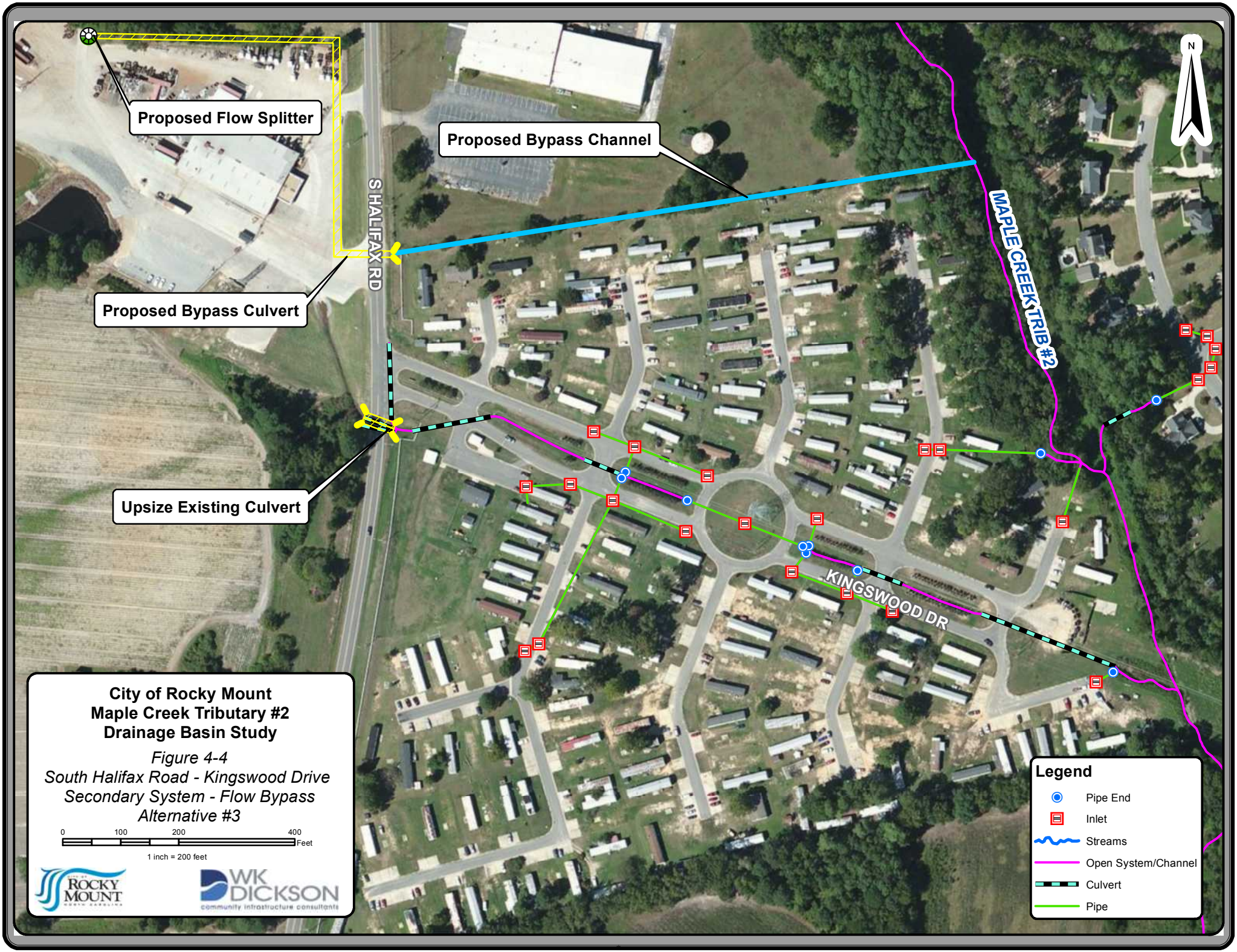
- The Rocky Mount Recyclers finished floor is only 1.12 feet above the existing South Halifax Road at the culvert crossing. This results in routine flooding of this adjacent facility and limits the potential to raise South Halifax Road.

- Upsizing the South Halifax Road culvert alone will increase flooding to the Kingswood Drive community.

- Improvements to Kingswood Drive will require coordination with the owner of the overhead high voltage transmission lines. Protection of and/or relocation of transmission structures may be required.

Several possible solutions including constructing a secondary roadway access point to Kingwoods Drive (used for safe entrance and exit during flooding events), installing a flow bypass system (to reroute large flows away from Kingswood Drive), and constructing an upstream detention area were presented and discussed with City staff for this secondary system. The alternative selected for inclusion in this study is a flow bypass system. This system should be designed to allow base flow and small storm events through the existing South Halifax culvert and Kingswood system, while sending larger flows through a new pipe and open channel system. As shown in Figure 4-4, the new channel system would discharge directly to Maple Creek Tributary #2.

This proposed flow bypass system is based off of State LiDAR and limited modeling. Therefore, it is recommended that prior to the final design of the flow bypass system that detailed survey be obtained to validate project feasibility. This survey data would also be used to complete a more comprehensive modeling effort. The total estimated cost to complete this alternative as shown is $3,712,580. For a complete breakdown of the costs, see Appendix K.


Proposed Flow Splitter
Proposed Bypass Channel
Proposed Bypass Culvert
Upsize Existing Culvert
S HALIFAX RD
MAPLE CREEK TRIB #2
KINGSWOOD DR
N
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Figure 4-4
South Halifax Road - Kingswood Drive
Secondary System - Flow Bypass
Alternative #3
0
100
200
400
Feet
1 inch = 200 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Legend
Pipe End
Inlet
Streams
Open System/Channel
Culvert
Pipe

Conclusion

The alternatives presented in this section are those that were selected based on discussions with City staff and that address the highest priority problems discovered during the basin study. As previously stated, the recommended Primary System design improvement is *Alternative #2 Woodstock Road Culvert Replacement without Upstream Detention*. The proposed detention areas reviewed in Alternatives #1 and #1A did not provide sufficient flow and WSEL reduction to justify the expense for construction. Based on the poor condition of the existing Woodstock Road Culvert and the reoccurring upstream flooding, Alternative #2 has been selected as the top priority for this basin and is recommended for immediate implementation.

Regarding the secondary system reviewed in this study, *Alternative #3 South Halifax Road & Kingswood Drive Improvements* recommends a bypass system that will collect and reroute storm flows around the South Halifax crossing and Kingswood Drive community. Because of the unique nature of this flooding problem and the large number of citizens affected, additional study is recommended to identify the most effective, cost-efficient, and beneficial solution. The cost benefit per capita for a capital improvement project designed to address the flooding at this location is exceptionally high and should be considered favorable by City staff.

A project that will effectively address the South Halifax Road and Kingswood Drive flooding issues will provide potential for economic, public safety, water quality, and flood control benefits. A solution at this location may also have potential to reduce flows and WSELs along the primary channel. Improvement projects of this type may qualify for State and Federal grant funding. It is recommended that City staff pursue further development and implementation of an effective solution for this location as soon as possible.

Proposed improvements within the Maple Creek Tributary #2 watershed must adhere to the requirements set forth in Sections 401 and 404 of the Clean Water Act. Required permitting can range from activities that are pre-authorized to those requiring a pre-construction notification (PCN) for a Nationwide Permit (NWP). It is anticipated that NWP #3 (Maintenance), NWP #13 (Bank Stabilization), and NWP #27 (Stream and Wetland Restoration Activities) will be required to support the projects associated with the Maple Creek Tributary #2 Drainage Basin Study. More detailed explanations of the listed NWPs are provided below.

NWP #3 – Maintenance

This permit authorizes the repair, replacement or rehabilitation of any previously permitted or currently serviceable structure. A PCN is not required if minor deviations in the structure's configuration or filled area occur as a result of changes in materials, construction techniques, or safety standards necessary to make repair or replacement, provided that environmental impacts are minimal. A PCN to the United States Army Corp of Engineers (USACE) is required if a significant amount of sediment is excavated/filled within the channel. NC Division of Water Quality (DWQ) does not require a PCN for NWP #3 but usually receives one as a courtesy.

Other provisions imposed by the State of North Carolina require that culvert inverts must be buried a minimum of 1-foot below the streambed for culverts greater than or equal to 48 inches in diameter to allow low flow passage of water and aquatic life. Culverts less than 48 inches in diameter should be buried to a depth of 20% or greater of the diameter of the culvert.

NWP #13 – Bank Stabilization

This permit authorizes the reshaping of channel banks or bank stabilization activities that are necessary for erosion prevention. The placement of material is prohibited in any special aquatic site in a manner that may impede surface water flow into or out of a wetland area, or in a manner that will be eroded during normal or high flows. The activity must be part of a single and complete project and cannot exceed 1 cubic yard per running foot placed below the high water mark line. If stabilization activities exceed 500 linear feet, then a PCN is required for both the USACE and DWQ. DWQ must also be notified should fill be placed within the streambed.

NWP #27 – Stream and Wetland Restoration Activities

This permit authorizes stream enhancement, stream restoration, and channel relocation for restoration purposes that provide gains in aquatic functions. Stream channelization and the conversion of streams to other aquatic uses such as impoundments or waterfowl habitat are not authorized. A PCN to the USACE is required for any restoration activities occurring on private or public lands. DWQ requires a PCN if impacts are proposed for greater than 500 feet of stream bank or if in-stream structures are used.

Impacts proposed to the streams may need evaluation under the State Environmental Policy Act (SEPA). An Environmental Assessment (EA) is required under SEPA if greater than 500 linear feet of perennial stream is disturbed and stream restoration or enhancement is not performed. Channel disturbances are defined as activities that remove or degrade stream uses such as channelization, culvert placement, riprap, and other hard structures.

General Conditions for Permit Issuance

A list of some other conditions that should be followed under regulations provided by the USACE and DWQ are as follows:

- Soil erosion and sediment controls must be used and maintained in effective operating conditions during construction, and all exposed soil and fills should be stabilized at the earliest possible date.
- No activity is authorized under any NWP that is likely to jeopardize the existence of a threatened or endangered species, or which will destroy or adversely modify the habitat of such species.
- No activity is authorized that may affect historic properties listed or eligible for listing in the National Register of Historic Places.
- More than one NWP used for a single and complete project is prohibited (e.g. the Maple Creek Tributary #2 Drainage Basin project).
- Mitigation in all its forms will be required to the extent necessary to ensure that the adverse effects to the aquatic environment are minimal.
- Hardening techniques should be avoided and minimized to the greatest practicable extent.

Erosion and Sediment Control

North Carolina Department of Environment and Natural Resources (NCDENR) is another agency that requires notification before proposed activities are constructed. NCDENR requires that an erosion and sedimentation control plan be submitted to the Land Quality Section for approval before the start of construction.

Table 5-1: Permitting Matrix for Proposed Projects

	FEMA	404/401 (NWP)	NCDENR/ NPDES	NCDOT
City Design Standard	X	X	X	X
Alternative #1		X	X	
Alternative #1A		X	X	
Alternative #2		X	X	
Alternative #3		X	X	X

The City Design Standard includes stream grading, this will require mitigation fees of $400 per linear foot of affected stream. This contributes to the high cost associated with the City Design Standard.

SECTION 6
RESOLUTION OF CITIZENS COMPLAINTS

Citizen feedback has primarily been provided in the form of resident responses to the City of Rocky Mount generated questionnaires. In addition to the questionnaires, feedback and complaints were obtained at public meetings, from the City's Citizen Reporting Center, and from WK Dickson phone conversations. Citizens also provided pictures (See Appendix D). The information received from the residents assisted in identifying existing problems, verifying high water data, and checking to confirm the modeling results were reasonable.

Appendix D contains the complete table of residents' responses to the questionnaires and the corresponding resolution. All of the questionnaires received did not contain complaints, but they were included in the tally of responses. Of the 46 problems reported, ten (10) would be improved or resolved by the recommended alternatives while three (3) could be resolved by the City maintenance.

Approximately 75 percent of the responses received were concerning erosion and/or flooding related to the Maple Creek Tributary #2. The majority of the erosion problems reported during this study are not addressed by any of the recommended alternatives. However, it is recommended that monitoring pins be installed in the sections of stream with reported erosion. If significant erosion is found to be occurring, additional analysis will be required to determine what stream bank stabilization measures may be necessary.

Reports of structural flooding were also submitted from locations away from the studied primary and secondary system. Based on field observation conducted during the study, these complaints appear to be due to lack of infrastructure along the subdivision roads and flat elevation characteristic of the watershed. Although not addressed in the alternatives presented in this study, the installation of small secondary systems at these locations may help to address some of these issues.

The analysis and recommendations presented in the Maple Creek Tributary #2 Drainage Basin Study represents a holistic approach to basin level planning and storm water infrastructure management. This study will serve as a comprehensive assessment of the existing and future challenges as well as opportunities for improved stormwater management in the Maple Creek Tributary #2 basin.

Existing Conditions Analysis

The Existing Condition Analysis confirmed flooding problems reported by citizens and revealed that several of the primary and secondary systems' components do not meet the City of Rocky Mount's design standards and may cause flooding.

City Design Standard Analysis

The culvert improvements presented as part of the City Design Standard Analysis will increase the level of service for the crossings at Woodstock Road, Ketch Point Drive, and the East Railroad Crossing in order to comply with current City design standards and regulations. As a result of these improvements, the Michael Scott Drive culvert will require improvements meet City design standards. However, these improvements will cause an increase in flows and water surface elevations experienced along downstream tributary locations. If the improvements identified in the City Design Standard Analysis were implemented, properties along the tributary between Woodstock Road and Michael Scott Drive are projected to see an increase in water surface elevations by approximately one foot. These proposed culvert improvements will likely create new flooding issues at residences that currently do not have flooding problems. Additionally, the improvements presented Section 3 for the primary system will require extensive stream grading, channel improvements, and floodplain benching that will be difficult to complete due to private property impacts and the required permitting.

Similarly, the improvements needed to upgrade the secondary system at South Halifax Road and Kingswood Drive are cost prohibitive and if implemented will increase flows and WSELs at locations downstream. The improvements required to make this system compliant with City design standards will have undesirable results downstream. These improvements will require extensive coordination with property owners, NCDOT, and the owners of the above grade high voltage utility transmission line which runs along the Kingswood Drive system.

The negative effects of making the improvements identified in this section greatly outweigh the benefits. Therefore, none of the improvements described in this section of the report are recommended for implementation.

Alternative Analysis

The alternatives presented in Section 4 are those that were selected based on discussions with City staff and that address the highest priority problems discovered during the basin study. Replacement of the existing Woodstock Road Culvert as noted in Alternative #2 Woodstock Road Culvert Replacement without Upstream Detention is recommended for immediate implementation. Alternatives reviewed as a part of this study which include the addition of upstream detention areas (Alternatives #1 and #1A) are not recommended. The cost associated with these detention areas is not practical given the relatively negligible level of surface improvement and reduction to downstream WSELs achieved by implementation.

It is recommended that the secondary system located at South Halifax Road and Kingswood Drive be given high priority for improvement. The recommendation for a bypass system presented in this study is one possible improvement that will reduce flooding throughout this system. Additional study is recommended to identify the most effective, cost efficient and beneficial solution, prior to improvement implementation. A large number of residents will directly benefit from a capital improvement project at this location.

As a result of the erosion reported by citizens and the stream conditions observed during this study, it is recommended that monitoring pins be installed at select locations along the tributary and monitoring be conducted for a period of 12 to 24 months. This monitoring period will provide helpful insight to potential erosion and, if required, will serve as supporting evidence of needed stream bank stabilization improvements.

Appendix A:
Hydrologic Analysis

The purpose of the hydrologic analysis is to estimate the magnitude of selected frequency floods for sub-basins within the watershed. The US Army Corps of Engineers (USACE) HEC-HMS model was selected to model the Primary System defined as Maple Creek Tributary #2. HEC-HMS simulates the surface runoff response to precipitation for an interconnected system of surfaces, channels, and ponds. Input data for the HEC-HMS model was developed using topographic, land use, and soils maps in GIS to delineate and calculate the basin areas and Natural Resources Conservation Service (NRCS) hydrologic parameters. The HEC-HMS model offers a variety of methods for simulating the rainfall-runoff response, hydrograph development, channel and pond routing. The selection of methods for the analyses is based on the study objectives, data availability, and watershed characteristics. The precipitation data for the 24-hour duration, Type II storm was used to represent the synthetic rainfall event. The NRCS curve number approach was selected to calculate runoff volumes from the precipitation data, and the sub-basin unit hydrographs for these flood volumes were developed using the NRCS lag times. Where appropriate, storage routing was selected to model attenuation behind culvert embankments and the Modified Puls routing method was selected to account for channel routing.

For the secondary system, Hydraflow Storm Sewers 2011, an extension of AutoCAD Civil 3D, was used to generate peak flows using the Rational Method.

Sub-basin Delineation and Connectivity

The Maple Creek Tributary #2 basin was manually delineated into 14 sub-basins using digital topographic maps with 2-foot contour intervals obtained from NCDOT GIS database. The sub-basin divisions were selected at hydrologically and hydraulically significant points, such as major roadway crossings, stream convergences, known problem areas, etc. Basin sizes range from 24.5 to 213 acres. The watershed map included in Appendix C illustrates the sub-basin and hydrologic connectivity. Sub-watersheds were delineated as necessary for the secondary systems to accurately model the hydraulics of the system for the primary system.

Soils

The NRCS curve number method uses basin characteristics, such as soil types and land use, to compute the runoff response. The infiltration rate of a soil influences the volume of surface runoff that results from given storm events. Soils with high infiltration rates produce lower runoff than soils with lower infiltration rates. The Natural Resources Conservation Service has prepared soil maps for Nash County that identify four soil groups. The groups (A, B, C, and D) correspond to decreasing rates of infiltration. A general description of the four soil groups taken from the USDA, SCS, NEH-4 (1972) is presented in Table A-1.

Table A–1: Hydrologic Soils Groups

Soil Group	Description
A	Group A soils have high infiltration rates even when thoroughly wetted and consist chiefly of deep, well to excessively drained sand or gravels. These soils have a high rate of water transmission. (greater than 0.3 inch per hour)
B	Group B soils have moderate infiltration rates even when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission. (0.15 to 0.3 inch per hour)
C	Group C soils have slow infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission. (0.5 to 0.15 inch per hour)
D	Group D soils have a very slow infiltration rate when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay plan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission. (0 to 0.05 inch per hour)
B/D	The first letter applies to the drained condition and the second to the undrained condition. For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 60 centimeters (24inches) below the surface.

The NRCS soils map for the Maple Creek Tributary #2 basin was generated based on information provided by the City of Rocky Mount. Soils within the watershed are predominantly NRCS hydrologic soil groups B and C (See Table A-2 and Appendix C).

Table A–2: Area Distribution of Hydrologic Soil Groups

Soil Group	Total Area (acre)	Percent of Total Area
A	25	2%
B	510	48%
C	370	35%
D	18	2%
B/D	148	14%

Land Use

Land use is the watershed cover condition as it relates to the actual type of development and zoning within the watershed. Land use influences the runoff characteristics of a watershed, and combined with other basin characteristics, is used to determine the NRCS curve number for the basin.

The existing zoned land uses for the Maple Creek Tributary #2 basin were provided by the City of Rocky Mount. These zoning maps were used to develop the peak flows for the watershed. Seven land use categories were delineated within the Maple Creek Tributary #2 basin based on the information provided and field observation of the current uses (See Appendix C).

In its entirety, the Maple Creek Tributary #2 basin covers an area of approximately 1070 acres (~1.7 square miles). More than 75 percent of the basin is developed currently to its zoned land use. It is assumed that the undeveloped areas in the watershed will be developed as they are

currently zoned. Percentages of existing and future conditions land use group are listed in Table A-3 below.

Table A–3: Land Use/Zoning Groups

Land Use Group Name	Percent of Basin Area of Selected Land Use	
	Existing Conditions	Future Conditions
Agricultural	13%	15%
Commercial	4%	8%
Industrial	11%	17%
Office/Institutional	1%	2%
Open Space/Park	9%	0%
Residential – Multi-Family	15%	17%
Residential – Single Family	25%	31%
Right-of-Way	10%	10%
Woods	12%	0%

NRCS Curve Numbers

The NRCS curve number approach was used in computing the runoff response in HEC-HMS. Runoff curve numbers (RCNs) were generated using the NRCS document entitled Urban Hydrology for Small Watersheds, dated June 1986 and commonly referred to as TR-55. This method relates the drainage characteristics of soil group, land use category, and antecedent moisture conditions to assign a runoff curve number. The runoff curve number and an estimate of the initial surface moisture storage capacity are used to calculate a total runoff depth for a storm in a basin.

The antecedent moisture condition (AMC) refers to the total rainfall in a five-day period preceding a storm and relates to the soil moisture condition at the beginning of the storm event. The AMC value can be used as a calibration tool in the hydrologic computations where AMC-1 represents "dry" conditions and AMC-3 represents "wet" conditions. The average antecedent moisture conditions (AMC-2) are generally considered most representative for the humid southeastern portion of the country and were used for the hydrologic calculations in this study.

Runoff curve numbers were determined for each sub-basin based on the soil group, land use, and average AMC for the area. The curve numbers calculated for this study are listed in Table A-4. It should be noted that these values come from the City of Rocky Mount Design Manual and differ slightly from the values presented in the standard TR-55 document.

Table A–4: Curve Numbers Based on Land Use and Soil Groups

Land Use Category	Soil Group			
	A	B	C	D
Agricultural	72	81	88	91
Commercial	96	97	98	98
Industrial (Light and Heavy)	98	98	98	98
Office/Institutional	96	97	98	98
Open Space/Park	49	69	79	84
Residential – Multi-Family	86	90	93	96
Residential – Multi-Family (Medium Density)	77	85	90	92
Residential – Multi-Family (Mobile Home Park)	92	94	96	97
Residential – Single Family	71	80	87	92
Residential – Single Family (Low Density)	61	75	83	87
Residential – Single Family (Manufactured)	71	80	87	92
Right-of-Way	83	89	92	93
Woods	25	55	70	77

Source: *City of Rocky Mount Stormwater Design Manual, December 2006.*

For each sub-basin, the curve number was determined and weighted by area to calculate the composite curve number for each sub-basin. The composite curve numbers for the sub-basins within the watershed range from the high 70s to the mid 90s. The lower curve numbers are located at the downstream end of the watershed where the land use is mostly single family residential. The higher curve numbers represent commercial, industrial and multi-family residential with significant impervious areas. A summary of the hydrologic input data including the runoff curve numbers is shown in Table A-5. Drainage Basins referenced below are also shown on the Watershed Map (Figure C-1) found in Appendix C. The complete calculations are included in Appendix I.

Table A–5: Summary of Hydrologic Input Data

Drainage Basin ID	Drainage Area (acre)	Existing RCN	Future RCN	Time of Concentration (minute)
1A	213	89	96	95.77
1B	92	87	97	84.05
2	26	88	97	79.46
3	62	88	93	71.81
4	99	81	91	86.86
5	28	95	95	24.86
6	82	89	91	77.40
7	102	83	86	51.63
8	32	88	88	38.41
9	40	79	79	50.00
10	34	80	80	22.06
11	56	80	80	62.00
12	181	82	82	95.69
13	24	81	81	40.97

Hydrograph Translation

The lag time as defined by the NRCS for use in the NRCS dimensionless unit hydrograph method is the time, or lag, between the center of mass of rainfall excess and the peak of the unit hydrograph. The lag time is based on the sub-basin time of concentration, or travel time, and is a function of the sub-basin size, shape, slope, cover, and other basin characteristics. For the NRCS method, the sub-basin lag time is calculated to be 0.6 times the time of concentration for each sub-basin.

The times of concentrations for the sub-basins were calculated from the methodology described in TR-55. A summary of the calculations is shown in Appendix I. The longest flow path is divided into 3 types of flow; overland (sheet) flow, shallow concentrated flow, and channel flow. A spreadsheet was developed to tabulate the incremental travel times for each type of flow for each sub-basin. The incremental travel times were totaled and multiplied by 0.6 to compute the lag time for each sub-basin. The equation detailing the travel time for sheet flow is as follows:

$$T_t = \frac{.007\,(nL)^{0.8}}{(P_2)^{0.5}\,S^{0.4}}$$

T_t = Travel Time in hours
n = Manning Roughness Coefficient (Paved = 0.011, Unpaved = 0.24)
L = flow length in feet
P_2 = 2-year, 24 hour rainfall = 3.6 inches
S = slope of hydraulic grade line (land slope in ft/ft)

For shallow concentrated flow, the velocity (V) is calculated for either paved or unpaved sections by using the following equations:

$$\text{Unpaved } V = 16.1345\ (S)^{1/2}$$
$$\text{Paved } V = 20.3282\ (S)^{1/2}$$

The travel time for shallow flow is then calculated by dividing the flow length (L in feet) by velocity as follows:

$$T_t = \text{Travel Time} = L / (3600*V)$$

The open channel travel times are determined by a modified version of the Manning equation, which is as follows:

$$V = \frac{1.49\ R^{2/3}\ S^{0.5}}{n}$$

V = Average full-flow velocity (ft/s)
R = Hydraulic radius (ft)
S = Slope of hydraulic grade line (ft/ft)
n = Manning roughness coefficient

Rainfall

Rainfall distributions for Rocky Mount were derived using the NRCS Type II standard distribution. The rainfall depths for each design storm were developed from the intensity-duration-frequency curves provided in the City of Rocky Mount's Stormwater Design Manual. The rainfall depths for various duration and frequency storms for Rocky Mount, North Carolina are shown in Table A-6.

Table A–6: Rainfall Duration-Depth Frequency Table for Rocky Mount, North Carolina

Duration	Rainfall Depth (inches)				
	2-year	10-year	25-year	50-year	100-year
5-minute	0.48	0.63	0.68	0.75	0.81
15-minute	1.01	1.31	1.51	1.67	1.81
1-hour	1.70	2.41	2.84	3.17	3.50
2-hour	1.90	2.74	3.24	3.62	4.00
3-hour	2.13	3.06	3.63	4.05	4.50
6-hour	2.64	3.90	4.62	5.16	5.76
12-hour	3.12	4.68	5.52	6.24	6.84
24-hour	3.60	5.28	6.48	7.20	8.00

Storage Routing

Reservoir storage routing was used for routing hydrographs through the storage areas upstream from undersized structures (culverts). HEC-HMS is able to model the effects of an undersized culvert through inputs defining the relationship between water volume or area and elevation and the relationship between outflow and water surface elevations. The relationship between outflow and water surface elevations is developed using an iterative process between HEC-HMS and HEC-RAS. A rating curve generated using Hydroflow Hydrographs defines the outflow of the water leaving this system.

Structures having fill heights greater than or equal to 50 percent of the height of the structure were assumed to provide significant peak flow attenuation and therefore were routed in the HEC-HMS model. In addition, any structure which exhibited significant upstream floodplain storage or significant backwater from the HEC-RAS model output was analyzed for providing peak flow attenuation.

For each structure, the cutoff point in the backwater pool was determined where the structure routing ends and upstream channel routing begins. This determination was necessary so that available storage areas calculated for channel and structure routing did not overlap.

For each structure, the elevation-storage relation for the Modified Puls method was derived by calculating the surface area of the topographic contours from the upstream face of the structure to the routing cutoff point associated with the structure. A pair of "SA" (storage area) – "SE" (elevation) records, the elevation-storage relation for each structure was input from the planimetered information. To avoid interpolating storage areas for each stage-discharge point, a separate stage-discharge relation was entered into the HEC-HMS model on a pair of "SQ" (discharge) – "SE" (elevation) records based on the HEC-RAS model output.

However, the method described in the previous paragraph does not account for the reduction in tailwater on the structure due to the attenuation effects of the upstream storage, which in turn can affect the stage-discharge relation of the structure. Therefore, an iterative process for storage structures was followed with an objective to obtain a set of peak discharge values, runoff volumes, and water surface elevations that are "balanced" between the two models. The process was initiated by inputting a set of discharges into the HEC-RAS model to develop a set of discharge-storage relations for each reach. This initial set of relations was input into the HEC-HMS model. These values were supplemented by the depth-storage relation for each structure. The HEC-HMS model was run with these values to derive new discharges at downstream locations. These new values were input into the HEC-RAS model and it was recomputed. The new discharges and water surface elevations listed in the HEC-HMS summary output were compared with the discharges listed in the previous HEC-RAS run. When the values stabilized, the model was considered "balanced". If not, additional iterations were performed. Typically, three iterations are adequate to derive a balanced model.

Summary of Hydrologic Model Results

The HEC-HMS model was used to compute peak runoff for the 2-, 10-, 25-, 50- and 100- year design storms for the existing and future conditions. The curve numbers for the Maple Creek Tributary #2 basin range from 79 to 97 with the majority being in the lower 80s for the existing conditions and in the mid 90s for the future conditions. The time of concentrations were found to range from 22 minutes to 96 minutes.

The results of the existing conditions hydrologic model are summarized in Table A-7. The HEC-HMS input and output are included in Appendices H and I. Additionally, a CD is included in Appendix L and contains the digital files for the HEC-HMS model.

Table A–7 : Existing Flows with Attenuation from HEC-HMS

HEC-HMS Node	Road Name / Location	Storm Event				
		2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
Railroad East	Railroad Culvert	133	168	251	321	387
Junct-04	Intersection of Maple Creek Tributary #2 and Kingswood Drive	426	619	735	826	944
Junct-07	Between Hampton Drive and Ketch Point Drive	432	631	752	847	963
Ketch	Ketch Point Drive	436	639	759	852	973
Woodstock	Woodstock Road	441	649	766	868	996
Michael	Michael Scott Drive	470	720	885	1,026	1,184

** A map showing the HEC-HMS node locations is included in Appendix H with the HEC-HMS output.*

Comparison of Peak Flows

For comparison purposes, peaks flows were estimated using the U.S. Geological Survey (USGS) publication entitled "The National Flood-Frequency Program – Methods for Estimating Flood Magnitude and Frequency in Rural and Urban Areas in North Carolina – USGS Fact Sheet 007-00" (2001), commonly referred to as USGS regional regression equations, at three key locations within the watershed. Table A-8 compares the peak flows determined from the USGS regional regression equations for the Coastal region versus the peak flows from HEC-HMS. The HEC-HMS flows are between 10 to 20 percent lower than those calculated using the USGS Regression equations.

Table A–8: Comparison of Existing Conditions Peak Flows

Methodology	Location	25-year (cfs)	50-year (cfs)	100-year (cfs)
HEC-HMS	Basin 1A	285	324	364
	Intersection of Maple Creek Tributary #2 and Kingswood Drive	735	825	943
	D/S Limit of Maple Creek Tributary #2	893	1036	1196
USGS (2001)	Basin 1A	316	378	442
	Intersection of Maple Creek Tributary #2 and Kingswood Drive	836	991	1145
	D/S Limit of Maple Creek Tributary #2	851	1003	1156

Finally, a comparison was made to two historical studies prepared by WK Dickson in the Rocky Mount area. Since the Long Branch Drainage Basin and Maple Creek Tributary #1 Studies had similar land use, the results arrived at in those studies provided a good comparison to the current basin study. The Maple Creek Tributary #2 25-year existing conditions peak flow/acre averaged approximately 2.5 cfs per acre which is in line with results from the Long Branch and Maple Creek Tributary #1 results. Based on these comparisons, the peak flows generated using HEC-HMS are reasonable and were used to be evaluate culvert capacity in the watershed.

Appendix B:
Hydraulic Analysis

The purpose of the hydraulic modeling analysis is to determine an existing level of flooding for the stormwater drainage network and to develop proposed solutions to mitigate flooding on both the primary system and the secondary systems. Two different modeling methodologies were used. For the primary system, the Hydrologic Engineering Center River Analysis System (HEC-RAS) was used for hydraulic modeling. The HEC-RAS model calculates water surface profiles for steady, gradually varied flow, both sub-critical and supercritical, for user-specified discharges. The standard step backwater analysis for sub-critical flow was modeled for Maple Creek Tributary #2. The model calculates the effect of obstructions, such as culverts, and building structures in the channel and floodplain on the water surface profile. The hydraulic computations are based on the solution of a one-dimensional energy equation with energy loss due to friction evaluated by Manning's equation. For the secondary system, Hydraflow Storm Sewers was used to calculate the hydraulic grade lines using an energy grade based approach.

Study Limits

As discussed with City of Rocky Mount stormwater staff, study limits for the hydraulic evaluation include Maple Creek Tributary #2 from its confluence with Maple Creek at the downstream end to approximately 500 feet downstream of South Halifax Road. The study limits also include drainage systems that drain to Maple Creek Tributary #2.

Stormwater Inventory and Field Survey

The City of Rocky Mount provided a stormwater inventory of the existing drainage systems. However, the data did not include survey grade elevations. To augment the data, WK Dickson collected survey grade inventory data at each of the four major culvert crossings, as well as other critical elevations. The data was collected using NAD 83. Vertical elevations of the structures are based on NAVD 88. The stormwater inventory data is a useful tool for delineating watersheds and conceptual modeling, however a more detailed survey will be required for specific project final design.

Primary System

Cross Sections

Cross sections were located perpendicular to the flow and at intervals along the stream to characterize the flow capacity of the channel and floodplain for the selected reach. Along stream reaches where the shape, size, and geometry of the cross-section are varying, cross sections were cut at closer intervals than for reaches having little change in channel characteristic. Additional sections were cut as required by the HEC-RAS program to sufficiently model structures such as culverts.

Cross sections are identified by station number, which for the Maple Creek Tributary #2 basin model, refers to the approximate linear distance upstream from a reference point on the main channel or tributary reach. The cross sections depict the locations of cut sections from field topographic surveys. Similarly, the cross section at each road crossing represents the top-of-road cross section. The cross sections just upstream and just downstream of highest point of roadway (commonly referred to as the weir) represent the locations of the upstream and downstream faces, respectively, of the bridge or culvert in an area not impacted by roadway fill.

Roughness Coefficients

Manning's roughness coefficients, or 'n' values, represent the resistance to flow and influence the flow capacity of channels and floodplains. The HEC-RAS model uses these coefficients to compute friction loss longitudinally in the channel and floodplain. The roughness value is a function of the type and density of the vegetation, channel bottom and stream bank material, degree of channel meandering, and depth of flow.

Roughness coefficients were determined for all stream reaches for which hydraulic analyses were performed. The "Horizontal variation in n-values" option was enabled to allow for correct modeling of the widely varied surfaces on a given cross-section. The right or left bank of the stream is referenced facing downstream. Roughness coefficients used in this study are listed in Table B-1.

Table B-1: Roughness Coefficients

Location	Range of 'n' values
Main Channel	0.035 - 0.045
Left Overbank	0.06 - 0.12
Right Overbank	0.06 - 0.12

All roughness coefficients were estimated through field observation and by referencing standard engineering manuals.

Bridge, Culvert, and Roadway Data

Based on guidelines provided in the City of Rocky Mount's Stormwater Design Manual, the following standards and criteria were used to evaluate the drainage system:

Table B–2: City's Design Standards and Criteria

Roadway Type	Design Storm (years)	Freeboard (feet)
Residential (Local and Collector)	25	1.0
Commercial (Local and Collector)	50	0.5
Industrial (Local and Collector)	50	0.5
Minor and Major Arterial	50	0.5

*HW/D (the ratio of headwater depth to culvert depth) <1.2.

Culverts generally have different characteristics than the channel and floodplains away from roadway crossings. Often culverts constrict flood flows in the channel and floodplain which may create backwater effects upstream of the structure. The constriction can produce increased velocities and result in localized scour.

For culvert analysis, the HEC-RAS model utilizes the concepts of "Inlet" control and "Outlet" control to simplify complicated culvert hydraulics. Inlet control flow occurs when the flow carrying capacity of the culvert entrance is less than the flow capacity of the culvert barrel. Outlet control flow occurs when the culvert carrying capacity is limited by downstream conditions or by the flow capacity of the culvert barrel.

During inlet control computations, the culvert inlet acts as either a weir or an orifice, and the resulting headwater is computed. The equations used by HEC-RAS are the same as those developed by the Federal Highway Administration during extensive laboratory testing, which describe the inlet control headwater under various conditions.

For outlet control flow conditions, the required headwater is computed considering various conditions. For culverts flowing full, a form of the Bernoulli Equation, which considers friction losses, entrance losses and exit losses is utilized. Friction losses are based on Manning's equation. Entrance losses are computed as a coefficient times the velocity head in the culvert at the upstream end. Exit losses are computed as a coefficient times the change in velocity head from just inside the culvert (at the downstream end) to outside the culvert.

When the culvert is not flowing full, the direct step backwater procedure is used to calculate the profile through the culvert up to the culvert inlet. An entrance loss is then computed and added to the energy inside the culvert to obtain the upstream headwater. Culvert input data for the HEC-RAS model include:

- Shape and dimensions of the structure openings;
- Culvert length;
- Entrance loss coefficient, exit loss coefficient and coefficient of discharge for weir flow during roadway overtopping;
- Upstream and downstream invert elevations;
- Federal Highway Administration chart number for the culvert type;
- Top-of-road elevations to describe the weir during roadway overtopping and the weir crest length; and
- Four cross sections are required; one cross section sufficiently downstream of the culvert that flow is not affected by the culvert, one at the downstream end of the culvert, one at the upstream end of the culvert, and one located far enough upstream that the culvert has no effect on flow.

Energy Loss Coefficients

Contraction and expansion of flow produces energy losses caused by the transition. The magnitude of these losses is related to the velocity and the estimated loss coefficient. Where the transitions are gradual, the losses are small. At abrupt changes in cross-sectional area, the losses are higher. Energy losses resulting from expansion are greater than losses associated with contraction. Energy loss coefficients used for the Maple Creek Tributary #2 hydraulic models are presented in Table B-3 below:

Table B–3: Energy Loss Coefficients

Type of Transition	Expansion	Contraction
None	0	0
Gradual	0.3	0.1
Culvert sections	0.5	0.3

Starting Water Surface Elevation

The starting water surface elevations for the primary system HEC-RAS model was calculated using the slope-area method found in HEC-RAS using a slope of 0.005 feet/feet.

Model Run Descriptions and Assumptions

The HEC-RAS model was used to compute flood elevations at each cross-section for Maple Creek Tributary #2 for the 2-, 10-, 25-, 50- and 100-year floods. A hard copy of the HEC-RAS output is included in Appendix J and digital copy of the HEC-RAS is included on the CD in Appendix L.

The hydraulic analysis for this study is based only on the condition of unobstructed flow. Therefore, flood elevations shown on the profiles are considered valid only if hydraulic structures remain unobstructed and do not fail. Flood elevations may be raised by debris blockage of the channel or floodplain.

Model Verification

Efforts were made to verify the model for various storm events. Feedback obtained from the questionnaires was reviewed for relevant information that could be used to verify the model. However, most of the comments and responses received were not specific enough to verify the model. The feedback provided through emails and phone calls from residents living adjacent to the stream near the culverts was much more useful for obtaining high water marks. These residents were able to provide pictures of flood waters during high rain events, along with the dates of occurrence. This information was used to obtain rainfall totals for the corresponding events. These rainfall totals were used to determine which storm event it most closely matched. The water surface elevations (WSELs) generated by the model for the storm of interest were compared with those reported by the residents.

The resident located upstream the Woodstock Road culvert at 3901 Ketch Point Drive provided helpful information for verifying the model. The resident stated that in June 2006 during Tropical Storm Alberto approximately 29 inches of water flooded his garage. The property was surveyed and critical elevations were collected. They were compared to the water surface elevations obtained from the model for the 10-year design storm, which was determined to be equivalent to Tropical Storm Alberto. The existing conditions model with attenuation showed a WSEL equal to 115.7 feet. This is 30 inches higher than the surveyed elevation for the garage.

Additionally, several residents commented on the frequent overtopping of South Halifax Road. The flow generated in HEC-HMS at this location (Junction 3) for a 2-year storm event is 341 cfs. Hydraflow Express was used to check the flow required to cause the road to overtop. Hydraflow Express showed roadway overtopping anytime the flow is greater than 215 cfs. This is aligned with the frequency and severity of flooding reported by residents and business owners. This confirmed that the models are providing accurate and realistic results in these locations.

Secondary System

For the secondary system, flows calculated from the Rational Equation were used for the initial screening. The detailed analysis was completed using Hydraflow Storm Sewers 2011, an extension of AutoCAD Civil 3D. Secondary System analysis output is included in Appendix F.

Hydraflow Storm Sewers

The purpose of the hydrologic analysis for the secondary systems, or closed systems, was to estimate the peak runoff that would flow to the catch basins and into the closed system. The rational method was used for the closed system hydrologic analysis. The rational method can be expressed as follows:

$$Q = CiA$$

Q = maximum rate of runoff (cfs)
C = runoff coefficient representing a ratio of runoff to rainfall
i = average rainfall intensity for a duration equal to the time of concentration (in/hr)
A = drainage area contributing to the design location (acres)

Rainfall Intensity

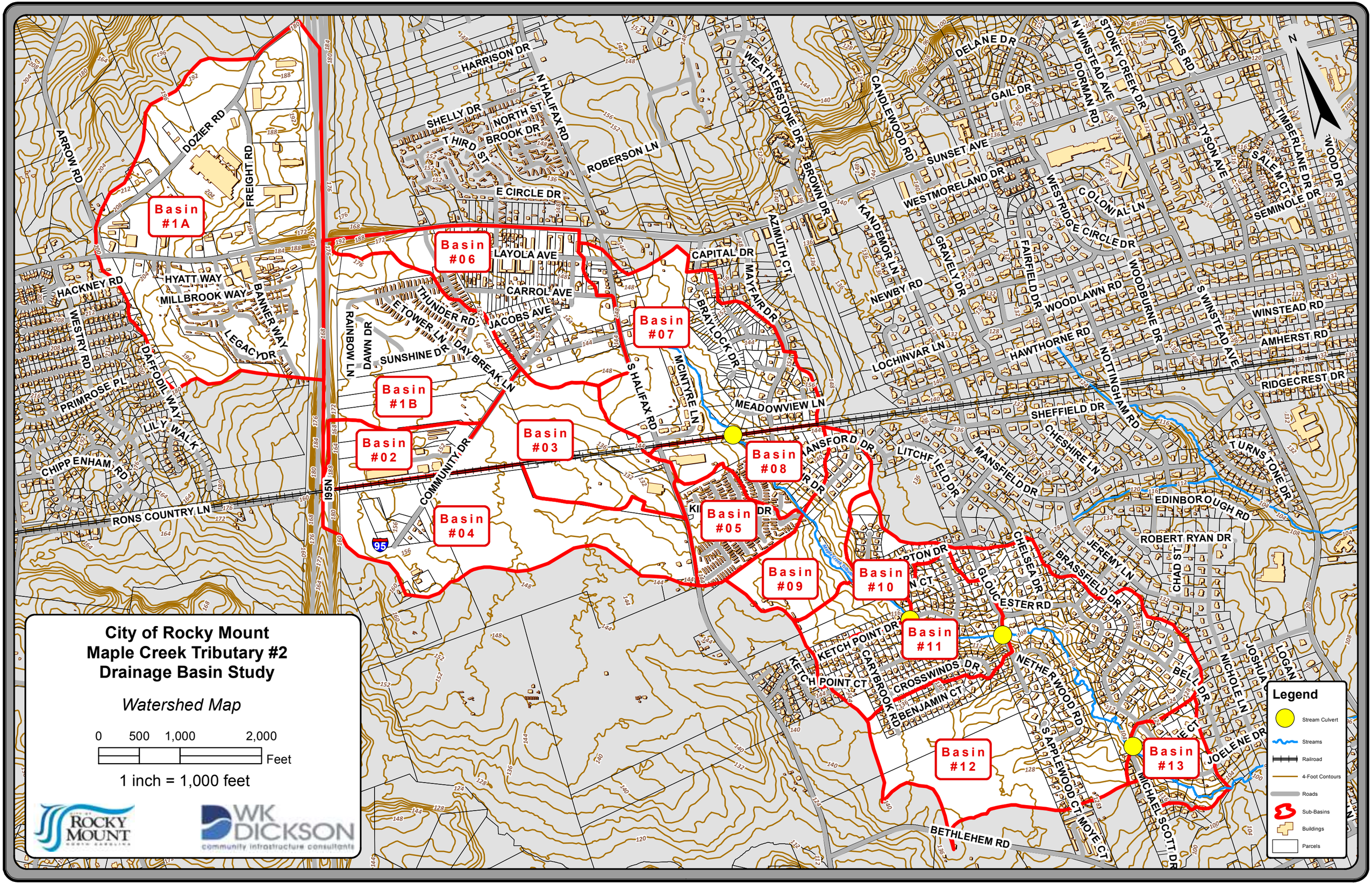
Hydraflow Storm Sewers computes rainfall intensity values based on the methods presented in FHWA Hydraulic Engineering Circular No. 12, Drainage of Highway Pavements. Precipitation values for the 2- and 100-year storm frequencies for 5, 15, and 60 minute durations are required for input. These input values were taken directly from Table 3.2, Intensity –Duration-Frequency Table – Rocky Mount, NC, from the City's Stormwater Manual.

Runoff Coefficients

Land use is the watershed cover and relates to the activities that occur in an area, that is, the zoned land uses, and to the kind of vegetation or surface cover associated with that use. Land use influences the runoff characteristics of a watershed, and combined with other basin characteristics are used to determine rational runoff coefficient. The predominant landuse surrounding the evaluated closed system is multi-family residential and commercial. Since some of the sub-basins were comprised of a high percentage of street area, a composite coefficient was developed to obtain a more accurate value that represented the runoff characteristics for each basin. The three coefficients used were 0.60 for residential, 0.85 for commercial, and 0.95 for asphalt. These values were obtained from the City of Rocky Mount Stormwater Design Manual.

Appendix C:
Maps

List of Contents:


City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Watershed Map
0 500 1,000 2,000
Feet
1 inch = 1,000 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants
Basin #1A
Basin #1B
Basin #02
Basin #03
Basin #04
Basin #05
Basin #06
Basin #07
Basin #08
Basin #09
Basin #10
Basin #11
Basin #12
Basin #13
Legend
Stream Culvert
Streams
Railroad
4-Foot Contours
Roads
Sub-Basins
Buildings
Parcels
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ARROW RD
DOZIER RD
FREIGHT RD
HACKNEY RD
HYATT WAY
MILLBROOK WAY
BANNER WAY
LEGACY DR
WESTRY RD
DAFFODIL WAY
PRIMROSE PL
LILY WALK
CHIPPENHAM RD
RONS COUNTRY LN
I95N
COMMUNITY DR
HARRISON DR
N HALIFAX RD
SHELLY DR
NORTH ST
THIRD ST
BROOK DR
ROBERSON LN
E CIRCLE DR
LAYOLA AVE
CARROL AVE
THUNDER RD
JACOBS AVE
E TOWER LN
DAY BREAK LN
SUNSHINE DR
RAINBOW LN
DAWN DR
S HALIFAX RD
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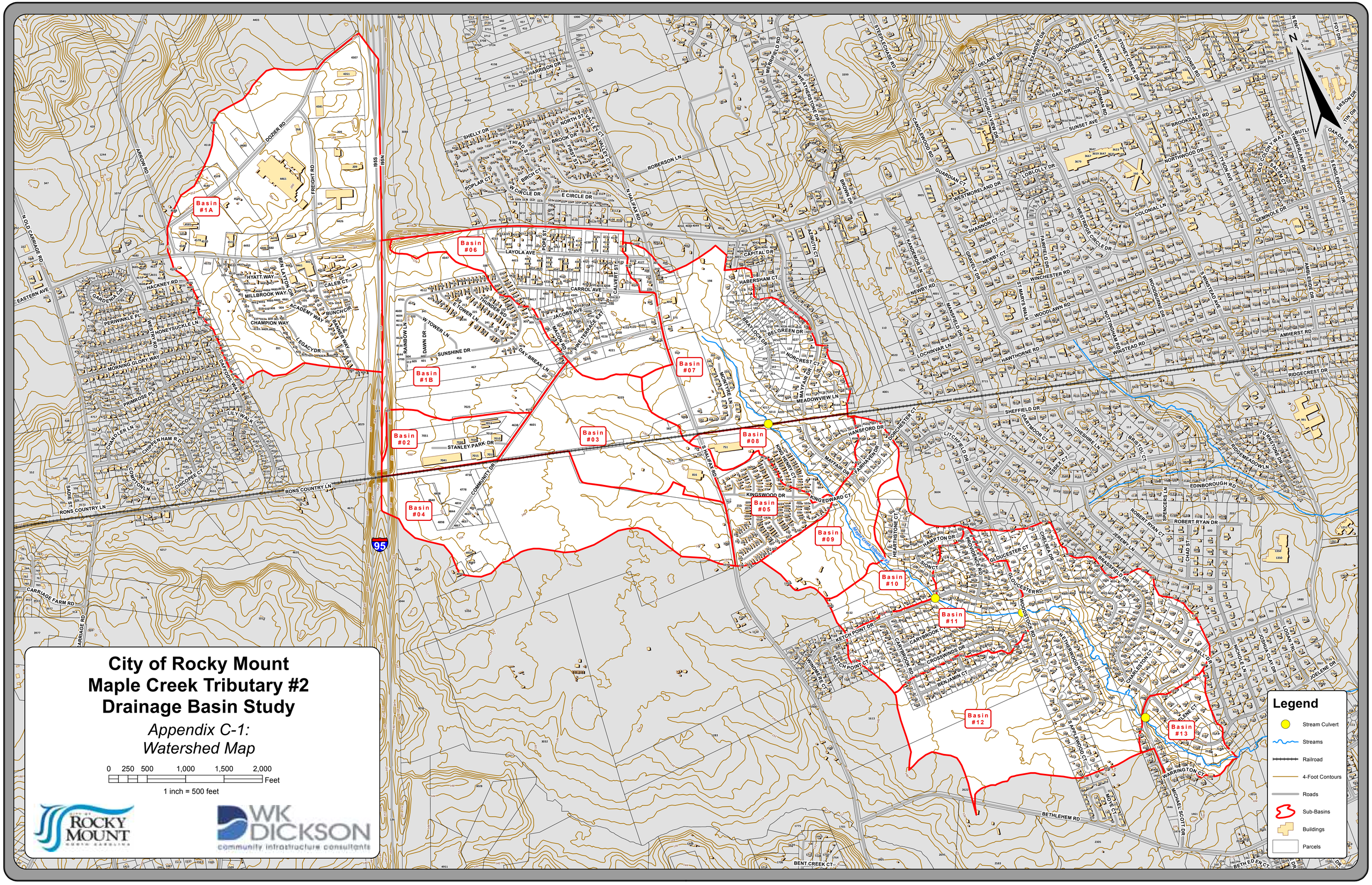
BROWN DR
AZIMUTH CT
CAPITAL DR
MAYFAIR DR
BRAYLOCK DR
MEADOWVIEW LN
MANSFORD DR
LITCHFIELD DR
MANSFIELD DR
CANDLEWOOD RD
KANDEMOR LN
NEWBY RD
LOCHINVAR LN
DELANE DR
GAIL DR
N WINSTEAD AVE
DORMAN RD
STONEY CREEK DR
JONES RD
SUNSET AVE
WESTMORELAND DR
GRAVELY DR
FAIRFIELD DR
WESTRIDGE CIRCLE DR
COLONIAL LN
TYSON AVE
TIMBERLANE DR
SALEM CT
WOOD DR
SEMINOLE DR
WOODLAWN RD
WOODBURNE DR
S WINSTEAD AVE
WINSTEAD RD
AMHERST RD
HAWTHORNE RD
NOTTINGHAM RD
RIDGECREST DR
SHEFFIELD DR
CHESHIRE LN
TURNSTONE DR
EDINBOROUGH RD
ROBERT RYAN DR
CHAD ST
JEREMY LN
BRASSFIELD DR
CHELSEA DR
GLOUCESTER RD
KETCH POINT DR
KETCH POINT CT
CARYBROOK RD
CROSSWINDS DR
BENJAMIN CT
NETHERWOOD RD
S APPLEWOOD CT
MOYE CT
MICHAEL SCOTT DR
BELL DR
NICHOLE LN
JOSHUA
LOGAN
JOELENE DR
BETHLEHEM RD


City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Appendix C-1:
Watershed Map
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Feet
1 inch = 500 feet
Legend
Stream Culvert
Streams
Railroad
4-Foot Contours
Roads
Sub-Basins
Buildings
Parcels
Basin #1A
Basin #1B
Basin #02
Basin #03
Basin #04
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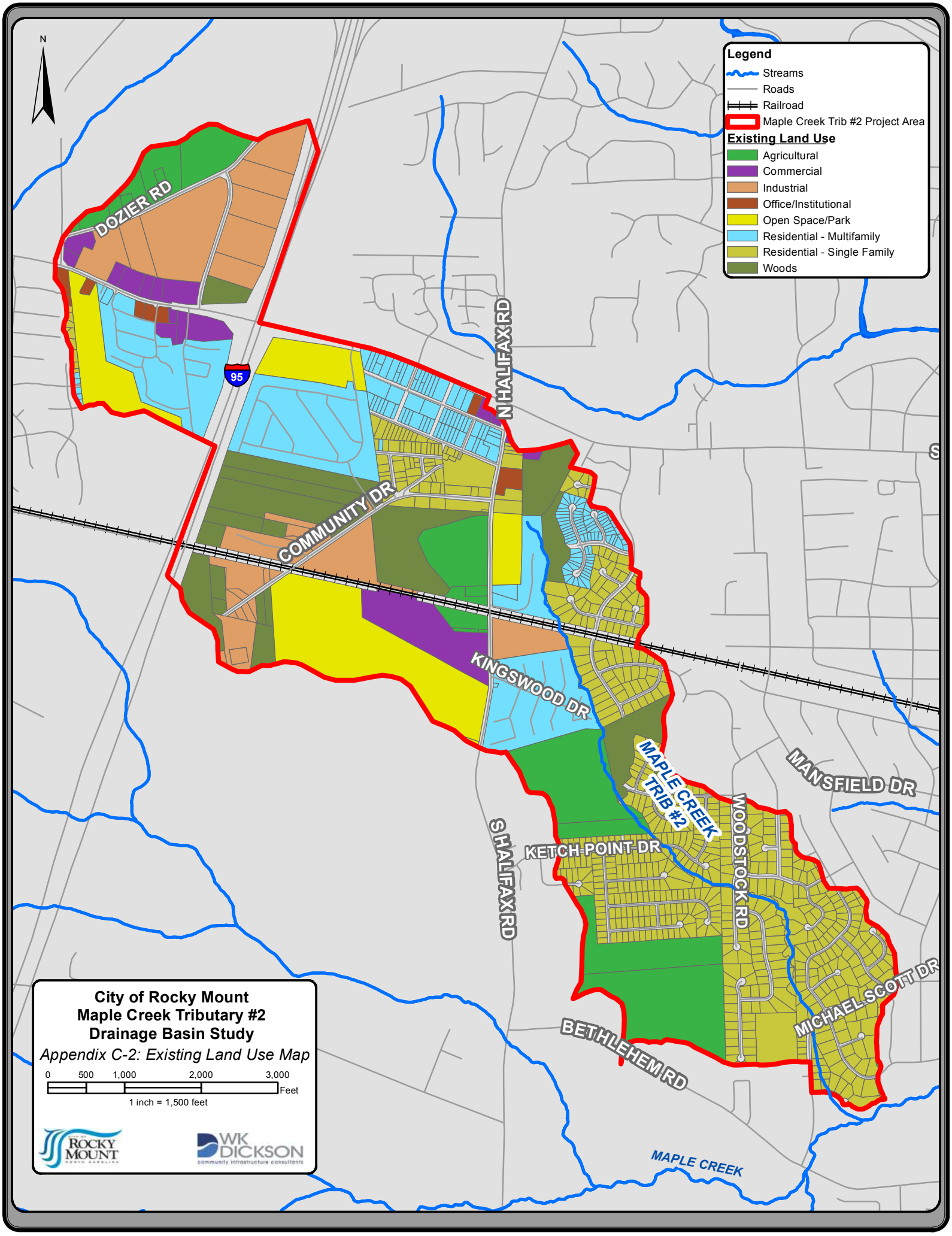
ROCKY MOUNT
WK DICKSON
community infrastructure consultants


N
Legend
Streams
Roads
Railroad
Maple Creek Trib #2 Project Area
Existing Land Use
Agricultural
Commercial
Industrial
Office/Institutional
Open Space/Park
Residential - Multifamily
Residential - Single Family
Woods
DOZIER RD
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N HALIFAX RD
COMMUNITY DR
KINGSWOOD DR
MAPLE CREEK TRIB #2
MANSFIELD DR
WOODSTOCK RD
S HALIFAX RD
KETCH POINT DR
MICHAEL SCOTT DR
BETHLEHEM RD
MAPLE CREEK
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Appendix C-2: Existing Land Use Map
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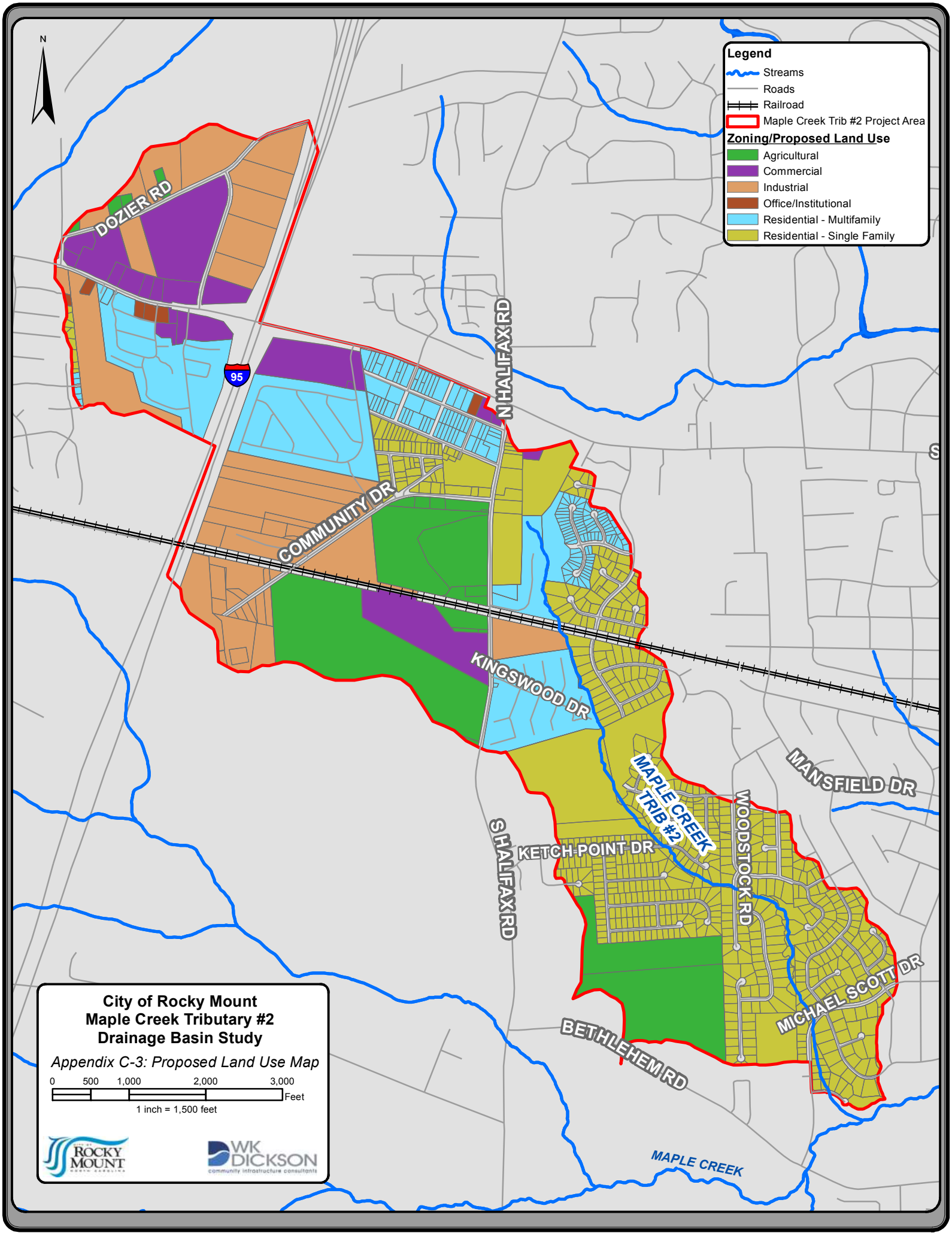
Feet
1 inch = 1,500 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants


N
Legend
Streams
Roads
Railroad
Maple Creek Trib #2 Project Area
Zoning/Proposed Land Use
Agricultural
Commercial
Industrial
Office/Institutional
Residential - Multifamily
Residential - Single Family
DOZIER RD
95
N HALIFAX RD
COMMUNITY DR
KINGSWOOD DR
MAPLE CREEK TRIB #2
MANSFIELD DR
WOODSTOCK RD
S HALIFAX RD
KETCH POINT DR
MICHAEL SCOTT DR
BETHLEHEM RD
MAPLE CREEK
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Appendix C-3: Proposed Land Use Map
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Feet
1 inch = 1,500 feet
ROCKY MOUNT
WK DICKSON
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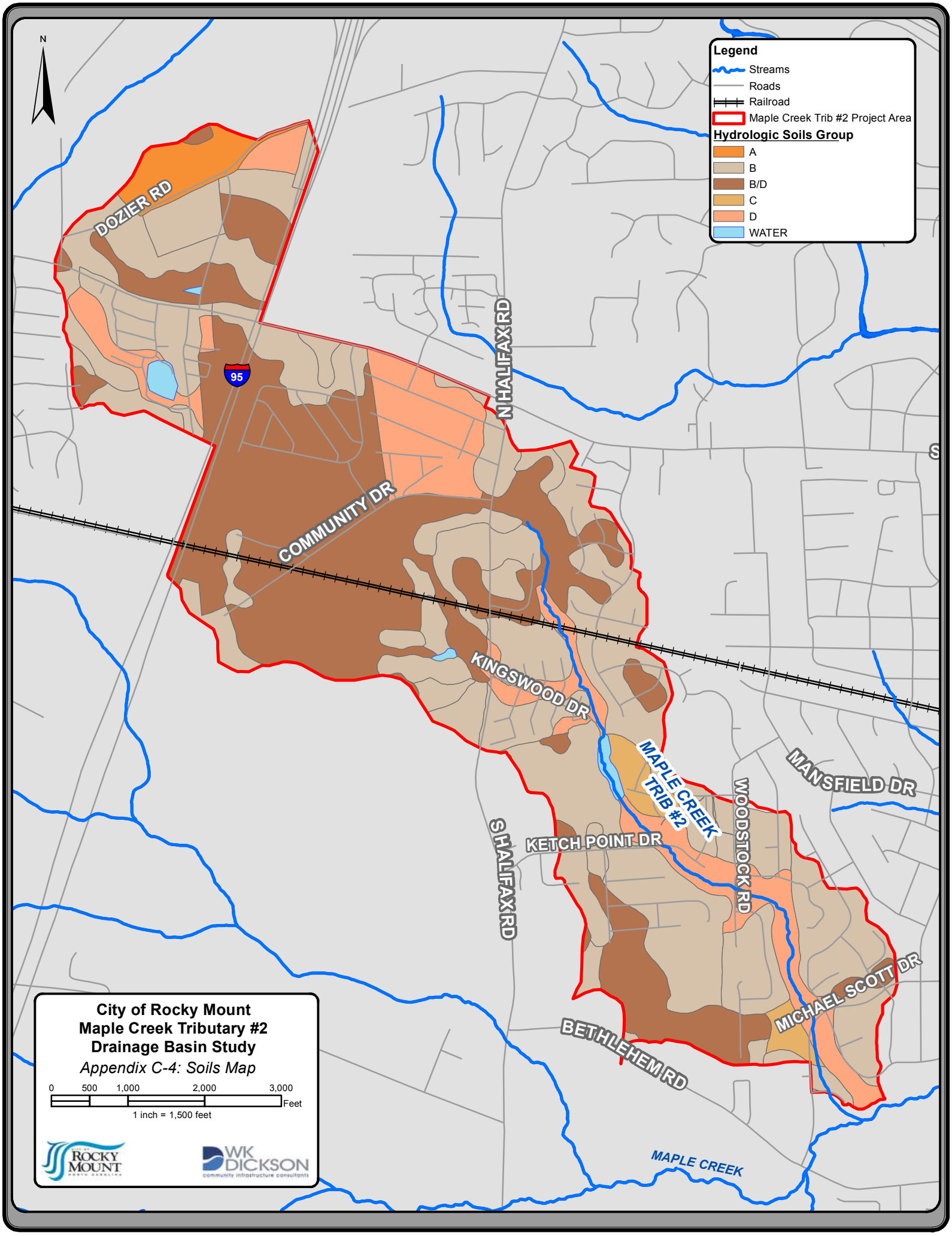
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Streams
Roads
Railroad
Maple Creek Trib #2 Project Area
Hydrologic Soils Group
A
B
B/D
C
D
WATER
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N HALIFAX RD
COMMUNITY DR
KINGSWOOD DR
MAPLE CREEK TRIB #2
WOODSTOCK RD
MANSFIELD DR
S HALIFAX RD
KETCH POINT DR
MICHAEL SCOTT DR
BETHLEHEM RD
MAPLE CREEK
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Appendix C-4: Soils Map
0
500
1,000
2,000
3,000
Feet
1 inch = 1,500 feet
ROCKY MOUNT
WK DICKSON
community infrastructure consultants

Appendix D:
Citizen Input

List of Contents:

City of Rocky Mount
Post Office Box 1180
Rocky Mount, NC 27802

PRSRT STD
US POSTAGE
PAID
ROCKY MOUNT, NC
27804
PERMIT NO. 1

City of Rocky Mount

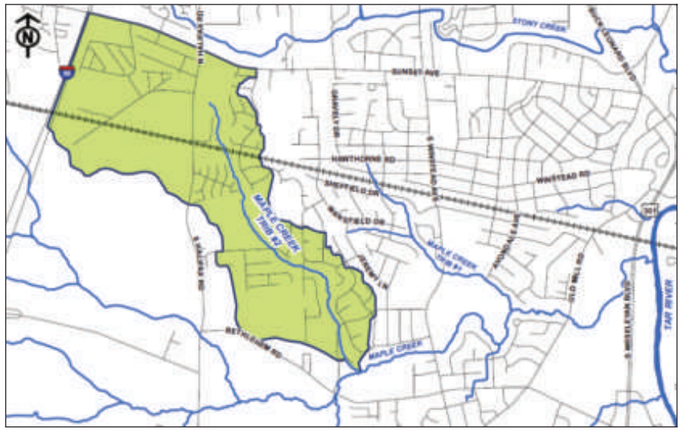
Stormwater Survey

Your Input Is Critical To The Success of the Project!

Mr. Jason Kennedy
Project Manager
WK Dickson
720 Corporate Center Dr.
Raleigh, NC 27607

PUBLIC MEETING NOTICE

The City of Rocky Mount is currently working on a Storm Drainage Basin Study in your neighborhood and is gathering information for preparation of the existing drainage system analysis including City-maintained pipes and ditches. A public meeting has been scheduled for **Thursday, March 1, 2012** to discuss the scope of the proposed drainage study for your area, the timeframe for completion of the project, and to answer any questions you may have. **Your input is critical to the success of the project!**



There are several ways to respond:

1. Complete the questionnaire included with this notice and return it to the following address:

Jason Kennedy, PE
WK Dickson
720 Corporate Center Drive
Raleigh, NC 27607

2. Complete the questionnaire online at http://rockymount.wkdickson.com

3. Bring the completed questionnaire with you to the public meeting.

Thursday, March 1, 2012

Maple Creek Tributary #2 Drainage Basin Study
Location: Calvary Baptist Church
505 South Englewood Drive
Time: 5:00 – 7:00 PM

The meeting is an open-house format, so please arrive any time between 5:00 PM and 7:00 PM to discuss this project and address any questions or concerns you may have with staff from the City of Rocky Mount and the engineering consultant, WK Dickson.

For more information, contact the City Project Manager, Blair Hinkle at 252-972-1520 or blair.hinkle@rockymountnc.gov or WK Dickson Project Manager, Jason Kennedy, PE at 919-782-0495 or jkennedy@wkdickson.com.

NOTES

Detach

The City of Rocky Mount would like your input and assistance with the Maple Creek Tributary #2 Drainage Basin Study. Our purpose is to obtain information about drainage and erosion problems and water quality concerns. Please take a few minutes to check the appropriate answer and write comments where needed. Thank you in advance for your input.

Name: _____

Property Address: _____

_____

Phone #: _____

1. How long have you owned or lived at this location? _____

2. Are there any soil erosion problems from a storm drainage system (i.e. pipes, drains, streams or ditches) on your property or in your neighborhood?
   ❑ Yes ❑ No
   If there are soil erosion problems, please indicate location and severity of problem.
   Location _____
   ❑ Minor ❑ Moderate ❑ Severe
   Location _____
   ❑ Minor ❑ Moderate ❑ Severe
   Location _____
   ❑ Minor ❑ Moderate ❑ Severe
   Location _____
   ❑ Minor ❑ Moderate ❑ Severe

3. Have you ever experienced flooding on your property during a (non-Hurricane) storm?
   ❑ Yes ❑ No
   If yes, check all situations that apply and note the frequency by choosing the appropriate letter from legend.

Legend	
A	Never experienced
B	Less than once per year
C	Once per year
D	2-3 times per year
E	More than 3 times per year
F	Every time it rains

   ❑ Water in storage building _____
   ❑ Water on air condition units _____
   ❑ Water in crawl space _____
   ❑ Water up to, or in the living space ____
   ❑ Yard flooding from stream/ditch _____
   ❑ Yard flooding from street runoff _____
   ❑ Yard flooding from adjacent property ___

4. If flooding occurred, please list the approximate date(s), location, and indicate depth of flooding.
   Date _____
   Location _____
   Depth of water _____

   Date _____
   Location _____
   Depth of water _____

5. Have you ever noticed flooded streets in your neighborhood?
   ❑ Yes ❑ No

6. If you noticed flooded streets, please provide the approximate date(s), location, and depth of flooding.
   Date _____
   Location _____
   Depth of water _____

   Date _____
   Location _____
   Depth of water _____

7. Are there any other problems with the storm drainage system (i.e. pipes, drains, streams, or ditches) on your property or in your neighborhood?
   ❑ Yes ❑ No
   If yes, check all situations that apply.
   ❑ Corroded pipes
   ❑ Sink holes
   ❑ Pipe blockage
   ❑ Stream or ditch blockage
   ❑ Drains in need of repair
   ❑ Other

8. Do you have any photographs, videotape, or other records of flooding problems that occurred on your property or in your neighborhood?
   ❑ No ❑ Photos ❑ Video
   ❑ Written ❑ Other

9. Has flooding increased on your property due to the filling of lots adjacent to, or near, your property?
   ❑ Yes ❑ No

Other comments including water quality concerns: _____
_____
_____
_____
_____

ALL RESIDENT RESPONSES TO QUESTIONNAIRES

Tabulated responses are to the following questions:

[1] How long have you owned or lived at this location?
[2] Are there any soil erosion problems from a storm drainage system (i.e. pipes, drains, streams or ditches) on your property or in your neighborhood?
[2a] If there are soil erosion problems, please indicate the location and severity of problem.
[3] Have you ever experienced flooding on your property during a (non-Hurricane)storm?
[3a] If yes, check all situations that apply and appropriate letter from legend.
A = Never experienced — D = 2-3 times per year
B = Less than once per year — E = More than 3 times per year
C = Once per year — F = Every time it rains
[4] If flooding occurred, please list the approximate date(s), location, and indicate depth of flooding.
[5] Have you ever noticed flooded streets in your neighborhood?
[6] If you noticed flooded streets, please provide the approximate date(s), location and depth of flooding.
[7] Are there any other problems with the storm drainage system (i.e. pipes, drains, streams or ditches) on your property or in your neighborhood?
[7a] If yes, check all situations that apply: corroded pipes, sink holes, pipe blockage, stream or ditch blockage, drains in need of repair, other.
1 = Corroded Pipes — 4= Stream or ditch blockage
2 = Sink holes — 5 = Drains in need of repair
3 = Pipe blockage — 6 = Other
[8] Do you have an photographs, videotape, or other records of flooding problems that occurred on your property or in your neighborhood (no, photos, video, written, other)?
[9] Has flooding increased on your property due to the filling of lots adjacent to, or near your property?

N/R = No response
N/A = Not applicable

Name	Address	Problem Type	Residency[1]	Erosion[2]	Erosion Notes[2a]	Flooding[3]	Flooding Notes[3a]	Flooding Events[4]	Street Flooding[5]	Street Flooding Notes[6]	Other Storm Drainage Problems[7]	Type of Storm Drainage Problems[7a]	Flood Records[8]	Increased Flooding[9]	Other Comments
Allen Beasley	801 Bell Dr.	None	4	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
Carl R. Carter	3916 Benjamin Ct.	Minor Flooding	20	No	N/A	No	N/A	N/R	Yes	Heavy rains; Benjamin Ct., corner of Beth; .5" in middle of Benjmain Ct. but 5" in gutters. The water doesn't drain well into the drain at the cul-de-sac	No	N/A	No	No	N/R
Richard J. Stankiewicz	3920 Benjamin Ct.	Minor Flooding	22	No	N/A	No	N/A	N/R	Yes	During hard rains; 2 drains get clogged with leaves; Cul-de-sac Benjamin Ct. (3")	N/R	N/R	N/R	No	N/R
Rolf Roetger	4013 Benjamin Ct.	Structural Flooding	20	No	N/A	Yes	Storage Building - F	1-2"	No	N/A	No	N/A	No	No	Problem is more building related than caused by the neighborhood design
Kenneth Mullen	4021 Benjamin Ct.	Structural Flooding	22	Yes	N/A	Yes	Storage Building - C Crawl Space - F Yard from Adjacent Property - F	Frequent; Yard (rear/side)	Yes	N/R	N/R	N/R	No	Yes	Thanks for the opportunity to comment on the drainage in the area of Benjamin Court. I will be out of the country on March 1, but would like to make a few comments for your study. I talked briefly with Blair and have filled out the questionnaire and returned it by mail. Basically, this area has had severe drainage problems since the subdivision was built. As I recall, aerial photography was used to determine elevations and the result was the streets being built higher than the lots. Most of the homes out here have sump pumps under them and the yards flood frequently. A number of French drains have been installed with wet wells, but there has been no relief. The neighborhood met with Mr. Varney and the City Engineer at the time (Roe O'Donnell or Russell Byrd – my memory fails me right now) to discuss the problem and the neighbors were very reserved out of respect for me and my position with the City and the fact that they didn't want to hurt their property value with a lot of press about the issues with the way the subdivision streets were built. I don't recall the name or title of the change, but after this subdivision was built there was some type of ordinance that was adopted to prevent this from happening again. There is a large drainage ditch behind the houses in the cul-de-sac on Benjamin Court as I recall, but there is not a method to get the water off the lots to the ditch other than just a natural flow, which is really slow. Looking a the elevation on the lot directly across from my house will give you an idea of the developers thinking when the subdivision was completed. It was the last house built in this block and it is clearly higher than any of the surrounding lots. I won't get stuck on engineering and design, but if you would take a look at this area it would be greatly appreciated. All you have to do is walk in mine and my neighbors back yard and you will see what I'm talking about. Thanks for your time and consideration
Michael "Scott" Ruce	2900 Brassfield Dr.	Structural Flooding	12	Yes	Behind house (Severe); Right side of property (Severe)	Yes	Storage Building - D Yard from Stream/Ditch - E	Mid-July; Backyard (2 - 3') Mid-August; Back and side yard (2-4')	No	N/A	Yes	3,4	No	Yes	N/R
Charles Desantis	3004 Brassfield Dr.	Erosion	22	Yes	maple creek shore line (Moderate); wet land back yard (Moderate)	Yes	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch - E Yard from Street - A Yard from Adjacent Property - D	spring,summer,fall every yr; back yard and garden(2-3 in)	Yes	with heavy rains spring,summer; corner charleston ct & brassfield dr (1-3 in)	Yes	2,4,6	No	Yes	With flooding or standing water the mosquito populations are terrible and it seems the city has dicontinued spraying for the insects. Always need bug repellent to avoid being bitten.
Joseph A. Grubb	3025 Brassfield Dr.	Structural Flooding	25	No	N/A	Yes	Crawl Space - D	N/R	No	N/A	No	N/A	No	No	N/R
Minnie Williams	306 Braylock Dr.	Pipe/Ditch	4	No	N/A	No	N/A	N/R	No	N/A	Yes	4	No	No	Stream or ditch becomes stagnant at times.
Bennett C. & Joyce R. Cockrell	312 Braylock Dr.	Pipe/Ditch	4	No	N/A	No	N/A	N/R	No	N/A	Yes	4	No	No	Stream or ditch blockage becomes stagnant at times.
Christine Yarboro	4424 Carroll Ave.	None	10	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
Robert & Connie Lipford	4000 Carysbrook Ct.	Structural Flooding	5.5	Yes	Storm drain pipe at creek (Severe); Ground behind storm drain at street (sink hole)	Yes	Storage Building - B Yard from Stream/Ditch - D Yard from Adjacent Property - D	Mid-August 2011 (not hurricane); backyard(18")	Yes	Mid August; Ketch Point (1-2")	Yes	2,3	Photos	No	Very concerned about the drain pipe at the creek becoming blocked.
Robert Paszek	100 Chelsea Ct.	None	30	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
A G Ingram	3503 Chelsea Dr.	None	44	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
Joe Feifer	3505 Chelsea Dr.	None	4.5	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
Sam Quigley	3528 Chelsea Dr.	Structural Flooding	16.5	No	N/A	Yes	Crawl Space - E Yard from Adjacent Property - E	During any medium to large rainfall; backyard (10"); Hurricance Flooyd 1999; Back and side yard (18")	Yes	At least 4 times during sudden heavy rains; In curve beside power lines (6-12")	Yes	4,6	N/R	Yes	Had to install drainage system in crawl space along with 2 sump pumps and a large sump pump in backyard to pump water to street ditch which drains much too slow. The entire area needs to have the drainage improved. Most houses have sump pumps or humidity systems to preserve the structures.
Jerry Barnes	3948 Crosswinds Dr.	Erosion	22	Yes	Behind residence on Ketch Point (Minor)	Yes	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch - A Yard from Street - C Yard from Adjacent Property - A	Don't know; Crosswinds(2-3"); Carybrook (2-3")	Yes	Occurs during hard downpours; too much water to drain off in present drain system	Yes	4,5	No	No	N/R

Name	Address	Problem Type	Residency[1]	Erosion[2]	Erosion Notes[2a]	Flooding[3]	Flooding Notes[3a]	Flooding Events[4]	Street Flooding[5]	Street Flooding Notes[6]	Other Storm Drainage Problems[7]	Type of Storm Drainage Problems[7a]	Flood Records[8]	Increased Flooding[9]	Other Comments
R.J. Raynor	3900 Gloucester Rd.	Yard Flooding	34	Yes	Backyard ditch (Moderate)	Yes	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch - D Yard from Street - B Yard from Adjacent Property - A	July, August, September; Backyard (12")	No	N/A	Yes	1,5	Photos	Yes	N/R
Tim Everett	3908 Gloucester Rd.	Erosion	11	Yes	Under driveway/drainage ditch (Minor)	Yes	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch - E Yard from Street - C Yard from Adjacent Property - B	Mid-August 2011; Backyard (1')	Yes	Mansfield & Newley (6-8")	No	N/A	Photos/ Videos	No	N/R
Debra F. Lee	4004 Gloucester Rd.	Erosion	30	Yes	Before grading and installation of rip-rap in December, we lost a wide swath of land along the drainage ditch easement on the south side of our house. So far the rip rap has held up, but the ditch extends into the woods behind our house making assessment of any further erosion difficult (Severe)	Yes	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch - C Yard from Adjacent Property - A	Fall, 2011; Mouth of drainage ditch (1 foot)	No	N/A	Yes	4	Photos	Yes	In the past, maintenance of the ditch easement consisted of ditch-witching the bottom of the channel and weed-eating that contributed to the large amount of erosion. Currently a large oak spans the ditch after it fell during Irene. The house at 4008 Gloucester, owned by Art and Susan Paschal, has had foundation problems possibly associated with the previous erosion. Please make sure they are contacted as they currently reside in Winston Salem and rent the property out. Art is the principal at Reynolds High School and I contact him through the school.
J.E. Drake	4012 Gloucester Rd.	None	12	No	N/A	No	N/A	N/R	No	N/A	N/R	N/R	No	No	N/R
Scott Wayland	4041 Gloucester Rd.	Erosion	22	Yes	Drainage ditch behind house. Slowing getting deeper (Moderate)	No	N/A	N/R	No	N/A	No	N/A	N/R	No	N/R
Paul Blount	100 Hampton Ct.	None	24	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	My property is pretty much at the top of the ridge that falls away to the NE and to the South
George J. Miller	4017 Hampton Dr.	Minor Flooding	17	No	N/A	Yes	Yard from Stream/Ditch - C	N/R	No	N/A	No	4	Photos/ Videos	No	Trees down in creek behind house need to be removed because they are blocking creek.
Tim Sikes	116 Hearthstone Ct.	None	13	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	When it rains hard & fast there are a few streets that get some standing water in various areas but I don't know about any bad flooding.
Stacey Patterson	117 Hearthstone Ct.	None	12	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
Mark Pearsall	109 Hillside Ct.	None	12	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
John Ashley Parker	2144 Joelene Dr.	Structural Flooding	8.5	Yes	along stream and edge of flower beds in my backyard (Minor)	Yes	Storage Building - B AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch - E Yard from Street - EYard from Adjacent Property - E	too many times to count; backyard (varies from 1 inch to 36 inches)	Yes	too many times to count; Joelene Dr, between my house and Winstead (up to 16 inches)	Yes	4	No	No	N/R
Russell & Nancy Proctor	2148 Joelene Dr.	Erosion	17	Yes	Jump Run Creek (Severe)	Yes	Yard from Stream/Ditch - E Yard from Street - E	Don't remember actual dates	Yes	Jeremy Ln/Joelene Dr.	Yes	4	Photos	Yes	N/R
Chris & Mary Chandler	2204 Joelene Dr.	Minor Flooding	3	No	N/A	Yes	Yard from Stream/Ditch - E	Whenever it rains heavily; Backyard; Entire bottom of yard becomes part of the creek	No	N/A	Yes	4	No	No	The creek makes up the back border of our property, and it is a mess. We went to great expense to clean up the creek trees that fell on our property during the hurricane, but the creek bed is still clogged with debris. The part of our yard that's nearest the creek, when it's not actually under water, is pretty much always a soggy muddy mess. Help!
Rick Hammock	3901 Ketch Point Dr.	Structural Flooding	8.5	Yes	Backyard/ditch (Severe)	Yes	Living Space - E Yard from Stream/Ditch - E Yard from Street - E	7/1/2006; Flooded Garage (23") 8/27/200; Flooded Garage (20+")	Yes	Too numerous to list	Yes	1,5,6	Photos	No	N/R
Richard Daniel	3908 Ketch Point Dr	None	10	No	N/A	N/R	N/A	N/R	Yes	where creek goes under Ketch Point Dr (10 inches)	Yes	N/R	No	N/R	almost every heavy rain the water comes over the banks into my neighbors' yard across the street. It has flooded my neighbers storage building
Maureen & John Peregord	3909 Ketch Point Dr.	Structural Flooding	12	Yes	Behind house (Severe)	Yes	Storage Building - D AC Units - D Yard from Stream/Ditch - D	Can't remember; Entire immediate are(2-3')	No	N/A	Yes	2,4	No	No	I have contacted the city-no response-erosion is rapidly approaching a power line pole - the city doesn't seem to care - if the pole goes down agains approx. 350 trees - some houses will be lost - but I might as well talk to a wall - the city does nothing!!
Delores Underwood	4036 Ketch Point Dr.	Minor Flooding	9	N/R	N/A	Yes	Yard from Adjacent Property - E	N/R	Yes	Sept. 2011	No	N/A	No	N/R	Since I am at the bottom of the hill, water seems to collect in my yard. This is not directly related to the ditch though.
Russell Osborne	4100 Ketch Point Dr.	None	26	No	N/A	No	N/A	N/R	Yes	Hurricane Floyd 1999; Ketch Point Drive at ditch (5") Summer 2011; Ketch Point Dr. at ditch (5")	No	N/A	No	No	N/R
David Oettinger	121 Manchester Ct.	Structural Flooding	17	No	N/A	Yes	Storage Building - A AC Units - A Crawl Space - D Living Space - A Yard from Stream/Ditch - A Yard from Street - A Yard from Adjacent Property - D	Heavy rains; comes from 125 to our yard to neighbors; Back corner of property (3-5")	No	N/A	No	N/A	Photos	No	Water flows from cul-de-sac towards Michael Scott - neighbor has pump in backyard
Ron C. Norris	604 Mayfair Dr.	Erosion	6	Yes	back of lot (Severe)	Yes	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch -C Yard from Street - C Yard from Adjacent Property - C	when ever there is a big rain	No	N/A	Yes	5	No	No	N/R
Moses & Katherine Cain	705 Mayfair Dr.	Erosion	5	Yes	Even numbered properties on 700 block of Mayfair Dr.	No	N/A	N/R	Yes	At intersection of Hansford Dr. & Mayfair Dr.	No	N/A	No	No	N/R
Clarence & Ida Arrington	4216 Meadowview Ln.	Structural Flooding	10	Yes	Backyard near storage building and ditch (Moderate)	Yes	Storage Building - E Crawl Space - E Yard from Stream/Ditch -E Yard from Street - E Yard from Adjacent Property - E	N/R	No	N/A	Yes	2	Photos	Yes	N/R
Pam Smith	1204 Michael Scott Dr.	Minor Flooding	10	N/R	N/A	Yes	Yard from Stream/Ditch - D	N/R	No	N/A	Yes	6	No	Yes	Ditch behind property floods easily with heavy rain and doesn't drain well (up to a week). Mosquitos are horrible. Drainage comes from street and contains trash which is then left in ditch.
James W. Grant & Susan L. Church	1212 Michael Scott Dr.	None	17.5	No	N/A	No	N/A	N/R	No	N/A	No	N/A	N/R	N/R	N/R
Robert K Miller	5009 Netherwood Rd.	Erosion	12	Yes	Eroding of ditch walls bordering back yard. (Moderate)	Yes	Yard from Stream/Ditch - B	2011; Back yard (12 inches)	No	N/A	No	N/A	No	No	N/R

Name	Address	Problem Type	Residency[1]	Erosion[2]	Erosion Notes[2a]	Flooding[3]	Flooding Notes[3a]	Flooding Events[4]	Street Flooding[5]	Street Flooding Notes[6]	Other Storm Drainage Problems[7]	Type of Storm Drainage Problems[7a]	Flood Records[8]	Increased Flooding[9]	Other Comments
William E. Gregory	5017 Netherwood Rd.	Erosion	34	Yes	Ditch (Moderate)	Yes	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch -D Yard from Street - A Yard from Adjacent Property - A	Hurricane Floyd 1999; Backyard ; Cover sewer drain so we could not see it	No	N/A	Yes	4	N/R	Yes	Any time we have a very hard rain that comes fast & it rains over 2.5 inches very quickly our backyard floods - in 4-5 hours the water has usually gone down
Brent Brondyke	5029 Netherwood Rd.	Minor Flooding	16	No	N/A	Yes	Yard from Stream/Ditch - D		No	N/A	N/R	N/R	N/R	No	If we get a hard, flooding rain, our ditch fills up and may overflow. Since our property juts out further than other properties, the debris from the storm ends up in our yard. This is our main concern.
Melissa Bridgers	5041 Netherwood Rd.	Erosion	5	Yes	Backyard (Moderate); Side (Minor)	Yes	Yard from Stream/Ditch - E	Several times this year; Backyard(6-8")	Yes	Ketch Point neighborhood (3-6")	Yes	1,4,5	No	Yes	Driving storms & heavy rain sticks water and debris end up in our yard (they come from areas down the street; the water gets so high & has a current that carries everything into our yard). Thank you for finally addressing these issues!
Phil Shehdan, Jr.	5044 Netherwood Rd.	Erosion	19	Yes	around the pipe that passes under Woodstock Rd (Severe)	No	Storage Building - A AC Units - A Crawl Space - A Living Space - A Yard from Stream/Ditch - A Yard from Street - A Yard from Adjacent Property - A	N/R	Yes	Not sure; Woodstock Rd; 1" Not much & very rare, only during a very heavy rain.	No	N/A	No	No	My property is the highest lot in the neighborhood. However, my neighbors down the street experience flooding in their backyards during fast/heavy rains. Very rarly does Woodstock Rd flood. However, as you know the creek fills up quick, but it also drains quickly too. I will not be able to attend the meeting, my son is getting married that weekend. Thank you.
Bobby Greene	5049 Netherwood Rd.	Erosion	23	Yes	Where Maple Creek Tributary passes through my property. (Severe); From a drainage ditch running beside my property (Moderate)	Yes	Yard from Stream/Ditch - E Yard from Adjacent Property - E	No records kept.	No	N/A	Yes	4	Photos	N/R	I estimate that I have lost 6+ feet of property at the two turns that the Maple Creek Tributary makes on my property since I have lived here. Most of this loss has come within the past approximately five years. I estimate a loss of approximately two feet to three feet of property at each of these two locations due to erosion during Hurricane Irene this past summer. In addition, there is a drainage ditch located beside my property that has become clogged with fallen trees. During heavy rains the water in this drainage ditch floods onto my property. I do have some pictures of the flooding during non-hurricane times. Due to another commitment I will not be able to attend the public meeting on March 1.
Gregory Hopkins	105 Sion Ct.	Structural Flooding	5	Yes	Yard (Moderate)	Yes	Crawl Space - D Living Space - A Yard from Adjacent Property - E	N/R	Yes	N/R	Yes	5	No	No	N/R
Heather Mitchell	109 Sion Ct.	None	5	No	N/A	No	N/A	N/R	No	N/A	No	N/A	N/R	No	I have not noticed any problems with our drainage system.
Joe Whaley	117 Sion Ct.	Erosion	16	Yes	Backyard (Moderate)	Yes	Yard from Adjacent Property - E	N/R	Yes	N/R	No	N/A	No	No	N/R
Leighann Wesley	200 S. Halifax Rd.	Minor Flooding	10	No	N/A	Yes	Yard from Stream/Ditch - D Yard from Street - D	N/R	Yes	N/R	No	N/A	No	No	N/R
Garry Ward	816 S. Halifax Rd.	Minor Flooding	36	No	N/A	Yes	Yard from Stream/Ditch - E Yard from Adjacent Property - E	Too many to name	Yes	N/R	Yes	6	Photos	Yes	We need more (bigger) drainage pipes downstream
Jim & Julia Rayborn	4041 Sunset Ave.	None	3.5	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	Since I acquired this property I have not noticed any problems. I live out of town.
Steve Moore	108 Warrington Ct.	Erosion	13	Yes	Backyard (Moderate)	Yes	Yard from Stream/Ditch - F Yard from Adjacent Property - F	Backyard (1-3')	Yes	N/R	Yes	4	No	Yes	N/R
Kevin Holt	121 Warrington Ct.	Structural Flooding	15	Yes	N/A	Yes	Crawl Space - D Living Space - D Yard from Stream/Ditch - D	Heavy rains; Backyard (2-4")	No	N/A	Yes	4	Video	Yes	Easement through my backyard
R.E. Thompson, Jr.	1261 Winstead Ave.	None	16	No	N/A	No	N/A	N/R	No	N/A	No	N/A	No	No	N/R
Clayton T. LaBau	3904 Woodstock Rd.	Erosion	25	Yes	Creekside	Yes	Yard from Stream/Ditch - E	Anytime over 1.5"; All along creek (2-10')	Yes	Hurricane Floyd (6" in street)	Yes	2,3,4,6	N/R	Yes	My property now floods anytime more than 1.5" of rain. Constantly worse through the years. 3 reasons - One- excessive building with no provision for additional water - Two - culverts too small for flow - Three - creek filled in with dirt. All three condtions must be rectified to obtain any relief from flood.

Rocky Mount Recyclers
South Halifax Road and Kingswood Drive
Date of Pictures: Unknown


ROCKY MOUNT RECYCLERS INC.


816 S. Halifax Rd
ROCKY MOUNT RECYCLERS INC.
S ← Halifax Rd → N


Kingsway Mobile Home Park
S. Halifax Rd N

2204 Joelene Drive
Date of Pictures: 3-24-12

Woodstock Road Culvert
Date of Pictures: 3-24-12


Locate

M E E T I N G M I N U T E S

720 Corporate Center Drive, Raleigh, North Carolina 27607 919.782.0495

DATE: March 5, 2012

TO: Blair Hinkle

FROM: Jason Kennedy

WKD #: 20110202.00.RA (Maple Creek Tributary #2 Drainage Study)

Maple Creek Tributary #2 Drainage Study
Public Meeting #1 – March 1, 2012
5:00 PM to 7:00 PM at Calvary Baptist Church

Maple Creek Tributary #2 Design Team Participants:

- Mr. Jonathan Boone – Director of Public Works
- Ms. Karen Callaway – Stormwater Engineer
- Ms. Ebony Hagans – Project Engineer, WK Dickson
- Mr. Blair Hinkle – Assistant Director of Public Works & Stormwater Manager
- Mr. Jason Kennedy – Project Manager, WK Dickson
- Mr. David Kiker – Technical Manager, WK Dickson

Citizen Input

A copy of the sign-in sheet from the public meeting is attached. Below is a summary of the comments obtained from those in attendance.

- **2900 Brassfield Drive (Scott Rose)**
  - Any time it rains heavy and hard, 3 feet of water ponds up in Mr. Rose's back yard.
    - The creek runs through his back yard; upstream of his yard are two smaller ditches that come into the main creek before hitting a hard bend. The water is unable to efficiently make the turn so it ends up in his yard; the City may want to look at straightening this section of the stream.
  - Mr. Rose expressed concern about large trees on the bank that may fall.
  - Last summer has been the worst; it has caused damage to his fence in certain spots.
  - A shed on Mr. Rose's property has had water in it.

- One of the double box culverts located at Michael Scott is full of debris; there never appears to be any flow in it.

- **3900 Gloucester Road (R.J. Raynor)**
  - Mr. Raynor has lived at the residence since 1977.
  - Hurricane Floyd was the only time he can recall Woodstock Road overtopping; during Floyd the water reached his foundation.
  - A section of Mr. Raynor's back yard floods at least twice per year. It typically stays up for 2 hours.
  - He loses pine needles and has to replace them when his yard floods.
  - The development of Ketch Point Drive in the late 1980s has caused things to get worse.
  - There is minor erosion; Mr. Raynor is concerned things will continue to get worse.
  - Mr. Raynor has provided pictures of his back yard and the Woodstock culvert.

- **4017 Hampton Drive (George Miller)**
  - Mr. Miller has lived at the residence for 17 years.
  - Last year, several trees fell into the creek; one hit a sanitary sewer manhole. He would like for the trees to be removed.
  - Mr. Miller has not experienced any yard or structural flooding.
  - The floodplain has only gotten wet once since he has lived in home.
  - Mr. Miller has provided pictures of the creek overflowing.

- **3901 Ketch Point Drive (Rick Hammock)**
  - Mr. Hammock's garage was flooded in June 2006 during Tropical Storm Alberto. Approximately 29 inches of water got into the garage.
  - No flooding was experienced during Hurricane Floyd in 1999; not sure what has changed between 1999 and 2006 in the watershed.
  - Every time it rains, several inches of water remains in yard for over 24 hours.
  - Over the last couple of years, Mr. Hammock's property has eroded away; this is causing depreciation of his property, which is one of his major concerns.
  - Mr. Hammock has provided pictures of the flooding.

- **4036 Ketch Point Drive (Delores Underwood)**
  - Ms. Underwood has lived at the residence for 10 years.
  - She has not experienced any flooding. Her back yard and side yard stays wet due to overland flow coming from adjacent homes and yards; none of the runoff is coming from the road or City property. It is coming from private property.
  - The stream contains a lot of debris. She also mentioned there are a lot of weeds along the channel and these try to work their way into her landscaped yard. She would like the City to come out more often and take care of the weeds.

- **600 Mayfair Drive (Stacy Eldson)**
    - Ms. Eldson's backyard contains a large, man-made earthen barrier to provide privacy to the yard from the adjacent development.
    - Yard drains towards edge of backyard and eventually flows into a surface drain, into a closed pipe, and under the large man-made earthen barrier.
    - When the drainage system is cleaned out, it works. It requires maintenance.
    - The back yard stays wet; the outfall side of earthen barrier near the creek is very muddy.

- **705 Mayfair Drive (Moses Cain)**
    - Mr. Cain has lived at the residence for 5 years.
    - He has observed surcharging at the intersection of Mayfair Drive and Hansford Drive.
    - There is standing water in the back of homes located between 700 and 714 Mayfair Drive).
    - The City has come out and done maintenance.

- **1204 Michael Scott Drive (Pam Smith)**
    - Ms. Smith has lived at property for 12 years.
    - The channel is rip rap lined.
    - She is experiencing yard flooding; the water sits in the ditch for up to a week.
    - The ditch has trash and debris.
    - There is major erosion at 101Charleston Court.
    - The neighbor at 1208 Michael Scott Drive is putting together an agreement to improve ditch.

- **4040 Sunset Avenue (Mary Daughtridge)**
    - Ms. Daughtridge has lived in the watershed most of her life (approximately 75 years) and had seen it grow from mainly agricultural to a mix of residential and agricultural. She currently lives north of Sunset Ave near its intersection with N. Halifax Road.
    - The most pressing issue is at the intersection of S. Halifax Road and Kingswood Drive. This sag overtops if 2 inches of rain comes down in a short period of time. The City or NCDOT will come out and put signs on either side of the sag to keep cars from crossing the road.
    - Ms. Daughtridge believes our stream names were incorrect. North Branch of Jumping Run and South Branch of Jumping Run confluence at the Whitney Farm.
    - The 4 or 5-acre pond was breached in the late 1980s because the owner did not make the necessary changes to upgrade the dam and a new subdivision developed downstream. They did not want to accept the liability of a breach resulting in flooding of homes. The dam was breached manually to get rid of the dam and impoundment of water.
    - There may be a culvert located under the railroad track approximately 1000 feet west of its intersection with S. Halifax Road.

- When the roads in front of one of her rental properties were built they did not properly account for drainage patterns and this has caused the yard to remain very wet. This is located in the Capital Drive area near Sunset Avenue (outside the watershed).

- **3904 Woodstock Road (Clay LaBau)**
  - Mr. LaBau's gazebo floods 2 to 3 times per year; the water gets to the roof of the gazebo once per year.
    - No other structural flooding.
  - The upstream section of the creek is full of sediment and other types of debris.
  - He believes the upstream pond was breached about 15 years ago.

Sign In Sheet

Maple Creek Tributary #2 Public Meeting - March 1, 2012

	NAME	ADDRESS	PHONE NUMBER	EMAIL ADDRESS	PREFERRED METHOD OF CONTACT (EMAIL OR PHONE)
1	Mary W. Daughtridge	4040 Sunset Ave R M	443-1824		
2	Paul Whitley	1012 Halifax Rd Rocky Mt	828-989-2915		
3	[illegible]	3904 Woodstock Rd - R.M.	252-937-6551		
4	Rick Hammock	3901 Ketch Point Dr RMNC	252-443-3469		
5	Mandy Chandler	2204 Joelene Drive	252-443-1486	marandachandler@hotmail.com	phone
6	Gregory Hopkins	105 Sion Ct	451-1693		phone
7	Moses A. Cain	705 Mayfair Dr.	443-5767		
8	Scott Rose	2900 Brassfield Dr Rocky Mount NC	567-6644		
9	George Miller	4617 Hampton Dr	252-937-4608	gjmmill@aol.com	
10	R.J. Raynor	3900 Gloucester Rd.	252 446-5229	rj.raynor@frontier.com	
11	Delores Underwood	4036 Ketch Point Dr.	252-443-4657	dundrwood@aol.com	
12	Pam Smith	1204 Michael Scott Dr	252-908-0117		
13	Stacy Eidson	600 Mayfair Dr	252.443-7554	stacyeidson@embarqmail.com	email
14					
15					

MEETING MINUTES

720 Corporate Center Drive, Raleigh, North Carolina 27607 919.782.0495

DATE: September 13, 2012

TO: Blair Hinkle

FROM: Jason Kennedy

WKD #: 20110202.00.RA (Maple Creek Tributary #2 Drainage Study)

Maple Creek Tributary #2 Drainage Study
Public Meeting #2 – September 6, 2012
5:30 PM to 7:00 PM at Calvary Baptist Church

Maple Creek Tributary #2 Design Team Participants:

- Mr. Jonathan Boone – Director of Public Works
- Ms. Ebony Hagans – Project Engineer, WK Dickson
- Mr. Blair Hinkle – Assistant Director of Public Works & Stormwater Manager
- Mr. Jason Kennedy – Project Manager, WK Dickson
- Mr. Scott Sigmon – Stormwater Program Manager, WK Dickson

The meeting began at approximately 5:30. Blair Hinkle provided a formal presentation (see attached) of the Basin Study including study objectives, study findings, and what will be completed moving forward as a result of the study. Primary points conveyed in the presentation include:

- Four major culvert crossings were analyzed and all but one was found to be operating acceptably.
- The existing Woodstock Road culvert was found to be in poor condition and is scheduled to be replaced in Fiscal Year 2014.
- The secondary system located along Kingswood Drive and the culvert under South Halifax Road were found to be undersized. Additional coordination and study is required to determine a practical solution at this location.
- The replacement of the existing Woodstock Road culvert will provide significant water surface elevation (WSEL) reduction for homes upstream of Woodstock Road and will create minimal WSEL increases downstream of Woodstock Road.

During and following the presentation, several residents made comments or posed questions. A summary of these comments and questions along with their answers are as follows:

- The City must take accountability for the problems it has created. The City had an opportunity to extend South Applewood Court out to Bethlehem Road which would have provided a second point of access for the residents along Netherwood, Woodstock, and Applewood. Instead, the City allowed an apartment complex to be built so this is no longer an option.

- Are there any plans to fix the identified erosion issues?
    - City Response: Erosion is being looked at but there is no specific timeframe for fixing it. Monitoring pins will be installed in the eroding section of stream to track and repair as necessary.

- Are there any stream restoration projects planned between Woodstock Road and Ketch Point Drive?
    - City Response: No, there are no stream restoration projects planned; no trenching or channel widening is planned in that reach or in any reach of stream studied as part of this project. The City believes replacing the culvert at Woodstock Road is a better use of funds.

- Are there any plans for detention projects?
    - City Response: There are currently no plans in place but the City is looking into upstream detention options. It will help to reduce the flooding elevations for the lower portion of the basin. These will be more long term solutions that need to be budgeted for.

- Has a study been done on Maple Creek and how it will be impacted by the increased flow from the upsized culvert at Woodstock Road? As a resident that lives two houses above the confluence, this is a concern of mine.
    - City Response: Maple Creek was considered as part of the study. We will be happy to discuss this in greater detail with you at the end of the meeting.

- What is the projected start date for the Woodstock Road culvert replacement?
    - City Response: The first part of fiscal year 2014.

- How is traffic going to be handled during the culvert replacement?
    - City Response: We are evaluating several potential options. One includes shifting road over with temporary culverts.

- What is a blue line stream? What are the restrictions for working on them?
    - City Response: Blue line streams are depicted on USGS quad maps and are governed by additional requirements and environmental regulations. It requires significant permitting from the State that can be very costly and time-consuming.

- Where are detention areas that have looked at? They would need to be west of Halifax Road.

- City Response: No specific detention areas have been looked at or evaluated. No property had has been acquired to date. There is more undeveloped property located west of Halifax Road so this area will be considered.

- Is the City planning to do anything west of Halifax Road?
  - City Response: No, we recognize that there are issues but there are no immediate plans in place for this area. We will continue to look at feasible and cost-effective solutions.

- Is the replacement culvert at Woodstock Road going to be concrete?
  - City Response: Yes, it will be a double reinforced box culvert (RCBC) similar to what is installed at Ketch Point Drive and Michael Scott Drive.

- Will the roadway elevation at Woodstock Road be raised?
  - City Response: No, the grade at Woodstock Road will not be raised. The current elevation will be maintained.

- Since the City cannot generate such large sums of money, are there funding opportunities to help with these types of projects?
  - City Response: Realistically, there are not a lot of grants for infrastructure upgrade projects but more for environmental and restoration type projects. In recent years, funding across the board has drastically been cut. However, the City will be looking into funding sources for projects including the Halifax and Kingswood project.

Citizen Input

A copy of the sign-in sheet from the public meeting is attached. Below is a summary of the comments obtained from those in attendance.

- **1012 Brassfield Court (Willie Blount)**
  - Ms. Blount resides in the Brassfield Court cul-de-sac. She stated that whenever there is a heavy downpour, water pools in the cul-de-sac. She indicated that she is not a huge problem but something she has observed.

- **1329 Michael Scott Drive (Cheryl Collins)**
  - Ms. Collins indicated that with the new FEMA map updates she was required to carry flood insurance. Since then she has had an elevation certificate completed for her home in order to have the requirement for flood insurance dropped.
  - Her main concerns were that the proposed project would cause more flooding to her property and cause her to have to once again carry flood insurance for her home.

- **3904 Woodstock Road (Clay LaBau)**
  - Mr. LaBau's gazebo floods 2 to 3 times per year; the water gets to the roof of the gazebo once per year. No other structural flooding.

- Mr. LaBau complained of having to remove debris from the stream in his yard.

- **4224 Carroll Avenue (Lucy Taylor)**
  - Ms. Taylor indicated there are drainage channels that run through her property, which appear to be blue line streams. She stated because of the flat topography, water will sit in the channel and keep her yard wet for days after a rain event.
  - She also indicated that standing water under her house has caused the floor of her home to rot and require replacement.
  - Ms. Taylor indicated approximately 8-10 years ago someone from the City visited her home and promised to address the problem but never did.

PUBLIC MEETING #2 PRESENTATION

Maple Creek Tributary #2 Public Meeting #2

Review of Analysis & Proposed Solutions

September 6, 2012

Project Team

- City Staff
  - Blair Hinkle, P.E. – Stormwater Manager
  - Jonathan Boone, P.E. – Dir of Public Works
- WK Dickson
  - Scott Sigmon, P.E. – Program Manager
  - Jason Kennedy, P.E.- Project Manager
  - Ebony Hagans, P.E. – Project Engineer

Meeting Objectives

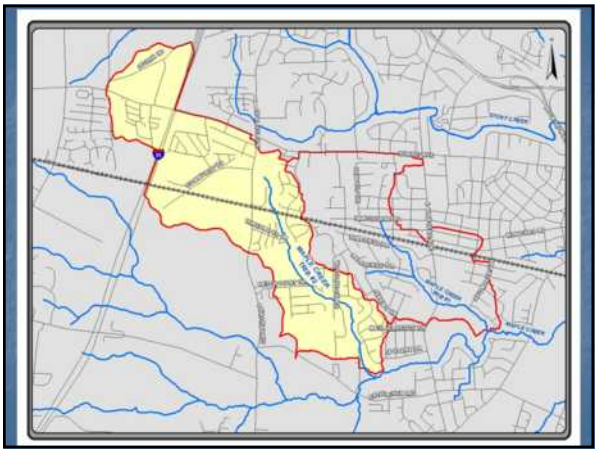
- Discuss:
  - What we did
  - What we found
  - What it means
  - Short Term & Long Term Projects
- Answer questions
- Receive additional feedback & input

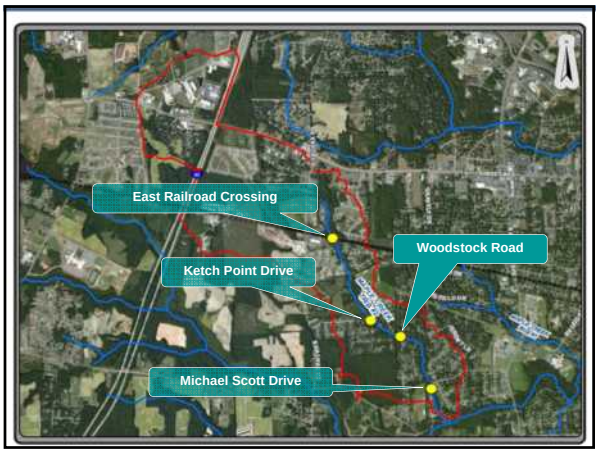
Project Goals

- Determine specific flooding locations
- Validate our models with citizen input
- Determine cause(s) of flooding
- Identify Capital Projects to effectively and efficiently reduce flooding and prevent property damage

What We Did

- Basin Master Plan
  - 1,070 ac (1.7 mi^2)
  - Main Tributary Evaluation (10,000 ft)
    - Railroad Culvert
    - Ketch Point Dr Culvert
    - Woodstock Rd Culvert
    - Michael Scott Dr Culvert
  - Secondary System Evaluation (2,000 ft)
    - Halifax Rd Culvert
    - Kings Way MHP System





Railroad Culvert

Ketch Point Dr Culvert

Woodstock Rd Culvert

Michael Scott Dr Culvert

Halifax Rd Culvert

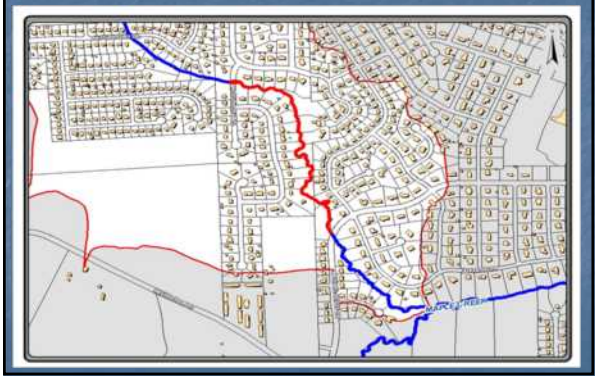
What We Found

- Upstream of Woodstock Rd
  - Serious "nuisance" flooding
  - Severe cases of structural flooding (out-buildings)
- Downstream of Woodstock Rd
  - Cases of "nuisance" flooding
  - Limited structural flooding (out-buildings)
  - Stream bank erosion

Woodstock Rd

March 24, 2012

Erosion



Erosion

Erosion

What it Means

- Woodstock Rd is an important point in the basin
  - Does not have the capacity to pass enough water to prevent flooding
  - Single point of access to approx. 70 residents.
  - In poor structural condition
- Other primary culverts are performing acceptably and in good condition
- Halifax Rd culvert & Kings Way MHP drainage system are undersized

Selecting Projects

- Project Prioritization
  - Public Safety/Property Damage/Nuisance
  - Budget / CIP
    - $1m - $1.5m per year capital budget
- Woodstock Rd Culvert
  - Public Safety Issue
  - Property Damage & Nuisance Flooding as well
  - Financially Feasible

The Plan to Fix It (Step 1)

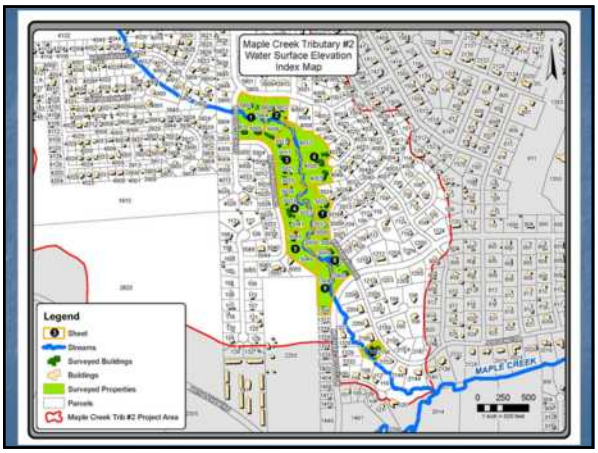
- Replace the Woodstock Rd Culvert
  - Fiscal Year 2014 (7/13-6/14)
  - From Twin 7'x4.5' Metal to Twin 10'x6' RCBC
  - $450,000 Capital Project
- Install Monitoring Pins in eroding section of ditch to track and repair new erosion
- Ensure Kings Way system remains free of obstruction

Woodstock Rd Culvert Replacement

- Benefits
  - Replace a structurally failing culvert
  - Ensure access to neighborhood during significant rain events
  - Reduce upstream flooding by **over two feet**
- Cost
  - Increase downstream flooding by **around one inch**

Culvert Replacement Analysis

- Heightened analysis because of downstream water surface elevation (WSE) increase
- Additional survey data collected
- Individual property maps drawn using model output and new survey data to depict effects
- End result
  - Significant reduction in upstream flooding
  - Negligible increase downstream



Woodstock Culvert Upgrade

- 35% Plans under review
- Our focus moving forward:
  - Ensure access during construction (FY14)
  - Complete replacement with minimal impact on residents
  - Provide thorough and timely communication

Long Term Plan (Step 2)

- Woodstock Rd Culvert Replacement does not eliminate flooding in the basin
- Must reduce inflow to the creek in order to reduce flooding
- Reduction in inflow may be achieved through upstream stormwater detention facilities (e.g. ponds)
  - City will work to identify candidate areas for acquisition and construction of ponds over the next several years.

Upstream Detention

- Will reduce flooding elevation for the entire basin downstream of the pond
- Will provide additional system capacity to accommodate future development (Basin only 65% built out)

Moving Forward

- City constantly analyzing and prioritizing needs
- Solutions for Halifax & Kings Way are incredibly expensive and long range.
  - $3-10 million
  - Looking at possible options and funding sources.

General Questions?

- Representatives from the City & WK Dickson will be glad to address site-specific questions following the General Question session.

Sign In Sheet

Maple Creek Tributary #2 Public Meeting - September 6, 2012

	NAME	ADDRESS	PHONE NUMBER	EMAIL ADDRESS	PREFERRED METHOD OF CONTACT (EMAIL OR PHONE)
1	CLAY LABAU	3904 Woodstock Rd	252-406-3903		phone
2	LANA VANDERLINDEN	3904 BENJAMIN CT	252-903-3206	lanvan730@gmail.com	e-mail
3	Kenneth Mullen	4021 Benjamin Ct	252-443-2754	kmullen@suddenlink.com	either
4	Cheryl Collins	1325 Michael Scott Dr	252-451-8910	Cherylstitches@yahoo.com	either
5	BOBBY GREENE	5049 NETHERWOOD RD.	252-443-5922	bggreene123@SUDDENLINK.NET	EITHER
6	GEORGE MILLER	4017 HAMPTON DR	252-937-4602	gjmmill@aol.com	either
7	Eugene Scofield	1205 Michael Scott Dr.	252-937-6449		
8	W B Bullock	3112 Ridgecrest Dr.	252-937-4719		
9	Paul Blount	160 Hampton Ct	252-937-4028	paul.blount@gmail.com	email
10	Jane Seeger	4165 Meadowview Ln	252-443-1662	jfseeger@suddenlink.net	either
11	Rick Hammock	3901 KETCH POINT DR	252-443-3469		Phone
12	Willie Blount	1012 Brassfield Ct	252-445-4309		phone
13	Lucy W. Taylor	4224 Carroll Ave	252-977-1469	Taylonrchymnt@AOL.Com	Phone
14	Tom Everett	3908 Gloucester Rd	252-443-7591	easternwm@suddenlink.net	email
15	Russell Proctor	2148 Joelene Drive	252-442-2724(B)	proctorr@estitel.com	email

Sign In Sheet

Maple Creek Tributary #2 Public Meeting - September 6, 2012

	NAME	ADDRESS	PHONE NUMBER	EMAIL ADDRESS	PREFERRED METHOD OF CONTACT (EMAIL OR PHONE)
1	W. B. Rose.	905 OLD MILL RD	CEL 813-1904	WBRose@WBRose.com	PHONE
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

RESOLUTION TO CITIZENS COMPLAINTS

Address	Erosion?	House/Yard Flooding?	Street Flooding?	Storm Drainage Problems?	Problem to be Improved or Resolved by Recommended Alternative	Problem to be Resolved by City Maintenance	No Resolution	No Problems
801 Bell Dr.	No	No	No	No				X
3916 Benjamin Ct.	No	No	Yes	No			X	
3920 Benjamin Ct.	No	No	Yes	N/R			X	
4013 Benjamin Ct.	No	Yes	No	No			X	
4021 Benjamin Ct.	Yes	Yes	Yes	N/R			X	
2900 Brassfield Dr.	Yes	Yes	No	Yes			X	
3004 Brassfield Dr.	Yes	Yes	Yes	Yes			X	
3025 Brassfield Dr.	No	Yes	No	No			X	
306 Braylock Dr.	No	No	No	Yes		X		
312 Braylock Dr.	No	No	No	Yes		X		
4424 Carroll Ave.	No	No	No	No				X
4000 Carysbrook Ct.	Yes	Yes	Yes	Yes	X			
100 Chelsea Ct.	No	No	No	No				X
3503 Chelsea Dr.	No	No	No	No				X
3505 Chelsea Dr.	No	No	No	No				X
3528 Chelsea Dr.	No	Yes	Yes	Yes			X	
3948 Crosswinds Dr.	Yes	Yes	Yes	Yes	X			
3900 Gloucester Rd.	Yes	Yes	No	Yes	X			
3908 Gloucester Rd.	Yes	Yes	Yes	No	X			
4004 Gloucester Rd.	Yes	Yes	No	Yes			X	
4012 Gloucester Rd.	No	No	No	N/R				X
4041 Gloucester Rd.	Yes	No	No	No			X	
100 Hampton Ct.	No	No	No	No				X
4017 Hampton Dr.	No	Yes	No	No		X		
116 Hearthstone Ct.	No	No	No	No				X
117 Hearthstone Ct.	No	No	No	No				X
109 Hillside Ct.	No	No	No	No				X
2144 Joelene Dr.	Yes	Yes	Yes	Yes			X	

Address	Erosion?	House/Yard Flooding?	Street Flooding?	Storm Drainage Problems?	Problem to be Improved or Resolved by Recommended Alternative	Problem to be Resolved by City Maintenance	No Resolution	No Problems
2148 Joelene Dr.	Yes	Yes	Yes	Yes			X	
2204 Joelene Dr.	No	Yes	No	Yes			X	
3901 Ketch Point Dr.	Yes	Yes	Yes	Yes	X			
3908 Ketch Point Dr	No	N/R	Yes	Yes	X			
3909 Ketch Point Dr.	Yes	Yes	No	Yes	X			
4036 Ketch Point Dr.	N/R	Yes	Yes	No			X	
4100 Ketch Point Dr.	No	No	Yes	No	X			
121 Manchester Ct.	No	Yes	No	No			X	
604 Mayfair Dr.	Yes	Yes	No	Yes			X	
705 Mayfair Dr.	Yes	No	Yes	No			X	
4216 Meadowview Ln.	Yes	Yes	No	Yes			X	
1204 Michael Scott Dr.	N/R	Yes	No	Yes			X	
1212 Michael Scott Dr.	No	No	No	No				X
5009 Netherwood Rd.	Yes	Yes	No	No			X	
5017 Netherwood Rd.	Yes	Yes	No	Yes			X	
5029 Netherwood Rd.	No	Yes	No	N/R			X	
5041 Netherwood Rd.	Yes	Yes	Yes	Yes			X	
5044 Netherwood Rd.	Yes	No	Yes	No			X	
5049 Netherwood Rd.	Yes	Yes	No	Yes			X	
105 Sion Ct.	Yes	Yes	Yes	Yes			X	
109 Sion Ct.	No	No	No	No				X
117 Sion Ct.	Yes	Yes	Yes	No			X	
200 S. Halifax Rd.	No	Yes	Yes	No			X	
816 S. Halifax Rd.	No	Yes	Yes	Yes			X	
4041 Sunset Ave.	No	No	No	No				X
108 Warrington Ct.	Yes	Yes	Yes	Yes			X	
121 Warrington Ct.	Yes	Yes	No	Yes			X	
1261 Winstead Ave.	No	No	No	No				X
3904 Woodstock Rd.	Yes	Yes	Yes	Yes	X			
* Additional problems would be improved/resolved with the installation of floodplain benching between Woodstock Road and Michael Scott Drive.								

Appendix E:
Culvert Analysis and Sufficiency Evaulation

List of Contents:

Project: Maple Creek Tributary #2, Rocky Mount, NC

Prepared by: EVH

Checked by: JPK

Date: April 10, 2012

**Data for Sufficiency Evaluation is output from HEC-RAS.*

Sufficiency Evaluation - Existing Conditions Analysis

Does not meet design criteria

Design Storm 2-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	106.42	106.21	105.31	106.42	110.94	238.87		0.6	100.5	100.5	5.7	5.8	4.73	5.71	0.71
Micheal Scott Drive #2	8' x 8' RCBC	8.0	106.42	106.21	104.95	106.42	110.94	231.13		0.6	100.23	100.23	5.2	5.8	4.73	5.98	0.75
Woodstock Road #1	4.5' x 7' Elliptical CMP	7.0	114.61	114.49	114.61	114.56	115.2	217.7		3.01	108.53	108.53	9.5	10.6	0.71	5.96	0.85
Woodstock Road #2	4.5' x 7' Elliptical CMP	7.0	114.61	114.49	114.5	114.61	115.2	223.3		3.01	108.32	108.32	8.9	10.7	0.71	6.17	0.88
Ketch Point Drive #1	9' x 4' RCBC	4.0	116.99	116.82	115.52	116.98	117.31	216.46		0.79	111.28	111.28	6.0	6.0	0.49	5.54	1.39
Ketch Point Drive #2	9' x 4' RCBC	4.0	116.99	116.82	115.46	117.01	117.31	219.54		0.79	111.18	111.18	6.1	6.1	0.49	5.64	1.41
East Railroad Crossing	48" RCP	4.0	133.92	133.8	132.27	133.92	134.83	133.0		3.48	125.95	125.95	10.6	10.6	1.03	7.85	1.96

Design Storm 10-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	107.72	107.41	106.92	107.7	110.94	363.67		1.18	100.5	100.5	7.68	7.89	3.53	6.91	0.86
Micheal Scott Drive #2	8' x 8' RCBC	8.0	107.72	107.41	106.58	107.73	110.94	356.33		1.18	100.23	100.23	7.01	8	3.53	7.18	0.90
Woodstock Road #1	4.5' x 7' Elliptical CMP	7.0	115.7	115.62	115.71	115.46	115.2	253.69	134.9	3.54	108.53	108.53	10.25	10.9	-0.42	7.09	1.01
Woodstock Road #2	4.5' x 7' Elliptical CMP	7.0	115.7	115.62	115.61	115.69	115.2	260.41	134.9	3.54	108.32	108.32	10.3	11.21	-0.42	7.30	1.04
Ketch Point Drive #1	9' x 4' RCBC	4.0	117.89	117.68	115.91	117.88	117.31	246.45	143.98	1.03	111.28	111.28	6.9	6.9	-0.37	6.40	1.60
Ketch Point Drive #2	9' x 4' RCBC	4.0	117.89	117.68	115.84	117.9	117.31	248.57	143.98	1.03	111.18	111.18	6.9	6.9	-0.37	6.50	1.63
East Railroad Crossing	48" RCP	4.0	135.08	135.08	134.39	135.08	134.83	149.55	18.45	4.55	125.95	125.95	11.9	11.9	-0.25	9.13	2.28

Design Storm 25-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	108.54	108.2	107.94	108.55	110.94	450.04		1.64	100.5	100.5	8.87	9.24	2.74	7.70	0.96
Micheal Scott Drive #2	8' x 8' RCBC	8.0	108.54	108.2	107.51	108.53	110.94	434.96		1.64	100.23	100.23	7.97	9.22	2.74	7.97	1.00
Woodstock Road #1	4.5' x 7' Elliptical CMP	7.0	115.9	115.8	115.99	115.9	115.2	261.95	240.56	3.44	108.53	108.53	10.59	10.78	-0.60	7.27	1.04
Woodstock Road #2	4.5' x 7' Elliptical CMP	7.0	115.9	115.80	115.71	115.89	115.2	263.49	240.56	3.44	108.32	108.32	10.4	10.8	-0.60	7.48	1.07
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.18	117.94	115.98	118.17	117.31	251.33	254.42	1.05	111.28	111.28	7.0	7.0	-0.63	6.66	1.67
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.18	117.94	115.92	118.19	117.31	253.25	254.42	1.05	111.18	111.18	7.0	7.0	-0.63	6.76	1.69
East Railroad Crossing	48" RCP	4.0	135.4	135.39	135.31	135.4	134.83	148.67	103.2	4.5	125.95	125.95	11.8	11.8	-0.56	9.44	2.36

Design Storm 50-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	109.24	108.86	108.71	109.23	110.94	518.81		2.06	100.5	100.5	9.71	10.25	2.08	8.36	1.05
Micheal Scott Drive #2	8' x 8' RCBC	8.0	109.24	108.86	108.33	109.24	110.94	507.19		2.06	100.23	100.23	8.78	10.33	2.08	8.63	1.08
Woodstock Road #1	4.5' x 7' Elliptical CMP	7.0	116.09	115.98	115.98	116.09	115.2	261.86	340.99	3.39	108.53	108.53	10.58	10.58	-0.78	7.45	1.06
Woodstock Road #2	4.5' x 7' Elliptical CMP	7.0	116.09	115.98	115.77	116.1	115.2	265.15	340.99	3.39	108.32	108.32	10.5	10.6	-0.78	7.66	1.09
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.38	118.1	115.99	118.36	117.31	251.98	345.19	1.02	111.28	111.28	7.0	7.0	-0.79	6.82	1.71
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.38	118.1	115.95	118.39	117.31	254.83	345.19	1.02	111.18	111.18	7.1	7.1	-0.79	6.92	1.73
East Railroad Crossing	48" RCP	4.0	135.56	135.56	135.5	135.56	134.83	147.66	173.34	4.43	125.95	125.95	11.8	11.8	-0.73	9.61	2.40

Design Storm 100-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	110.01	109.59	109.55	110	110.94	597.79		2.56	100.5	100.5	10.58	11.38	1.35	9.09	1.14
Micheal Scott Drive #2	8' x 8' RCBC	8.0	110.01	109.59	109.18	110.02	110.94	586.21		2.56	100.23	100.23	9.56	11.49	1.35	9.36	1.17
Woodstock Road #1	4.5' x 7' Elliptical CMP	7.0	116.25	116.12	115.83	116.25	115.2	257.28	477.82	3.25	108.53	108.53	10.4	10.4	-0.92	7.59	1.08
Woodstock Road #2	4.5' x 7' Elliptical CMP	7.0	116.25	116.12	115.63	116.25	115.2	260.9	477.82	3.25	108.32	108.32	10.3	10.3	-0.92	7.80	1.11
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.58	118.25	116.02	118.57	117.31	253.32	463.71	0.98	111.28	111.28	7.0	7.0	-0.94	6.97	1.74
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.58	118.25	115.98	118.59	117.31	255.97	463.71	0.98	111.18	111.18	7.1	7.1	-0.94	7.07	1.77
East Railroad Crossing	48" RCP	4.0	135.67	135.66	135.62	135.67	134.83	146.48	240.52	4.36	125.95	125.95	11.7	11.7	-0.83	9.71	2.43

Sufficiency Evaluation (City of Rocky Mount Stormwater Design Manual)

- Residential Local and Collector Roadways – 25-year design storm with 1 foot of freeboard.
- Commercial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Industrial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Minor and Major Arterial Roadways – 50-year design storm with 0.5 foot of freeboard.
- HW/D (headwater depth to culvert depth) < 1.2.

Project: Maple Creek Tributary #2, Rocky Mount, NC

Prepared by: EVH

Checked by: JPK

Date: April 10, 2012

**Data for Sufficiency Evaluation is output from HEC-RAS.*

Sufficiency Evaluation - City Design Standard Analysis

Does not meet design criteria

Design Storm 2-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	Double 8' x 8' RCBC	8.0	107.01	106.73	106.54	107.01	110.94	508.14		0.77	100.5	100.5	6.9	7.1	4.21	6.23	0.78
Micheal Scott Drive #2	72" RCP	6.0	107.01	106.73	106.46	106.99	110.94	92.86		0.77	102.23	102.23	5.0	7.2	4.21	4.50	0.75
Woodstock Road	Triple 10' x 7' RCBC	7.0	111.65	111.10	109.04	111.65	115.2	488		0.37	104.87	104.87	2.9	2.7	4.10	6.23	0.89
Ketch Point Drive	Quad 12' x 7' RCBC	7.0	115.32	115.06	111.39	115.32	117.31	436		0.06	108.24	108.24	1.5	1.5	2.25	6.82	0.97
East Railroad Crossing #1	48" RCP	4.0	131.27	130.02	129.45	131.27	134.83	173.67		0.73	125.95	125.95	3.5	3.6	4.81	4.07	1.02
East Railroad Crossing #2	Double 72" RCP	6.0	131.27	130.02	128.6	131.25	134.83	39.33		0.73	125.95	125.95	3.1	3.1	4.81	4.07	0.68

Design Storm 10-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	Double 8' x 8' RCBC	8.0	108.82	108.38	108.67	108.82	110.94	847.63		1.58	100.5	100.5	9.27	9.94	2.56	7.88	0.98
Micheal Scott Drive #2	72" RCP	6.0	108.82	108.38	108.49	108.83	110.94	180.37		1.58	102.23	102.23	7.43	10.16	2.56	6.15	1.03
Woodstock Road	Triple 10' x 7' RCBC	7.0	112.88	111.96	110.45	112.88	115.2	830		0.43	104.87	104.87	4.61	4.61	3.24	7.09	1.01
Ketch Point Drive	Quad 12' x 7' RCBC	7.0	116.29	115.79	112.32	116.29	117.31	737		0.09	108.24	108.24	2.6	2.6	1.52	7.55	1.08
East Railroad Crossing #1	48" RCP	4.0	132.33	131.19	130.62	132.33	134.83	284.79		0.01	125.95	125.95	5.2	5.4	3.64	5.24	1.31
East Railroad Crossing #2	Double 72" RCP	6.0	132.33	131.19	129.44	132.32	134.83	62.21		0.01	125.95	125.95	5.0	5.0	3.64	5.24	0.87

Design Storm 25-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	Double 8' x 8' RCBC	8.0	110.06	109.55	110.06	109.91	110.94	1067.13		2.35	100.5	100.5	10.47	11.64	1.39	9.05	1.13
Micheal Scott Drive #2	72" RCP	6.0	110.06	109.55	110.11	110.07	110.94	236.87		2.35	102.23	102.23	9.41	11.53	1.39	7.32	1.22
Woodstock Road	Triple 10' x 7' RCBC	7.0	113.68	112.69	111.26	113.68	115.2	1051		0.21	104.87	104.87	5.84	5.84	2.51	7.82	1.12
Ketch Point Drive	Quad 12' x 7' RCBC	7.0	116.83	116.17	112.85	116.83	117.31	932		0.11	108.24	108.24	3.2	3.2	1.14	7.93	1.13
East Railroad Crossing #1	48" RCP	4.0	133	131.86	131.3	133	134.83	355.17		0.47	125.95	125.95	6.3	6.5	2.97	5.91	1.48
East Railroad Crossing #2	Double 72" RCP	6.0	133	131.86	129.92	133	134.83	75.83		0.47	125.95	125.95	6.0	6.0	2.97	5.91	0.99

Design Storm 50-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	Double 8' x 8' RCBC	8.0	111.07	110.24	112	110.96	110.94	1272.76	256.45	2.51	100.5	100.5	11.36	12.71	0.70	9.74	1.22
Micheal Scott Drive #2	72" RCP	6.0	111.07	110.24	111.56	111.15	110.94	281.34	256.45	2.51	102.23	102.23	11.17	12.81	0.70	8.01	1.34
Woodstock Road	Triple 10' x 7' RCBC	7.0	115.34	114.51	112.79	115.34	115.2	1489.59	17.41	0.74	104.87	104.87	8.28	8.28	0.69	9.64	1.38
Ketch Point Drive	Quad 12' x 7' RCBC	7.0	117.92	116.91	113.94	117.92	117.31	1212.98	155.02	0.15	108.24	108.24	4.2	4.2	0.40	8.67	1.24
East Railroad Crossing #1	48" RCP	4.0	133.73	132.46	131.94	133.73	134.83	422.48		0.93	125.95	125.95	7.5	7.5	2.37	6.51	1.63
East Railroad Crossing #2	Double 72" RCP	6.0	133.73	132.46	130.42	133.72	134.83	90.52		0.93	125.95	125.95	7.2	7.2	2.37	6.51	1.09

Design Storm 100-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	Double 8' x 8' RCBC	8.0	112.13	111.89	112.13	111.11	110.94	1291.62	437.34	4	100.5	100.5	11.53	17.44	-0.95	11.39	1.42
Micheal Scott Drive #2	72" RCP	6.0	112.13	111.89	112.13	111.54	110.94	297.04	437.34	4	102.23	102.23	11.8	14.5	-0.95	9.66	1.61
Woodstock Road	Triple 10' x 7' RCBC	7.0	115.8	115.22	113.84	115.8	115.2	1504.76	187.25	1.02	104.87	104.87	8.36	8.36	-0.02	10.35	1.48
Ketch Point Drive	Quad 12' x 7' RCBC	7.0	118.27	117.16	114.32	118.27	117.31	1236.18	296.82	0.17	108.24	108.24	4.3	4.3	0.15	8.92	1.27
East Railroad Crossing #1	48" RCP	4.0	134.3	132.88	132.42	134.3	134.83	472.7		1.28	125.95	125.95	8.4	8.4	1.95	6.93	1.73
East Railroad Crossing #2	Double 72" RCP	6.0	134.3	132.88	130.78	134.28	134.83	101.3		1.28	125.95	125.95	8.1	8.1	1.95	6.93	1.16

Sufficiency Evaluation (City of Rocky Mount Stormwater Design Manual)

- Residential Local and Collector Roadways – 25-year design storm with 1 foot of freeboard.
- Commercial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Industrial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Minor and Major Arterial Roadways – 50-year design storm with 0.5 foot of freeboard.
- HW/D (headwater depth to culvert depth) <1.2.

Project: Maple Creek Tributary #2, Rocky Mount, NC

Prepared by: EVH

Checked by: JPK

Date: April 10, 2012

**Data for Sufficiency Evaluation is output from HEC-RAS.*

Sufficiency Evaluation - Alternative #1 Woodstock Road Culvert Replacement and Hampton Detention Area

Does not meet design criteria

Design Storm 2-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	107.14	106.87	106.23	107.14	110.94	308.27		0.9	100.5	100.5	6.9	7.0	4.07	6.37	0.80
Micheal Scott Drive #2	8' x 8' RCBC	8.0	107.14	106.87	105.86	107.14	110.94	298.73		0.9	100.23	100.23	6.2	7.0	4.07	6.64	0.83
Woodstock Road #1	10' x 6' RCBC	6.0	112.58	112.19	112.52	112.57	115.2	247.04		0.61	107.25	107.25	7.6	6.9	3.01	4.94	0.82
Woodstock Road #2	10' x 6' RCBC	6.0	112.58	112.19	112.22	112.59	115.2	221.96		0.61	107.25	107.25	6.8	6.2	3.01	4.94	0.82
Ketch Point Drive #1	9' x 4' RCBC	4.0	117.05	116.88	115.52	117.03	117.31	216.99		0.8	111.28	111.28	6.0	6.0	0.43	5.60	1.40
Ketch Point Drive #2	9' x 4' RCBC	4.0	117.05	116.88	115.46	117.06	117.31	220.01		0.8	111.18	111.18	6.1	6.1	0.43	5.70	1.43
East Railroad Crossing	48" RCP	4.0	135.29	135.29	135.14	135.29	134.83	149.42	64.55	4.54	125.95	125.95	11.9	11.9	-0.46	9.34	2.34

Design Storm 10-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	109.37	108.99	108.86	109.37	110.94	532.96		2.15	100.5	100.5	9.87	10.46	1.95	8.49	1.06
Micheal Scott Drive #2	8' x 8' RCBC	8.0	109.37	108.99	108.48	109.38	110.94	521.04		2.15	100.23	100.23	8.93	10.54	1.95	8.76	1.10
Woodstock Road #1	10' x 6' RCBC	6.0	114.58	114.11	114.58	114.25	115.2	413.86		1.62	107.25	107.25	10.18	9.23	1.09	6.86	1.14
Woodstock Road #2	10' x 6' RCBC	6.0	114.58	114.11	114.32	114.58	115.2	401.14		1.62	107.25	107.25	9.78	8.94	1.09	6.86	1.14
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.13	117.89	116.06	118.12	117.31	255.19	232.7	1.09	111.28	111.28	7.1	7.1	-0.58	6.61	1.65
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.13	117.89	116.01	118.14	117.31	257.11	232.7	1.09	111.18	111.18	7.1	7.1	-0.58	6.71	1.68
East Railroad Crossing	48" RCP	4.0	135.65	135.65	135.54	135.65	134.83	147.89	199.11	4.45	125.95	125.95	11.8	11.8	-0.82	9.70	2.43

Design Storm 25-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	110.73	110.29	110.73	110.72	110.94	673.63		3.06	100.5	100.5	11.32	12.45	0.65	9.79	1.22
Micheal Scott Drive #2	8' x 8' RCBC	8.0	110.73	110.29	110.12	110.74	110.94	656.37		3.06	100.23	100.23	10.26	12.48	0.65	10.06	1.26
Woodstock Road #1	10' x 6' RCBC	6.0	115.59	115.37	115.59	114.79	115.2	468.8	90.4	2.38	107.25	107.25	10.13	9.39	-0.17	8.12	1.35
Woodstock Road #2	10' x 6' RCBC	6.0	115.59	115.37	115.59	115.27	115.2	468.8	90.4	2.38	107.25	107.25	10.1	9.4	-0.17	8.12	1.35
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.5	118.19	116.11	118.49	117.31	257.19	415.87	1.04	111.28	111.28	7.1	7.1	-0.88	6.91	1.73
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.5	118.19	116.08	118.52	117.31	259.94	415.87	1.04	111.18	111.18	7.2	7.2	-0.88	7.01	1.75
East Railroad Crossing	48" RCP	4.0	135.81	135.81	135.67	135.81	134.83	147.42	283.58	4.42	125.95	125.95	11.7	11.7	-0.98	9.86	2.47

Design Storm 50-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	111.58	111.39	111.58	111.13	110.94	713.54	164.79	3.85	100.5	100.47	11.51	12.61	-0.45	10.89	1.36
Micheal Scott Drive #2	8' x 8' RCBC	8.0	111.58	111.39	111.6	111.59	110.94	726.66	164.79	3.85	100.23	100.66	11.35	13.19	-0.45	11.16	1.40
Woodstock Road #1	10' x 6' RCBC	6.0	115.88	115.61	116.54	115.87	115.2	537.2	228.94	2.11	107.25	107	10.74	10.74	-0.41	8.36	1.39
Woodstock Road #2	10' x 6' RCBC	6.0	115.88	115.61	115.84	115.9	115.2	487.86	228.94	2.11	107.25	107	9.8	9.8	-0.41	8.36	1.39
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.83	118.42	116.15	118.82	117.31	258.5	630.55	0.95	111.28	111.10	7.2	7.2	-1.11	7.14	1.79
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.83	118.42	116.11	118.84	117.31	260.95	630.55	0.95	111.18	110.96	7.3	7.3	-1.11	7.24	1.81
East Railroad Crossing	48" RCP	4.0	135.89	135.89	135.84	135.89	134.83	146.39	366.61	4.36	125.95	126.13	11.7	11.7	-1.06	9.94	2.49

Design Storm 100-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	111.92	111.7	111.9	111.31	110.94	730.92	318.93	3.97	100.5	100.5	11.56	12.58	-0.76	11.20	1.40
Micheal Scott Drive #2	8' x 8' RCBC	8.0	111.92	111.7	111.95	111.93	110.94	754.15	318.93	3.97	100.23	100.23	11.78	13.33	-0.76	11.47	1.43
Woodstock Road #1	10' x 6' RCBC	6.0	116.14	115.83	116.5	116.13	115.2	533.99	387.45	2.04	107.25	107.25	10.68	10.68	-0.63	8.58	1.43
Woodstock Road #2	10' x 6' RCBC	6.0	116.14	115.83	115.78	116.15	115.2	483.56	387.45	2.04	107.25	107.25	9.7	9.7	-0.63	8.58	1.43
Ketch Point Drive #1	9' x 4' RCBC	4.0	119.03	118.55	116.19	119.01	117.31	260.23	763.22	0.91	111.28	111.28	7.2	7.2	-1.24	7.27	1.82
Ketch Point Drive #2	9' x 4' RCBC	4.0	119.03	118.55	116.15	119.04	117.31	262.54	763.22	0.91	111.18	111.18	7.3	7.3	-1.24	7.37	1.84
East Railroad Crossing	48" RCP	4.0	136	135.99	135.91	136	134.83	147.02	426.14	4.39	125.95	125.95	11.7	11.7	-1.16	10.04	2.51

Sufficiency Evaluation (City of Rocky Mount Stormwater Design Manual)

- Residential Local and Collector Roadways – 25-year design storm with 1 foot of freeboard.
- Commercial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Industrial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Minor and Major Arterial Roadways – 50-year design storm with 0.5 foot of freeboard.
- HW/D (headwater depth to culvert depth) < 1.2.

Project: Maple Creek Tributary #2, Rocky Mount, NC

Prepared by: EVH

Checked by: JPK

Date: September 10, 2012

**Data for Sufficiency Evaluation is output from HEC-RAS.*

Sufficiency Evaluation - Alternative #1A Woodstock Road Culvert Replacement and Railroad West and Community Drive Detention Areas

Does not meet design criteria

Design Storm 2-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	107.11	106.84	106.19	107.1	110.94	304.73		0.88	100.5	100.5	6.8	6.9	4.10	6.34	0.79
Micheal Scott Drive #2	8' x 8' RCBC	8.0	107.11	106.84	105.81	107.11	110.94	295.27		0.88	100.23	100.23	6.2	7.0	4.10	6.61	0.83
Woodstock Road #1	10' x 6' RCBC	6.0	112.68	112.28	112.64	112.68	115.2	256.59		0.65	107.25	107.25	7.8	7.1	2.92	5.03	0.84
Woodstock Road #2	10' x 6' RCBC	6.0	112.68	112.28	112.32	112.69	115.2	230.41		0.65	107.25	107.25	6.9	6.3	2.92	5.03	0.84
Ketch Point Drive #1	9' x 4' RCBC	4.0	117.04	116.87	115.51	117.02	117.31	215.98		0.79	111.28	111.28	6.0	6.0	0.44	5.59	1.40
Ketch Point Drive #2	9' x 4' RCBC	4.0	117.04	116.87	115.45	117.05	117.31	219.02		0.79	111.18	111.18	6.1	6.1	0.44	5.69	1.42
East Railroad Crossing	48" RCP	4.0	135.29	135.29	135.14	135.29	134.83	149.42	64.55	4.54	125.95	125.95	11.9	11.9	-0.46	9.34	2.34

Design Storm 10-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	109.18	108.8	108.64	109.17	110.94	513.25		2.03	100.5	100.5	9.64	10.17	2.14	8.30	1.04
Micheal Scott Drive #2	8' x 8' RCBC	8.0	109.18	108.8	108.27	109.19	110.94	501.75		2.03	100.23	100.23	8.73	10.25	2.14	8.57	1.07
Woodstock Road #1	10' x 6' RCBC	6.0	114.6	114.12	114.6	114.25	115.2	414.6		1.64	107.25	107.25	10.22	9.25	1.08	6.87	1.15
Woodstock Road #2	10' x 6' RCBC	6.0	114.6	114.12	114.35	114.59	115.2	402.4		1.64	107.25	107.25	9.83	8.97	1.08	6.87	1.15
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.08	117.85	116.04	118.07	117.31	254.3	213.45	1.09	111.28	111.28	7.1	7.1	-0.54	6.57	1.64
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.08	117.85	115.99	118.09	117.31	256.26	213.45	1.09	111.18	111.18	7.1	7.1	-0.54	6.67	1.67
East Railroad Crossing	48" RCP	4.0	135.65	135.65	135.54	135.65	134.83	147.89	199.11	4.45	125.95	125.95	11.8	11.8	-0.82	9.70	2.43

Design Storm 25-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	110.37	109.94	109.96	110.36	110.94	635.58		2.8	100.5	100.5	10.96	11.91	1.00	9.44	1.18
Micheal Scott Drive #2	8' x 8' RCBC	8.0	110.37	109.94	109.57	110.39	110.94	623.42		2.8	100.23	100.23	9.9	12.03	1.00	9.71	1.21
Woodstock Road #1	10' x 6' RCBC	6.0	115.62	115.39	115.62	114.8	115.2	470.88	101.23	2.42	107.25	107.25	10.22	9.46	-0.19	8.14	1.36
Woodstock Road #2	10' x 6' RCBC	6.0	115.62	115.39	115.62	115.29	115.2	470.88	101.23	2.42	107.25	107.25	10.2	9.5	-0.19	8.14	1.36
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.49	118.18	116.11	118.48	117.31	256.88	410.5	1.04	111.28	111.28	7.1	7.1	-0.87	6.90	1.73
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.49	118.18	116.07	118.51	117.31	259.63	410.5	1.04	111.18	111.18	7.2	7.2	-0.87	7.00	1.75
East Railroad Crossing	48" RCP	4.0	135.81	135.81	135.67	135.81	134.83	147.42	283.58	4.42	125.95	125.95	11.7	11.7	-0.98	9.86	2.47

Design Storm 50-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	111.3	111.14	111.3	111	110.94	700.9	67.63	3.73	100.5	100.5	11.48	12.63	-0.20	10.64	1.33
Micheal Scott Drive #2	8' x 8' RCBC	8.0	111.3	111.14	111.13	111.3	110.94	704.47	67.63	3.73	100.23	100.23	11.01	13.06	-0.20	10.91	1.36
Woodstock Road #1	10' x 6' RCBC	6.0	115.81	115.52	116.62	115.79	115.2	542.64	186.94	2.15	107.25	107.25	10.85	10.85	-0.32	8.27	1.38
Woodstock Road #2	10' x 6' RCBC	6.0	115.81	115.52	115.9	115.82	115.2	492.41	186.94	2.15	107.25	107.25	9.9	9.9	-0.32	8.27	1.38
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.74	118.36	116.13	118.73	117.31	257.7	574.08	0.97	111.28	111.28	7.2	7.2	-1.05	7.08	1.77
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.74	118.36	116.09	118.76	117.31	260.21	574.08	0.97	111.18	111.18	7.2	7.2	-1.05	7.18	1.80
East Railroad Crossing	48" RCP	4.0	135.89	135.89	135.84	135.89	134.83	146.39	366.61	4.36	125.95	125.95	11.7	11.7	-1.06	9.94	2.49

Design Storm 100-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	111.69	111.49	111.68	111.18	110.94	718.05	210.62	3.88	100.5	100.5	11.52	12.58	-0.55	10.99	1.37
Micheal Scott Drive #2	8' x 8' RCBC	8.0	111.69	111.49	111.71	111.69	110.94	735.33	210.62	3.88	100.23	100.23	11.49	13.24	-0.55	11.26	1.41
Woodstock Road #1	10' x 6' RCBC	6.0	116.06	115.74	116.56	116.06	115.2	538.13	336.76	2.07	107.25	107.25	10.76	10.76	-0.54	8.49	1.42
Woodstock Road #2	10' x 6' RCBC	6.0	116.06	115.74	115.83	116.07	115.2	487.11	336.76	2.07	107.25	107.25	9.7	9.7	-0.54	8.49	1.42
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.94	118.51	116.2	118.93	117.31	260.58	691.46	0.95	111.28	111.28	7.2	7.2	-1.20	7.23	1.81
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.94	118.51	116.16	118.95	117.31	262.96	691.46	0.95	111.18	111.18	7.3	7.3	-1.20	7.33	1.83
East Railroad Crossing	48" RCP	4.0	136	135.99	135.91	136	134.83	147.02	426.14	4.39	125.95	125.95	11.7	11.7	-1.16	10.04	2.51

Sufficiency Evaluation (City of Rocky Mount Stormwater Design Manual)

- Residential Local and Collector Roadways – 25-year design storm with 1 foot of freeboard.
- Commercial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Industrial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Minor and Major Arterial Roadways – 50-year design storm with 0.5 foot of freeboard.
- HW/D (headwater depth to culvert depth) < 1.2.

Project: Maple Creek Tributary #2, Rocky Mount, NC

Prepared by: EVH

Checked by: JPK

Date: April 10, 2012

**Data for Sufficiency Evaluation is output from HEC-RAS.*

Sufficiency Evaluation - Alternative #2 Woodstock Road Culvert Replacement without Upstream Detention

Does not meet design criteria

Design Storm 2-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	107.11	106.85	106.19	107.11	110.94	305.23		0.89	100.5	100.5	6.8	7.0	4.09	6.35	0.79
Micheal Scott Drive #2	8' x 8' RCBC	8.0	107.11	106.85	105.82	107.11	110.94	295.77		0.89	100.23	100.23	6.2	7.0	4.09	6.62	0.83
Woodstock Road #1	10' x 6' RCBC	6.0	112.69	112.29	112.64	112.68	115.2	257.12		0.65	107.25	107.25	7.8	7.1	2.91	5.04	0.84
Woodstock Road #2	10' x 6' RCBC	6.0	112.69	112.29	112.33	112.7	115.2	230.88		0.65	107.25	107.25	6.9	6.4	2.91	5.04	0.84
Ketch Point Drive #1	9' x 4' RCBC	4.0	117.04	116.87	115.52	117.03	117.31	216.49		0.79	111.28	111.28	6.0	6.0	0.44	5.59	1.40
Ketch Point Drive #2	9' x 4' RCBC	4.0	117.04	116.87	115.46	117.06	117.31	219.51		0.79	111.18	111.18	6.1	6.1	0.44	5.69	1.42
East Railroad Crossing	48" RCP	4.0	135.29	135.29	135.14	135.29	134.83	149.42	64.55	4.54	125.95	125.95	11.9	11.9	-0.46	9.34	2.34

Design Storm 10-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	109.25	108.86	108.72	109.24	110.94	519.82		2.07	100.5	100.5	9.72	10.27	2.08	8.36	1.05
Micheal Scott Drive #2	8' x 8' RCBC	8.0	109.25	108.86	108.34	109.25	110.94	508.18		2.07	100.23	100.23	8.79	10.35	2.08	8.63	1.08
Woodstock Road #1	10' x 6' RCBC	6.0	114.69	114.22	114.69	114.3	115.2	419.12		1.71	107.25	107.25	10.26	9.29	0.98	6.97	1.16
Woodstock Road #2	10' x 6' RCBC	6.0	114.69	114.22	114.52	114.69	115.2	410.88		1.71	107.25	107.25	9.99	9.1	0.98	6.97	1.16
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.11	117.88	116.07	118.1	117.31	255.24	224.59	1.09	111.28	111.28	7.1	7.1	-0.57	6.60	1.65
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.11	117.88	116.01	118.12	117.31	257.17	224.59	1.09	111.18	111.18	7.1	7.1	-0.57	6.70	1.68
East Railroad Crossing	48" RCP	4.0	135.65	135.65	135.54	135.65	134.83	147.89	199.11	4.45	125.95	125.95	11.8	11.8	-0.82	9.70	2.43

Design Storm 25-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	110.59	110.15	110.43	110.59	110.94	659.05		2.95	100.5	100.5	11.18	12.24	0.79	9.65	1.21
Micheal Scott Drive #2	8' x 8' RCBC	8.0	110.59	110.15	109.9	110.6	110.94	644.95		2.95	100.23	100.23	10.08	12.33	0.79	9.92	1.24
Woodstock Road #1	10' x 6' RCBC	6.0	115.47	115.21	115.47	114.73	115.2	459.43	51.01	2.2	107.25	107.25	9.74	9.19	-0.01	7.96	1.33
Woodstock Road #2	10' x 6' RCBC	6.0	115.47	115.21	115.47	115.18	115.2	459.43	51.01	2.2	107.25	107.25	9.7	9.2	-0.01	7.96	1.33
Ketch Point Drive #1	9' x 4' RCBC	4.0	118.5	118.19	116.13	118.49	117.31	257.71	413.84	1.05	111.28	111.28	7.2	7.2	-0.88	6.91	1.73
Ketch Point Drive #2	9' x 4' RCBC	4.0	118.5	118.19	116.1	118.52	117.31	260.45	413.84	1.05	111.18	111.18	7.2	7.2	-0.88	7.01	1.75
East Railroad Crossing	48" RCP	4.0	135.81	135.81	135.67	135.81	134.83	147.42	283.58	4.42	125.95	125.95	11.7	11.7	-0.98	9.86	2.47

Design Storm 50-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	111.92	111.7	111.9	111.31	110.94	730.86	316.23	3.98	100.5	100.5	11.56	12.59	-0.76	11.20	1.40
Micheal Scott Drive #2	8' x 8' RCBC	8.0	111.92	111.7	111.94	111.93	110.94	753.9	316.23	3.98	100.23	100.23	11.78	13.33	-0.76	11.47	1.43
Woodstock Road #1	10' x 6' RCBC	6.0	116.28	115.95	116.48	116.27	115.2	532.85	491.45	2.01	107.25	107.25	10.66	10.66	-0.75	8.70	1.45
Woodstock Road #2	10' x 6' RCBC	6.0	116.28	115.95	115.77	116.29	115.2	482.7	491.45	2.01	107.25	107.25	9.7	9.7	-0.75	8.70	1.45
Ketch Point Drive #1	9' x 4' RCBC	4.0	119.13	118.61	116.15	119.12	117.31	258.5	848.76	0.84	111.28	111.28	7.2	7.2	-1.30	7.33	1.83
Ketch Point Drive #2	9' x 4' RCBC	4.0	119.13	118.61	116.1	119.14	117.31	260.74	848.76	0.84	111.18	111.18	7.2	7.2	-1.30	7.43	1.86
East Railroad Crossing	48" RCP	4.0	135.89	135.89	135.84	135.89	134.83	146.39	366.61	4.36	125.95	125.95	11.7	11.7	-1.06	9.94	2.49

Design Storm 100-Year Flood

Crossing	Culvert Size	Culvert Height (ft)	EG U/S (ft)	WSEL (ft)	EG IC (ft)	EG OC (ft)	Min Weir Elevation (ft)	Q Culvert (cfs)	Q Weir (cfs)	Delta WS (cfs)	Culvert Inv. U/S (ft)	Culvert Inv. D/S (ft)	Culvert Vel U/S (ft/s)	Culvert Vel D/S (ft/s)	Freeboard (ft)	U/S Head	HW/D
Micheal Scott Drive #1	8' x 8' RCBC	8.0	112.33	112.11	112.5	111.83	110.94	777.51	465.99	4.21	100.5	100.5	12.15	17.47	-1.17	11.61	1.45
Micheal Scott Drive #2	8' x 8' RCBC	8.0	112.33	112.11	112.16	112.16	110.94	770.96	465.99	4.21	100.23	100.23	12.05	13.31	-1.17	11.88	1.49
Woodstock Road #1	10' x 6' RCBC	6.0	116.54	116.19	116.33	116.53	115.2	522.76	695.05	1.91	107.25	107.25	10.46	10.46	-0.99	8.94	1.49
Woodstock Road #2	10' x 6' RCBC	6.0	116.54	116.19	115.66	116.55	115.2	474.2	695.05	1.91	107.25	107.25	9.5	9.5	-0.99	8.94	1.49
Ketch Point Drive #1	9' x 4' RCBC	4.0	119.31	118.68	116.06	119.3	117.31	254.9	1021.09	0.7	111.28	111.28	7.1	7.1	-1.37	7.40	1.85
Ketch Point Drive #2	9' x 4' RCBC	4.0	119.31	118.68	116.01	119.32	117.31	257.01	1021.09	0.7	111.18	111.18	7.1	7.1	-1.37	7.50	1.88
East Railroad Crossing	48" RCP	4.0	136	135.99	135.91	136	134.83	147.02	426.14	4.39	125.95	125.95	11.7	11.7	-1.16	10.04	2.51

Sufficiency Evaluation (City of Rocky Mount Stormwater Design Manual)

- Residential Local and Collector Roadways – 25-year design storm with 1 foot of freeboard.
- Commercial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Industrial Local and Collector Roadways – 50-year design storm with 0.5 foot of freeboard.
- Minor and Major Arterial Roadways – 50-year design storm with 0.5 foot of freeboard.
- HW/D (headwater depth to culvert depth) < 1.2.

Appendix F:
Hydraflow Storm Sewer Output

List of Contents:

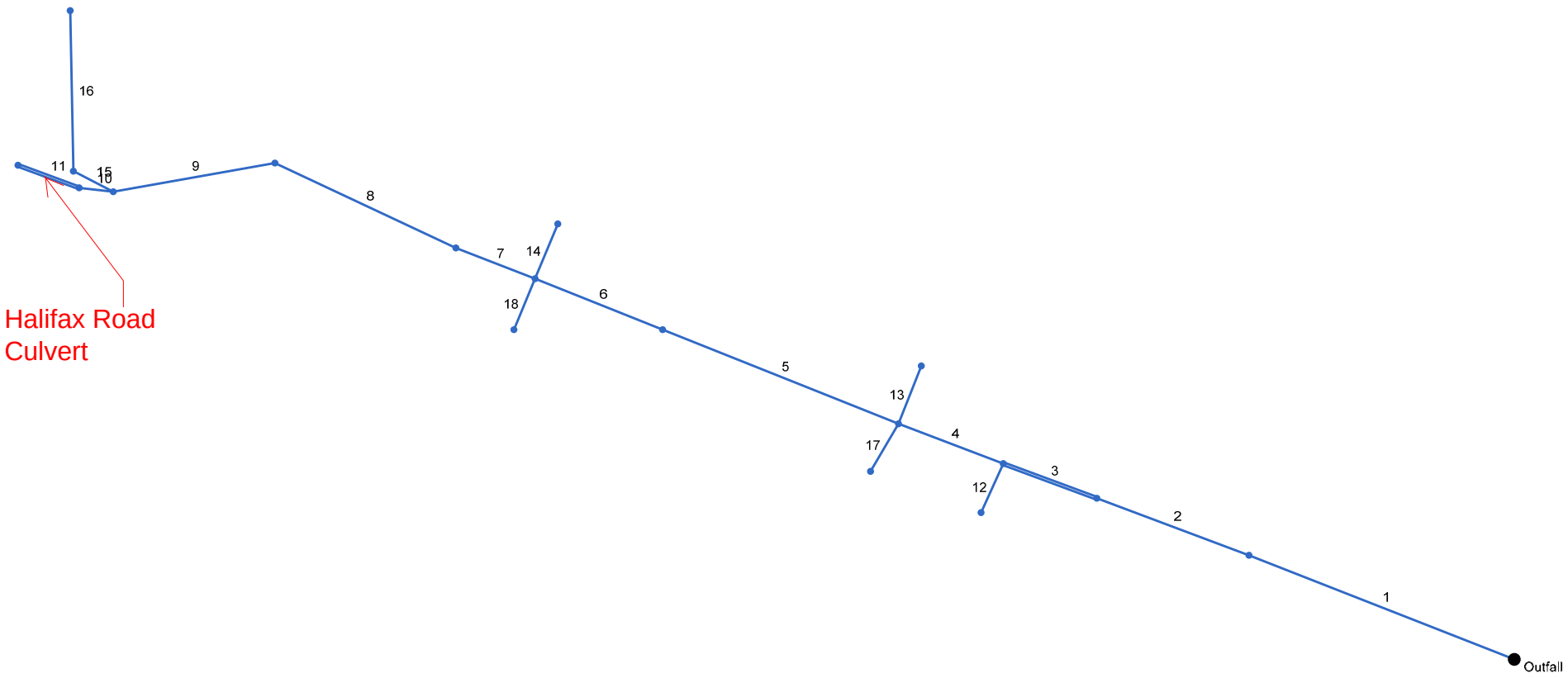
MAPLE CREEK TRIBUTARY #2

DRAINAGE BASIN STUDY

SECONDARY SYSTEM ANALYSIS: SOUTH HALIFAX ROAD – KINGSWOOD DRIVE

EXISTING CONDITIONS

Hydraflow Storm Sewers Extension for AutoCAD® Civil 3D® 2011 Plan



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2012

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Pipe_1	374.3	42	Cir	247.0	120.00	120.86	0.348	123.50*	157.71*	n/a	183.83 i	End	Manhole
2	Channel_1	374.3	48x96	Box	140.8	120.86	121.35	0.348	183.83*	183.83*	n/a	184.14	1	Manhole
3	Pipe_3	374.3	42	Cir(2b)	86.4	121.35	121.65	0.347	184.14*	187.14*	5.88	193.02	2	Manhole
4	Channel_4	362.3	48x96	Box	97.1	121.61	121.95	0.350	193.02*	197.73*	1.99	199.72	3	Manhole
5	Pipe_1	334.2	42	Cir	220.0	121.95	122.72	0.350	199.72*	224.01*	2.81	226.83	4	Manhole
6	Channel_6	334.2	48x96	Box	119.1	122.72	123.14	0.353	226.83*	231.73*	1.70	233.43	5	Manhole
7	Pipe_7	298.1	42	Cir	73.5	123.14	123.40	0.354	233.43*	239.89*	2.24	242.13	6	Manhole
8	Channel_8	298.1	48x96	Box	173.3	123.40	124.01	0.352	242.13*	247.82*	0.85	248.67	7	Manhole
9	Pipe_9	298.1	42	Cir	142.2	124.07	123.71	-0.253	248.67*	291.23*	9.85	301.08	8	Manhole
10	Channel_10	294.1	48x96	Box	29.7	123.71	125.09	4.648	301.08*	302.03*	0.37	302.40	9	Manhole
11	Pipe_11	294.1	42	Cir(2b)	56.5	125.09	124.72	-0.655	302.40*	303.61*	3.63	307.24	10	Manhole
12	Pipe_12	12.00	24	Cir	46.7	122.71	122.78	0.150	193.02*	193.05*	0.23	193.36	3	Manhole
13	Pipe_13	8.00	24	Cir	54.1	122.86	122.94	0.148	199.72*	199.79*	0.10	199.89	4	Manhole
14	Pipe_14	8.00	24	Cir	51.6	123.37	123.45	0.155	233.43*	233.50*	0.10	233.60	6	Manhole
15	Channel_15	4.00	48x96	Box	38.9	123.71	123.77	0.154	301.08*	301.08*	0.00	301.08	9	Manhole
16	Pipe_16	4.00	24	Cir	139.7	123.77	123.98	0.150	301.08*	301.13*	0.03	301.15	15	Manhole
17	Pipe_17	20.10	24	Cir	48.0	123.19	123.26	0.146	199.72*	200.10*	0.64	200.73	4	Manhole
18	Pipe_18	28.10	24	Cir	47.9	123.46	123.55	0.146	233.43*	234.17*	1.24	235.41	6	Manhole

NOTES: Return period = 2 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control.

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		[illegible]		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	247.0	0.00	0.00	0.00	0.00	0.00	0.0	8.1	0.0	374.3	59.37	38.91	42	0.35	120.00	120.86	123.50	157.71	126.00	128.00	Pipe_1
2	1	140.8	0.00	0.00	0.00	0.00	0.00	0.0	7.9	0.0	374.3	97.11	11.70	48 x 96 b	0.35	120.86	121.35	183.83	183.83	128.00	126.50	Channel_1
3	2	86.4	0.00	0.00	0.00	0.00	0.00	0.0	7.9	0.0	374.3	118.6	19.45	42(2b)	0.35	121.35	121.85	184.14	187.14	126.50	126.50	Pipe_3
4	3	97.1	0.00	0.00	0.00	0.00	0.00	0.0	7.7	0.0	362.3	97.39	11.32	48 x 96 b	0.35	121.61	121.95	193.02	197.73	126.50	127.00	Channel_4
5	4	220.0	0.00	0.00	0.00	0.00	0.00	0.0	7.6	0.0	334.2	59.51	34.74	42	0.35	121.95	122.72	199.72	224.01	127.00	127.50	Pipe_1
6	5	119.1	0.00	0.00	0.00	0.00	0.00	0.0	7.4	0.0	334.2	97.77	10.44	48 x 96 b	0.35	122.72	123.14	226.83	231.73	127.50	127.50	Channel_6
7	6	73.5	0.00	0.00	0.00	0.00	0.00	0.0	7.4	0.0	298.1	59.82	30.99	42	0.35	123.14	123.40	233.43	239.89	127.50	128.00	Pipe_7
8	7	173.3	0.00	0.00	0.00	0.00	0.00	0.0	7.1	0.0	298.1	97.66	9.32	48 x 96 b	0.35	123.40	124.01	242.13	247.82	128.00	129.00	Channel_8
9	8	142.2	0.00	0.00	0.00	0.00	0.00	0.0	7.0	0.0	298.1	0.00	30.99	42	-0.25	124.07	123.71	246.67	291.23	129.00	130.00	Pipe_9
10	9	29.7	0.00	0.00	0.00	0.00	0.00	0.0	0.1	0.0	294.1	354.9	9.19	48 x 96 b	4.65	123.71	125.09	301.08	302.03	130.00	130.00	Channel_10
11	10	56.5	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	294.1	0.00	15.29	42(2b)	-0.65	125.09	124.72	302.40	303.61	130.00	130.00	Pipe_11
12	3	46.7	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	12.00	8.76	3.82	24	0.15	122.71	122.78	193.02	193.15	126.50	128.00	Pipe_12
13	4	54.1	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	8.00	8.70	2.55	24	0.15	122.86	122.94	199.72	199.79	127.00	126.50	Pipe_13
14	6	51.6	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	8.00	8.90	2.55	24	0.15	123.37	123.45	233.43	233.50	127.50	128.00	Pipe_14
15	9	38.9	0.00	0.00	0.00	0.00	0.00	0.0	1.8	0.0	4.00	64.68	0.13	48 x 96 b	0.15	123.71	123.77	301.08	301.08	130.00	130.00	Channel_15
16	15	139.7	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	4.00	8.77	1.27	24	0.15	123.77	123.98	301.08	301.13	130.00	132.00	Pipe_16
17	4	48.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	20.10	8.64	6.40	24	0.15	123.19	123.26	199.72	200.10	127.00	127.50	Pipe_17
18	6	47.9	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	28.10	8.64	8.95	24	0.15	123.48	123.55	233.43	234.17	127.50	127.50	Pipe_18

[illegible] 18 [illegible] 2012

NOTES:Intensity = 74.06 / (Inlet time + 13.30) ^ 0.88 [illegible]

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	42	374.2	120.00	126.35	3.50	9.62	38.90	23.53	149.88	n/a	247 00	120.86	160.54	3.50**	9.62	38.89	23.52	184 06i	n/a	n/a	10.66	0.15	n/a
2	48 96 B	374.2	120.86	183.79	4.00	32.00	11.69	2.13	185.92	5.168	140.79	121.35	183.79	4.00**	32.00	11.69	2.13	185.92	5.168	5.168	7.276	0.15	n/a
3	42(2b)	374.2	121.35	184 11	3.50	19.24	19.45	5.88	189.99	3.460	86.42	121.85	187.10	3.50	19.24	19.45	5.88	192.98	3.459	3.459	2.990	1.00	5.88
4	48 96 B	362.2	121 61	192.98	4.00	32.00	11.32	1.99	194.97	4.842	97.13	121.95	197.89	4.00	32.00	11.32	1.99	199.88	4.842	4.842	4.703	1.00	1.99
5	42	334.1	121.95	199.88	3.50	9.62	34.73	18.76	218 43	11 033	220 05	122.72	223 98	3.50**	9.62	34.73	18.75	242 71	11 028	11 030	24.27	0.15	2.81
6	48 96 B	334.1	122.72	226 77	4.00	32.00	10.44	1.69	228 46	4.120	119.05	123.14	231 67	4.00	32.00	10.44	1.69	233 37	4.120	4.120	4.905	1.00	1.69
7	42	298.0	123.14	233 37	3.50	9.62	30.98	14.92	248 29	8.777	73.54	123.40	239 83	3.50**	9.62	30.97	14.92	254 74	8.774	8.776	6.453	0.15	2.24
8	48 96 B	298.0	123.40	242 07	4.00	32.00	9.31	1.35	243 41	3.278	173.29	124 01	247 74	4.00	32.00	9.31	1.35	249 09	3.278	3.278	5.680	0.63	0.85
9	42	298.0	124.07	248 59	3.50	9.62	30.98	14.92	263 52	29.915	142.20	123 71	291 13	3.50**	9.62	30.97	14.92	306 05	29.904	29.909	42.53	0.66	9.84
10	48 96 B	294.0	123 71	300 98	4.00	32.00	9.19	1.31	302 29	3.190	29.69	125.09	301 92	4.00	32.00	9.19	1.31	303 24	3.190	3.190	0.947	0.28	0.37
11	42(2b)	294.0	125.09	302 29	3.50	19.24	15.28	3.63	305 92	2.136	56.52	124.72	303 50	3.50	19.24	15.28	3.63	307 13	2.135	2.135	1.207	1.00	3.63
12	24	12.00	122 71	192.98	2.00	3.14	3.82	0.23	193 21	0.282	46.71	122.76	193 11	2.00	3.14	3.82	0.23	193.34	0.282	0.282	0.132	1.00	0.23
13	24	8.00	122.86	199.88	2.00	3.14	2.55	0.10	199.78	0.125	54.11	122.94	199.75	2.00	3.14	2.55	0.10	199.85	0.125	0.125	0.068	1.00	0.10
14	24	8.00	123.37	233 37	2.00	3.14	2.55	0.10	233 47	0.125	51.62	123.45	233 43	2.00	3.14	2.55	0.10	233 53	0.125	0.125	0.065	1.00	0.10
15	48 96 B	4.00	123 71	300 98	4.00	32.00	0.13	0.00	300 98	0.001	38.86	123.77	300 98	4.00	32.00	0.13	0.00	300 98	0.001	0.001	0.000	0.90	0.00
16	24	4.00	123.77	300 98	2.00	3.14	1.27	0.03	301 00	0.031	139.85	123.98	301 02	2.00	3.14	1.27	0.03	301 05	0.031	0.031	0.044	1.00	0.03
17	24	20.10	123.19	199.88	2.00	3.14	6.40	0.64	200 31	0.790	47.96	123.26	200 08	2.00	3.14	6.40	0.64	200 69	0.790	0.790	0.379	1.00	0.64
18	24	28.10	123.48	233 37	2.00	3.14	8.95	1.24	234 61	1.544	47.92	123.55	234 11	2.00	3.14	8.94	1.24	235 35	1.544	1.544	0.740	1.00	1.24

Hydraflow HGL Computation Procedure

Hydraflow computes the HGL using the Bernoulli energy equation. Manning's equation is used to determine energy losses due to pipe friction. In a standard step, iterative procedure, Hydraflow assumes upstream HGLs until the energy equation balances. If the energy equation cannot balance, supercritical flow exists and critical depth is temporarily assumed at the upstream end. A supercritical flow Profile is then computed using the same procedure in a downstream direction using momentum principles.The computed HGL is checked against inlet control.

Col. 1 The line number being computed. Calculations begin at Line 1 and proceed upstream.

Col. 2 The line size. In the case of non-circular pipes, the line rise is printed above the span.

Col. 4 The elevation of the downs

Col. 5 Elevation of the hydraulic grade line at the downstream end. This is computed as the upstream HGL + Minor loss of this line's downstream line.

Col. 6 The downstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size.

Col. 7 Cross-sectional area of the flow at the downstream end.

Col. 8 The velocity of the flow at the downstream end, (Col. 3 / Col. 7).

Col. 9 Velocity head (Velocity

Col. 10 The elevation of the energy grade line at the downstream end, HGL + Velocity head, (Col. 5 + Col. 9).

Col. 11 The friction slope at the downstream end (the S or Slope term in Manning's equation).

Col. 13 The elevation of the up

Col. 14 Elevation of the hydraulic grade line at the upstream end.

Col. 15 The upstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size.

Col. 16 Cross-sectional area of the flow at the upstream end.

Col. 17 The velocity of the flow at the upstream end, (Col. 3 / Col. 16).

Col. 18 Velocity head (Velocity

Col. 19 The elevation of the energy grade line at the upstream end, HGL + Velocity head, (Col. 14 + Col. 18) .

Col. 20 The friction slope at the upstream end (the S or Slope term in Manning's equation).

Col. 21 The average of the downstream and upstream friction slopes.

Col. 22 Energy loss. Average Sf/100 x Line Length (Col. 21/100 x Col. 12). Equals (EGL upstream - EGL downstream) +/- tolerance.

Col. 23 The junction loss co

Col. 24 Minor loss. (Col. 23 x Col. 18). Is added to upstream HGL and used as the starting HGL for the next upstream line(s).

New Summary

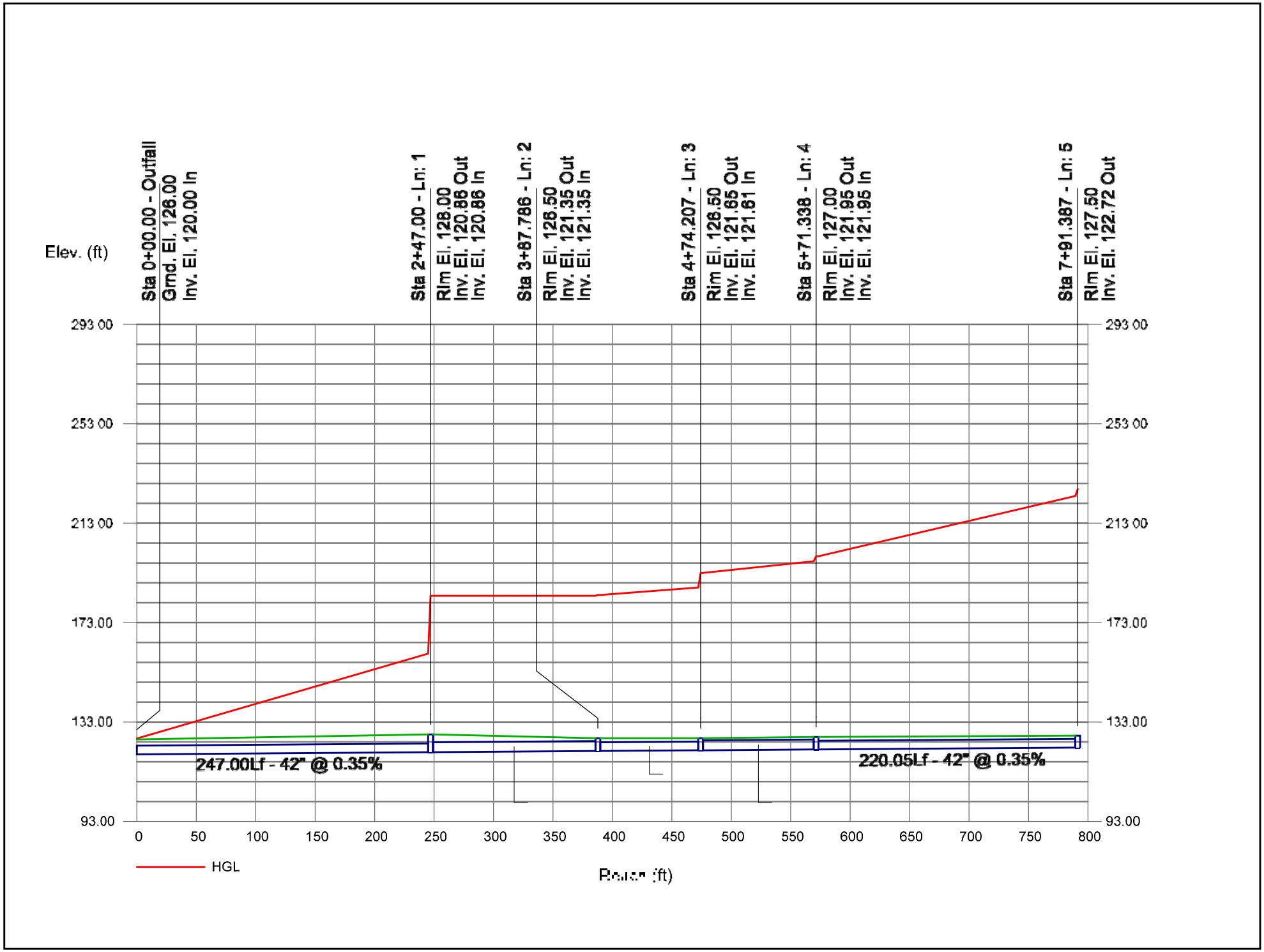
Line No.	DnStm Ln No	Line Length (ft)	Drng Area (ac)	Total Area (ac)	Runoff Coeff (C)	Incr CxA	Total CxA	Inlet Time (min)	Tc (min)	i Inlet (in/hr)	Total Runoff (cfs)	Known Q (cfs)	Flow Rate (cfs)	Capac Full (cfs)	Vel Up (ft/s)	Line Size (in)	Line Slope (%)	Invert Dn (ft)	Invert Up (ft)	HGL Dn (ft)	HGL Up (ft)
1	Outfall	247 00	0.00	0.00	0.00	0.00	0.00	0.0	8.1	0.00	0.00	0.00	374 20	59.37	38.89	42	0.35	120.00	120.86	126.35	160.54
2	1	140.79	0.00	0.00	0.00	0.00	0.00	0.0	7.9	0.00	0.00	0.00	374 20	97.11	11.69	48 x 96	0.35	120.86	121.35	183.79	183.79
3	2	86.42	0.00	0.00	0.00	0.00	0.00	0.0	7.9	0.00	0.00	0.00	374 20	118.55	19.45	42(2b)	0.35	121.35	121.65	184 11	187.10
4	3	97.13	0.00	0.00	0.00	0.00	0.00	0.0	7.7	0.00	0.00	0.00	362 20	97.39	11.32	48 x 96	0.35	121 61	121.95	192.98	197.89
5	4	220 05	0.00	0.00	0.00	0.00	0.00	0.0	7.6	0.00	0.00	0.00	334 10	59.51	34.73	42	0.35	121.95	122.72	199.88	223 98
6	5	119.05	0.00	0.00	0.00	0.00	0.00	0.0	7.4	0.00	0.00	0.00	334 10	97.77	10.44	48 x 96	0.35	122.72	123.14	226 77	231 67
7	6	73.54	0.00	0.00	0.00	0.00	0.00	0.0	7.4	0.00	0.00	0.00	298 00	59.82	30.97	42	0.35	123.14	123.40	233 37	239 83
8	7	173.29	0.00	0.00	0.00	0.00	0.00	0.0	7.1	0.00	0.00	0.00	298 00	97.66	9.31	48 x 96	0.35	123.40	124 01	242 07	247 74
9	8	142.20	0.00	0.00	0.00	0.00	0.00	0.0	7.0	0.00	0.00	0.00	298 00	0.00	30.97	42	-0.25	124.07	123 71	246 59	291 13
10	9	29.69	0.00	0.00	0.00	0.00	0.00	0.0	0.1	0.00	0.00	0.00	294 00	354 86	9.19	48 x 96	4.65	123 71	125.09	300 98	301 92
11	10	56.52	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	294 00	294 00	0.00	15.28	42(2b)	-0.65	125.09	124.72	302 29	303 50
12	3	46.71	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	12.00	12.00	8.76	3.82	24	0.15	122 71	122.76	192.98	193 11
13	4	54.11	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	8.00	8.00	8.70	2.55	24	0.15	122.86	122.94	199.88	199.75
14	6	51.62	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	8.00	8.00	8.90	2.55	24	0.15	123.37	123.45	233 37	233 43
15	9	38.86	0.00	0.00	0.00	0.00	0.00	0.0	1.8	0.00	0.00	0.00	4.00	64.68	0.13	48 x 96	0.15	123 71	123.77	300 98	300 98
16	15	139.85	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	4.00	4.00	8.77	1.27	24	0.15	123.77	123.98	300 98	301 02
17	4	47.96	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	20.10	20.10	8.64	6.40	24	0.15	123.19	123.26	199.88	200 08
18	6	47.92	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	28.10	28.10	8.64	8.94	24	0.15	123.48	123.55	233 37	234 11

NOTES: Intensity = 74.06 / (Inlet time + 13.30) ^ 0.88 – Return period = 2 Yrs. ; i Inlet control; ** Critical depth

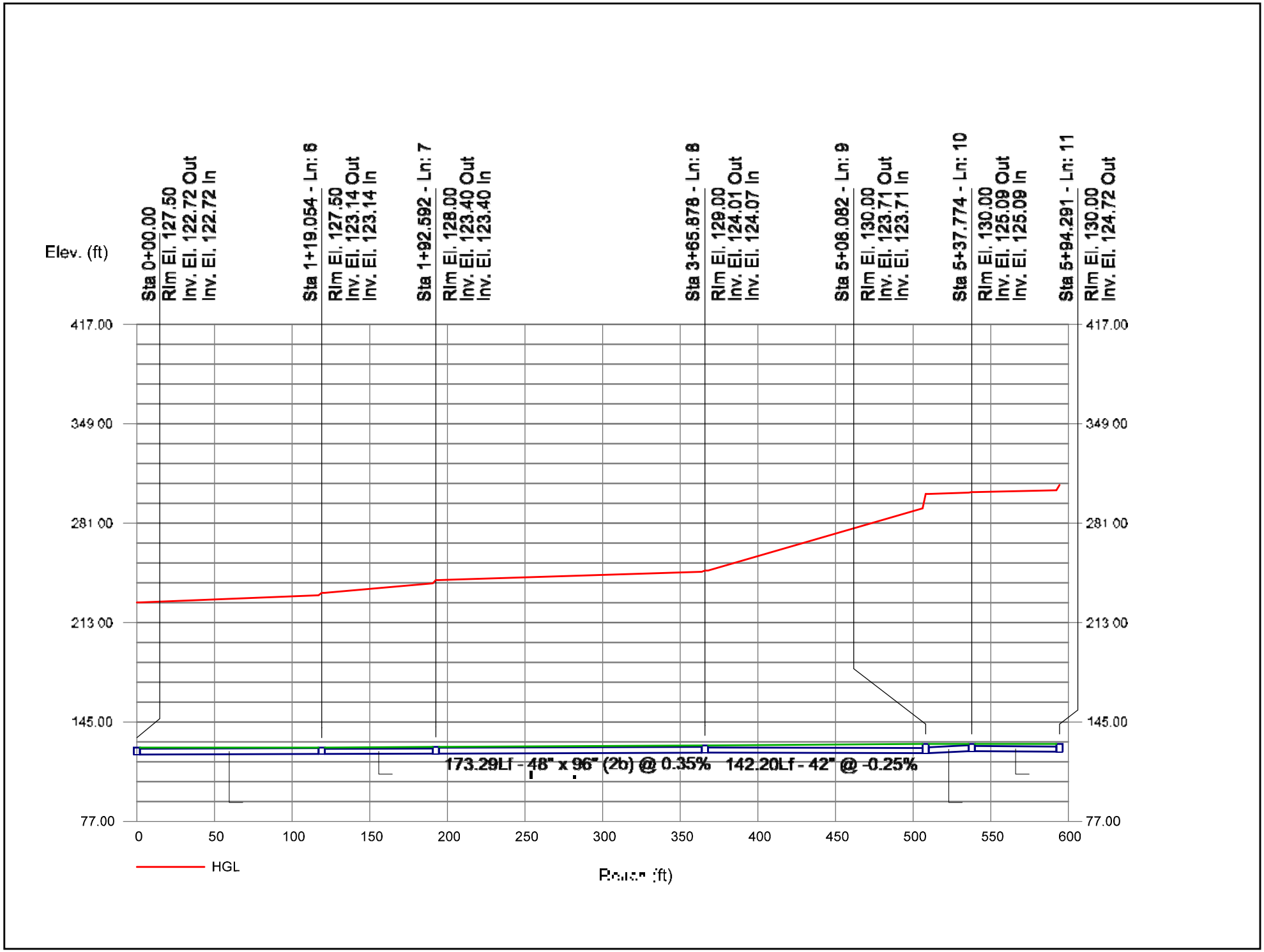
New Summary

Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Line ID	HGL Jnct (ft)
126.00	128.00		183 79 i
128.00	126.50		184 11
126.50	126.50		192.98
126.50	127.00		199.66
127.00	127.50		226 77
127.50	127.50		233 37
127.50	128.00		242 07
128.00	129.00		246 59
129.00	130.00		300 96
130.00	130.00		302 29
130.00	130.00		307 13
126.50	128.00		193.34
127.00	126.50		199.85
127.50	128.00		233 53
130.00	130.00		300 96
130.00	132.00		301 05
127.00	127.50		200 69
127.50	127.50		235 35

Storm Sewer


Sta 0+00.00 - Outfall
Grnd. El. 126.00
Inv. El. 120.00 In
Sta 2+47.00 - Ln: 1
Rim El. 128.00
Inv. El. 120.88 Out
Inv. El. 120.86 In
Sta 3+87.786 - Ln: 2
Rim El. 126.50
Inv. El. 121.35 Out
Inv. El. 121.35 In
Sta 4+74.207 - Ln: 3
Rim El. 126.50
Inv. El. 121.65 Out
Inv. El. 121.61 In
Sta 5+71.338 - Ln: 4
Rim El. 127.00
Inv. El. 121.95 Out
Inv. El. 121.95 In
Sta 7+91.387 - Ln: 5
Rim El. 127.50
Inv. El. 122.72 Out
Elev. (ft)
293.00
253.00
213.00
173.00
133.00
93.00
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
247.00Lf - 42" @ 0.35%
220.05Lf - 42" @ 0.35%
HGL

Storm Sewer


Elev. (ft)
Sta 0+00.00
Rim El. 127.50
Inv. El. 122.72 Out
Inv. El. 122.72 In
Sta 1+19.054 - Ln: 6
Rim El. 127.50
Inv. El. 123.14 Out
Inv. El. 123.14 In
Sta 1+92.592 - Ln: 7
Rim El. 128.00
Inv. El. 123.40 Out
Inv. El. 123.40 In
Sta 3+65.878 - Ln: 8
Rim El. 129.00
Inv. El. 124.01 Out
Inv. El. 124.07 In
Sta 5+08.082 - Ln: 9
Rim El. 130.00
Inv. El. 123.71 Out
Inv. El. 123.71 In
Sta 5+37.774 - Ln: 10
Rim El. 130.00
Inv. El. 125.09 Out
Inv. El. 125.09 In
Sta 5+94.291 - Ln: 11
Rim El. 130.00
Inv. El. 124.72 Out
417.00
349.00
281.00
213.00
145.00
77.00
173.29Lf - 48" x 96" (2b) @ 0.35%
142.20Lf - 42" @ -0.25%
0
50
100
150
200
250
300
350
400
450
500
550
600
HGL

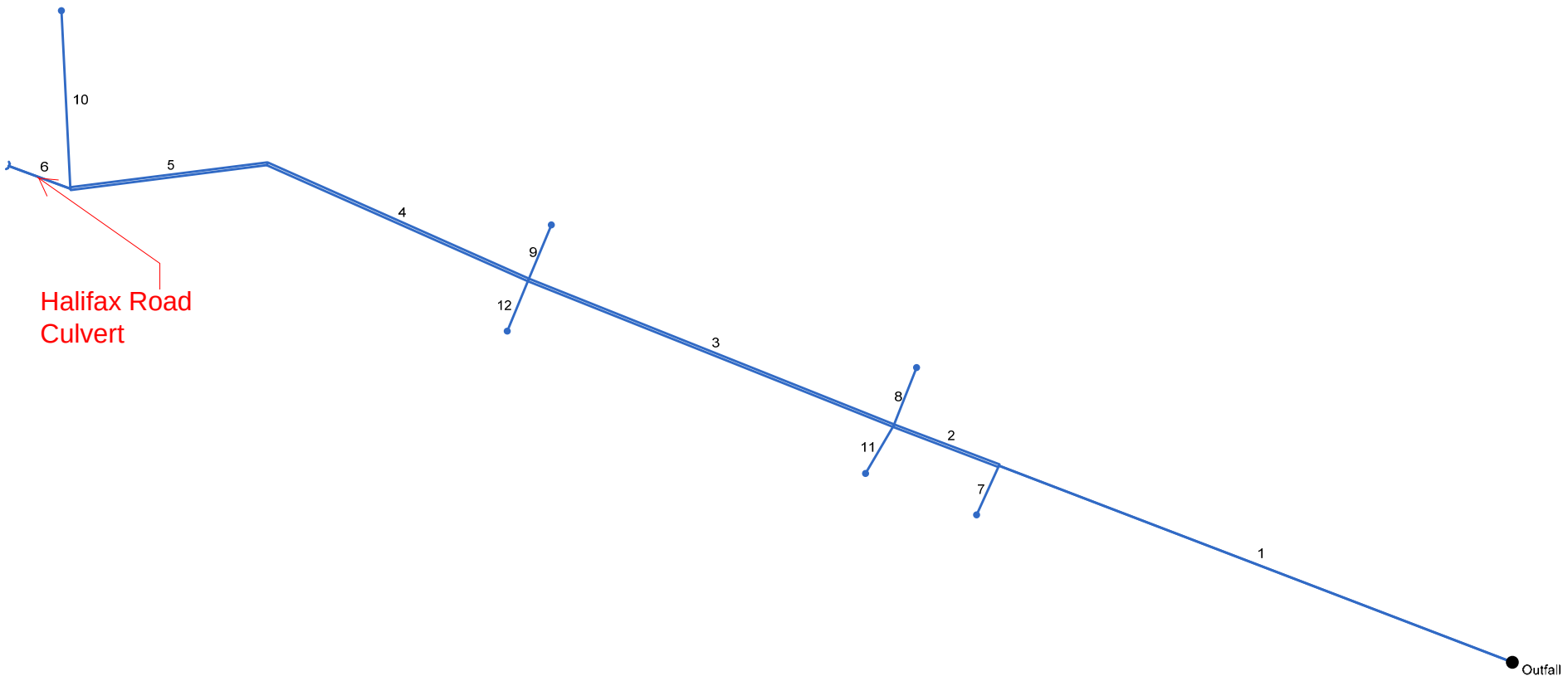
MAPLE CREEK TRIBUTARY #2

DRAINAGE BASIN STUDY

SECONDARY SYSTEM ANALYSIS: SOUTH HALIFAX ROAD – KINGSWOOD DRIVE

CITY DESIGN STANDARD

Hydraflow Storm Sewers Extension for AutoCAD® Civil 3D® 2011 Plan



Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Pipe_1	938.9	72x120	Box(2b)	474.1	119.00	120.99	0.420	123.09	125.08	n/a	125.08	End	None
2	Pipe_2	917.3	72x120	Box(2b)	97.1	120.99	121.40	0.422	125.08	125.42	0.00	125.42	1	None
3	Pipe_3	866.9	72x120	Box(2b)	339.1	121.40	122.82	0.419	125.42	126.69	n/a	126.69 j	2	None
4	Pipe_4	802.2	72x120	Box(2b)	246.7	122.82	123.86	0.422	126.69	127.54	n/a	127.54	3	None
5	Pipe_5	802.2	72x120	Box(2b)	170.9	123.86	124.56	0.421	127.54	128.26	0.92	128.26	4	None
6	Pipe_6	795.0	72x120	Box(2b)	56.5	124.56	124.82	0.425	128.26	128.46	n/a	131.43 i	5	[illegible] all
7	Pipe_7	21.60	24	Cir	46.7	121.37	121.60	0.492	125.08*	125.50*	0.00	125.50	1	Manhole
8	Pipe_8	14.40	24	Cir	54.1	121.86	122.13	0.499	125.42*	125.64*	0.00	125.64	2	Manhole
9	Pipe_9	14.40	24	Cir	51.6	124.79	125.05	0.504	126.69	126.85	n/a	126.90 i	3	Manhole
10	Pipe_10	7.20	24	Cir	154.3	125.64	126.41	0.499	128.26	128.41	0.00	128.41	5	Manhole
11	Pipe_11	36.00	24	Cir	48.0	121.86	122.10	0.500	125.42*	126.64*	n/a	128.41 i	2	Manhole
12	Pipe_12	50.30	24	Cir	47.9	123.56	123.80	0.501	126.69*	129.07*	n/a	135.[illegible]7 i	3	Manhole

[illegible] [illegible] s [illegible]2 [illegible] 2012

NOTES: Return period = 50 Yrs. ; *Surcharged (HGL above crown). ; i - Inlet control. ; j - Line contains hyd. jump.

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		[illegible]		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	474.1	0.00	0.00	0.00	0.00	0.00	0.0	3.2	0.0	938.9	1351.5	11.49	72(2b) x 120 b	0.42	119.00	120.99	123.09	125.08	126.00	128.00	Pipe_1
2	1	97.1	0.00	0.00	0.00	0.00	0.00	0.0	2.9	0.0	917.3	1355.4	11.31	72(2b) x 120 b	0.42	120.99	121.40	125.08	125.42	128.00	126.50	Pipe_2
3	2	339.1	0.00	0.00	0.00	0.00	0.00	0.0	2.2	0.0	866.9	1350.0	10.98	72(2b) x 120 b	0.42	121.40	122.82	125.42	126.89	126.50	127.50	Pipe_3
4	3	246.7	0.00	0.00	0.00	0.00	0.00	0.0	1.5	0.0	802.2	1354.5	10.63	72(2b) x 120 b	0.42	122.82	123.86	126.89	127.54	127.50	128.00	Pipe_4
5	4	170.9	0.00	0.00	0.00	0.00	0.00	0.0	1.1	0.0	802.2	1354.2	10.90	72(2b) x 120 b	0.42	123.86	124.56	127.54	128.26	128.00	130.00	Pipe_5
6	5	56.5	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	795.0	1359.5	10.83	72(2b) x 120 b	0.42	124.56	124.82	128.26	128.46	130.00	132.00	Pipe_6
7	1	46.7	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	21.60	15.87	6.88	24	0.49	121.37	121.60	125.08	125.50	128.00	128.00	Pipe_7
8	2	54.1	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	14.40	15.98	4.58	24	0.50	121.86	122.13	125.42	125.64	126.50	126.50	Pipe_8
9	3	51.6	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	14.40	16.05	4.75	24	0.50	124.79	125.05	126.89	126.85	127.50	127.50	Pipe_9
10	5	154.3	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	7.20	15.98	2.29	24	0.50	125.64	126.41	128.26	128.41	130.00	130.00	Pipe_10
11	2	48.0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	36.00	16.00	11.46	24	0.50	121.86	122.10	125.42	126.64	126.50	126.50	Pipe_11
12	3	47.9	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	50.30	16.01	16.01	24	0.50	123.56	123.80	126.89	129.07	127.50	127.50	Pipe_12

NOTES:Intensity = 137.03 / (Inlet time + 18.60) ^ 0.86

Hydraulic Grade Line Computations

Line	Size	Q	Downstream								Len	Upstream								Check		JL coeff	Minor loss
	(in)	(cfs)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	(ft)	Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)	(K)	(ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
1	72(2b) 120 B	938.9	119.00	123.36	4.38	87.60	10.72	1.79	125.17	0.199	474.12	120.99	125.08 j	4.09**	81.73	11.49	2.05	127.13	0.244	0.221	n/a	0.00	n/a
2	72(2b) 120 B	917.3	120.99	125.06	4.09	81.73	11.22	1.96	127.04	0.233	97.13	121.40	125.42	4.02**	80.47	11.40	2.02	127.44	0.244	0.238	n/a	0.00	0.00
3	72(2b) 120 B	866.9	121.40	125.42	4.02	80.47	10.77	1.80	127.23	0.218	339.10	122.82	126.69 j	3.87**	77.50	11.19	1.95	128.64	0.243	0.231	n/a	0.00	n/a
4	72(2b) 120 B	802.2	122.82	126.69	3.87	77.50	10.35	1.67	128.36	0.208	246.70	123.86	127.54	3.68**	73.60	10.90	1.85	129.39	0.243	0.226	n/a	0.50	n/a
5	72(2b) 120 B	802.2	123.86	127.54	3.68*	73.60	10.90	1.85	129.39	0.243	170.87	124.56	128.26	3.68**	73.60	10.90	1.85	130.11	0.243	0.243	n/a	0.50	0.92
6	72(2b) 120 B	795.0	124.56	128.26	3.68	73.60	10.80	1.81	130.07	n/a	56.52	124.82	128.48 j	3.66**	73.16	10.87	1.84	130.31i	n/a	n/a	n/a	0.30	n/a
7	24	21.60	121.37	125.06	2.00	3.14	6.88	0.74	125.81	0.912	46.71	121.60	125.50	2.00	3.14	6.88	0.73	126.24	0.912	0.912	0.426	0.00	0.00
8	24	14.40	121.86	125.42	2.00	3.14	4.58	0.33	125.75	0.406	54.11	122.13	125.64	2.00	3.14	4.58	0.33	125.97	0.405	0.405	0.219	0.00	0.00
9	24	14.40	124.79	126.69	1.90	3.09	4.66	0.34	127.03	n/a	51.62	125.05	126.85	1.80	2.98	4.83	0.36	127.22i	n/a	n/a	-0.181	0.00	n/a
10	24	7.20	125.64	128.26	2.00	3.14	2.29	0.08	128.34	0.101	154.32	126.41	128.41	2.00	3.14	2.29	0.08	128.49	0.100	0.101	0.155	0.00	0.00
11	24	36.00	121.86	125.42	2.00	3.14	11.46	2.04	127.47	n/a	47.96	122.10	126.64	2.00	3.14	11.46	2.04	128.68i	n/a	n/a	-0.826	0.00	n/a
12	24	50.30	123.56	126.69	2.00	3.14	16.01	3.99	130.68	n/a	47.92	123.80	129.07	2.00	3.14	16.01	3.99	133.05i	n/a	n/a	-1.615	0.00	n/a

Notes: * Normal depth assumed.; ** Critical depth.; j-Line contains hyd. jump.

Hydraflow HGL Computation Procedure

Hydraflow computes the HGL using the Bernoulli energy equation. Manning's equation is used to determine energy losses due to pipe friction. In a standard step, iterative procedure, Hydraflow assumes upstream HGLs until the energy equation balances. If the energy equation cannot balance, supercritical flow exists and critical depth is temporarily assumed at the upstream end. A supercritical flow Profile is then computed using the same procedure in a downstream direction using momentum principles.The computed HGL is checked against inlet control.

Col. 1 The line number being computed. Calculations begin at Line 1 and proceed upstream.

Col. 2 The line size. In the case of non-circular pipes, the line rise is printed above the span.

Col. 4 The elevation of the downs

Col. 5 Elevation of the hydraulic grade line at the downstream end. This is computed as the upstream HGL + Minor loss of this line's downstream line.

Col. 6 The downstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size.

Col. 7 Cross-sectional area of the flow at the downstream end.

Col. 8 The velocity of the flow at the downstream end, (Col. 3 / Col. 7).

Col. 9 Velocity head (Velocity

Col. 10 The elevation of the energy grade line at the downstream end, HGL + Velocity head, (Col. 5 + Col. 9).

Col. 11 The friction slope at the downstream end (the S or Slope term in Manning's equation).

Col. 13 The elevation of the up

Col. 14 Elevation of the hydraulic grade line at the upstream end.

Col. 15 The upstream depth of flow inside the pipe (HGL - Invert elevation) but not greater than the line size.

Col. 16 Cross-sectional area of the flow at the upstream end.

Col. 17 The velocity of the flow at the upstream end, (Col. 3 / Col. 16).

Col. 18 Velocity head (Velocity

Col. 19 The elevation of the energy grade line at the upstream end, HGL + Velocity head, (Col. 14 + Col. 18) .

Col. 20 The friction slope at the upstream end (the S or Slope term in Manning's equation).

Col. 21 The average of the downstream and upstream friction slopes.

Col. 22 Energy loss. Average Sf/100 x Line Length (Col. 21/100 x Col. 12). Equals (EGL upstream - EGL downstream) +/- tolerance.

Col. 23 The junction loss co

Col. 24 Minor loss. (Col. 23 x Col. 18). Is added to upstream HGL and used as the starting HGL for the next upstream line(s).

New Summary

Line No.	DnStm Ln No	Line Length (ft)	Drng Area (ac)	Total Area (ac)	Runoff Coeff (C)	Incr CxA	Total CxA	Inlet Time (min)	Tc (min)	i Inlet (in/hr)	Total Runoff (cfs)	Known Q (cfs)	Flow Rate (cfs)	Capac Full (cfs)	Vel Up (ft/s)	Line Size (in)	Line Slope (%)	Invert Dn (ft)	Invert Up (ft)	HGL Dn (ft)	HGL Up (ft)
1	Outfall	474.12	0.00	0.00	0.00	0.00	0.00	0.0	3.2	0.00	0.00	0.00	938.90	1351.54	11.49	[illegible](2b)	0.42	119.00	120.99	123.36	125.08 j
2	1	97.13	0.00	0.00	0.00	0.00	0.00	0.0	2.9	0.00	0.00	0.00	917.30	1355.39	11.40	[illegible](2b)	0.42	120.99	121.40	125.08	125.42
3	2	339.10	0.00	0.00	0.00	0.00	0.00	0.0	2.2	0.00	0.00	0.00	886.90	1349.96	11.19	[illegible](2b)	0.42	121.40	122.82	125.42	126.69 j
4	3	246.70	0.00	0.00	0.00	0.00	0.00	0.0	1.5	0.00	0.00	0.00	802.20	1354.49	10.90	[illegible](2b)	0.42	122.82	123.86	126.89	127.54
5	4	170.87	0.00	0.00	0.00	0.00	0.00	0.0	1.1	0.00	0.00	0.00	802.20	1354.21	10.90	[illegible](2b)	0.42	123.86	124.56	127.54	128.26
6	5	56.52	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	795.00	795.00	1359.45	10.87	[illegible](2b)	0.42	124.56	124.82	128.26	128.48 j
7	1	46.71	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	21.60	21.60	15.87	6.88	24	0.49	121.37	121.60	125.08	125.50
8	2	54.11	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	14.40	14.40	15.98	4.58	24	0.50	121.86	122.13	125.42	125.84
9	3	51.62	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	14.40	14.40	16.05	4.83	24	0.50	124.79	125.05	126.89	126.85
10	5	154.32	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	7.20	7.20	15.98	2.29	24	0.50	125.84	126.41	128.26	128.41
11	2	47.96	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	36.00	36.00	16.00	11.46	24	0.50	121.86	122.10	125.42	126.84
12	3	47.92	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.00	0.00	50.30	50.30	16.01	16.01	24	0.50	123.56	123.80	126.89	129.07

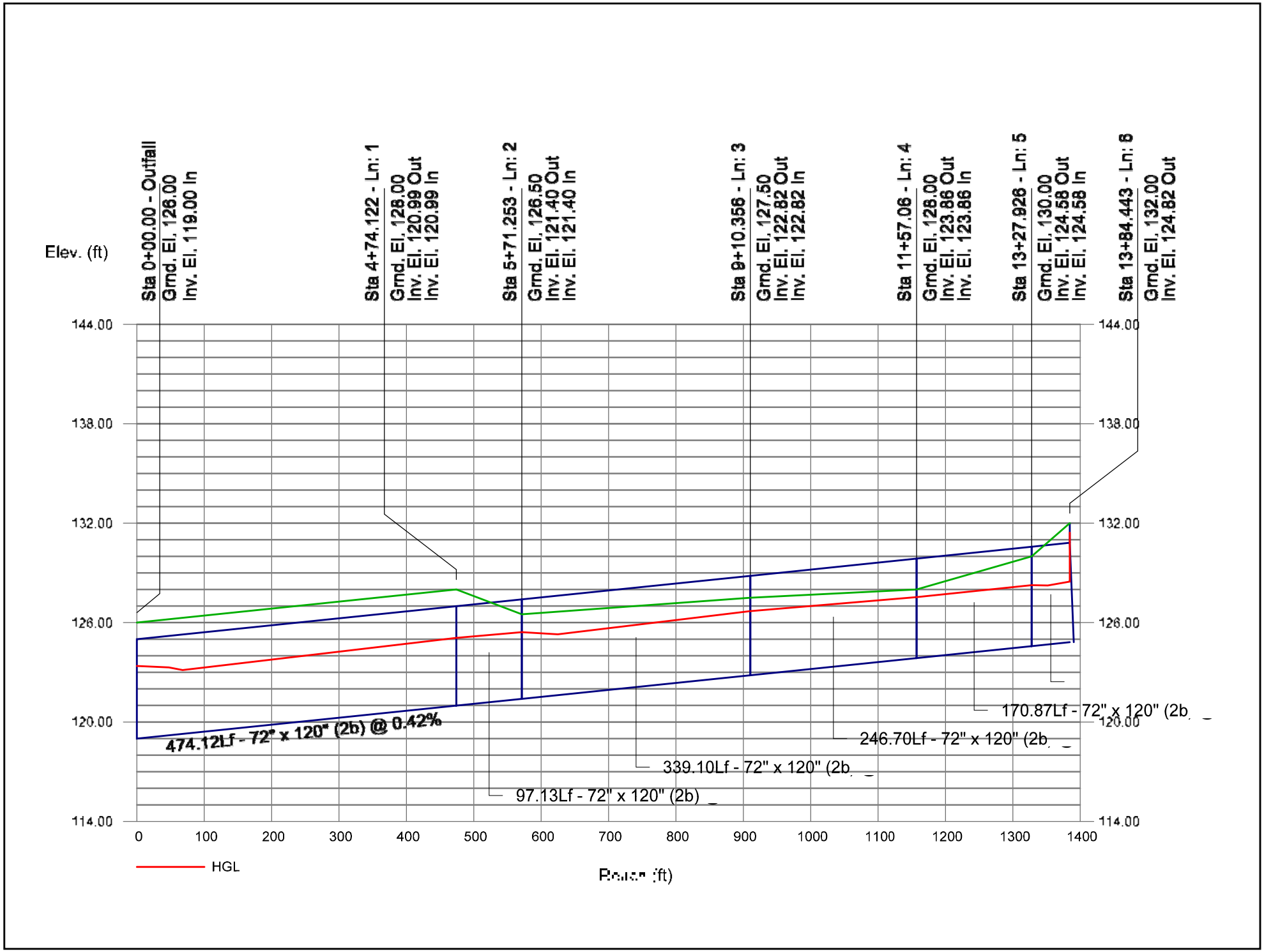
[illegible] [illegible] 2012

NOTES: Intensity = 137.03 / (Inlet time + 18.60) ^ 0.86 -- Return period = 50 Yrs. ; i Inlet control; ** Critical depth

New Summary

Gnd/Rim El Dn (ft)	Gnd/Rim El Up (ft)	Line ID	HGL Jnct (ft)
126.00	128.00		125.08
128.00	126.50		125.42
126.50	127.50		126.69
127.50	128.00		127.54
128.00	130.00		128.26
130.00	132.00		131 43 i
128.00	128.00		125.50
126.50	126.50		125.64
127.50	127.50		126 90 i
130.00	130.00		128 41
126.50	126.50		128 41 i
127.50	127.50		135 ·7 i

Storm Sewer


Elev. (ft)
Sta 0+00.00 - Outfall
Grnd. El. 128.00
Inv. El. 119.00 In
Sta 4+74.122 - Ln: 1
Grnd. El. 128.00
Inv. El. 120.99 Out
Inv. El. 120.99 In
Sta 5+71.253 - Ln: 2
Grnd. El. 126.50
Inv. El. 121.40 Out
Inv. El. 121.40 In
Sta 9+10.356 - Ln: 3
Grnd. El. 127.50
Inv. El. 122.82 Out
Inv. El. 122.82 In
Sta 11+57.06 - Ln: 4
Grnd. El. 128.00
Inv. El. 123.86 Out
Inv. El. 123.86 In
Sta 13+27.926 - Ln: 5
Grnd. El. 130.00
Inv. El. 124.58 Out
Inv. El. 124.58 In
Sta 13+84.443 - Ln: 6
Grnd. El. 132.00
Inv. El. 124.82 Out
144.00
138.00
132.00
126.00
120.00
114.00
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
474.12Lf - 72" x 120" (2b) @ 0.42%
97.13Lf - 72" x 120" (2b)
339.10Lf - 72" x 120" (2b
246.70Lf - 72" x 120" (2b
170.87Lf - 72" x 120" (2b
HGL

Appendix G:
Technical Memorandums

List of Contents:

MEMORANDUM

WK DICKSON
community infrastructure consultants

720 Corporate Center Drive Raleigh, North Carolina 27607 919.782.0495 tel. 919.782.9672 fax

NORTH CAROLINA PROFESSIONAL SEAL 033724 ENGINEER JASON P. KENNEDY

8-14-12

TO: **Blair Hinkle**

FROM: **Jason Kennedy**

DATE: **August 14, 2012**

RE: **Maple Creek Tributary #2 Drainage Basin Study**
Sanitary Sewer Manhole Elevation Analysis
(WKD Project # 20110202.00.RA)

As part of the Maple Creek Tributary #2 Drainage Basin Study, sanitary sewer manholes within the existing floodplain were surveyed and analyzed to determine if their rim elevations were above the floodplain. 17 sanitary sewer manholes were found to have rim elevations below the 100-year Existing Conditions floodplain generated by study water surface elevations (WSEL). It is recommended that each of these manholes have an additional 4-foot section added to provide the necessary rim elevation increase. Additionally, 11 sanitary sewer manholes were found to have rim elevations above the 100-year Existing Conditions floodplain, but do not have the NCDENR-required 2-foot freeboard. It is recommended that each of these manholes also have a 4-foot section added to provide the necessary freeboard, or have a vent pipe installed to vent 2 feet above the 100-year Existing Conditions floodplain.

The following memorandum presents the method for determining the amount of freeboard provided at each manhole, as well as a figure and table with the study results.

Summary of Findings:

Manholes inside Floodplain	*Rim Elevations Collected*	*Rim Elevations below 100-year WSEL.*	*Rims above 100-yr WSEL w/ insufficient Freeboard.*	*Recommended MH to be improved.*
40	33	17	11	28

Methodology

WK Dickson personnel obtained GIS sanitary sewer data from the City of Rocky Mount and used GIS to determine which manholes fell within the 100-year Existing Conditions floodplain, which was modeled as part of the Maple Creek Tributary #2 Drainage Basin Study. Forty (40) manholes met this criteria. Of the forty (40), only seven (7) had rim elevation data. A WK Dickson survey

crew was sent to Rocky Mount to collect rim elevations for the remaining sanitary sewer manholes. The survey data was then incorporated into the existing GIS data.

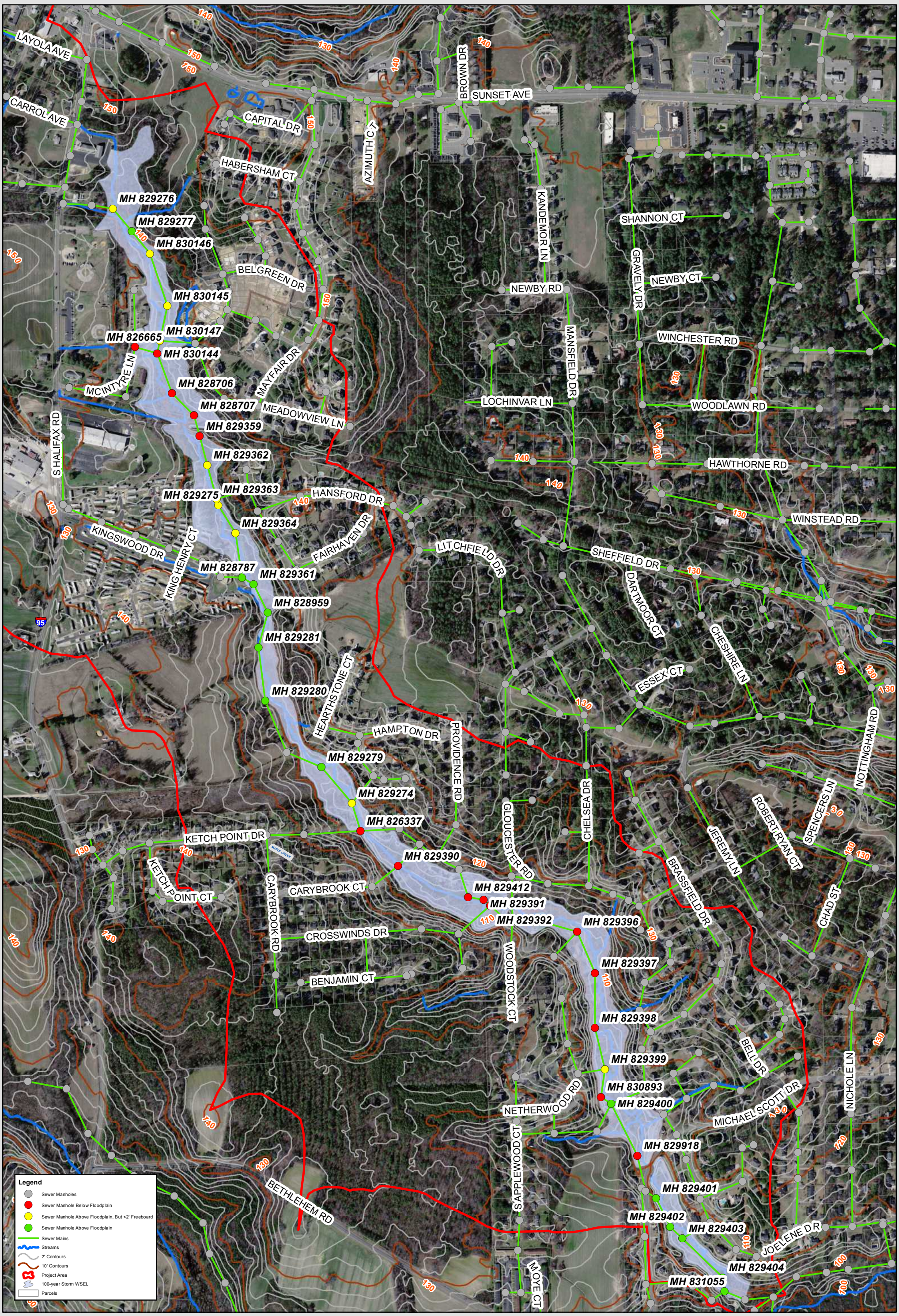
Each sanitary sewer manhole rim elevation was compared to the water surface extent at each location. The water surface was generated using HEC-RAS and AutoCAD Civil 3D, and produced a polygon showing the water surface extent in relation to existing contour data. Twenty-nine (29) of the manholes had a rim elevation far enough above or below the water surface elevation that a suitability determination could be made immediately. The other 11 manholes were close enough to the floodplain elevation that a precise water surface elevation had to be determined from the HEC-RAS model.

The results of this analysis were recorded in two new fields which were added to the GIS sewer data. That data was then compiled into Table 1 which is shown on the following pages. See Figure 1 for the physical locations of the manholes.

Maple Creek Tributary #2 Drainage Basin Study
Table 1 - Sanitary Sewer Manhole Elevations

Manhole ID	Rim Above Floodplain?	Rim Elevation* (ft)	Freeboard** (ft)
826337	No	117.50	-0.23
826665	No	135.43	-0.35
828706	No	134.10	-2.00
828707	No	133.19	-2.00
828787	Yes	128.67	4.00
828959	Yes	127.58	5.00
829274	Yes	119.63	1.11
829275	Yes	127.76	0.60
829276	Yes	142.59	1.00
829277	Yes	142.36	2.00
829279	Yes	122.69	3.00
829280	Yes	126.18	5.00
829281	Yes	125.97	4.00
829359	No	128.70	-3.00
829361	Yes	127.39	3.00
829362	Yes	128.70	0.19
829363	Yes	127.40	0.24
829364	Yes	126.96	0.43
829390	No	115.99	-1.00
829391	No	113.04	-3.00
829392	No	113.28	-3.00
829393	Yes	117.08	1.00
829395	No	111.79	-1.00
829396	No	111.42	-0.61
829397	No	110.38	-1.21
829398	No	109.68	-1.00
829399	No	109.00	-2.00
829400	Yes	111.05	1.00
829401	Yes	108.73	2.00
829402	Yes	109.62	4.00
829403	Yes	109.15	3.00
829404	Yes	107.10	3.00
829412	No	112.73	-3.00
829918	No	109.10	-1.00
830144	No	134.27	-2.00
830145	Yes	136.83	0.76
830146	Yes	140.90	1.00
830147	Yes	135.93	0.08
830893	No	108.32	-2.00
831055	Yes	106.31	2.00

*Rim Elevations were taken from City of Rocky Mount Sanitary Sewer GIS data and supplemented with WKD survey.
**Each freeboard was calculated by one of two methods: (1) Visually approximate the water surface elevation for the 100-Year Existing Conditions storm using the water surface extents generated from HEC-RAS and GIS contour data, then calculate the difference between the rim elevation and the approximated water surface elevation; or (2) Interpolate a water surface elevation at the manhole in HEC-RAS and calculate the difference between the rim elevation and the interpolated water surface elevation. The freeboard measurements in whole numbers were calculated using Method 1, while the decimal measurements were calculated using Method 2.



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0 300 600 1,200
1 inch = 600 feet

Maple Creek Tributary #2
Sewer Manhole Rim Survey Results

N W E S

CITY OF ROCKY MOUNT NORTH CAROLINA

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0 150 300 600
1 inch = 300 feet

Maple Creek Tributary #2
Sewer Manhole Rim Survey Results

N W E S

City of Rocky Mount North Carolina

M E M O R A N D U M

WK DICKSON
community infrastructure consultants

720 Corporate Center Drive Raleigh, North Carolina 27607 919.782.0495 tel. 919.782.9672 fax

NORTH CAROLINA PROFESSIONAL SEAL 035739 ENGINEER EBONY V. HAGANS

08/30/12

TO: **Blair Hinkle**

FROM: **Ebony Hagans**

DATE: **August 30, 2012**

RE: **Maple Creek Tributary #2 Drainage Basin Study**
Summary of Downstream Analysis for Woodstock Culvert Replacement – Task Order #16 (WKD Project # 20110202.00.RA)

The City of Rocky Mount has retained WK Dickson to complete a drainage basin study for the Maple Creek Tributary #2 watershed. One of the roadway crossings evaluated as part of the study is located at Woodstock Road. The existing double 7′ x 4.5′ elliptical corrugated metal pipe (CMP) at this location is only providing a 2-year level of service and is in poor condition. As a result, the City has chosen to replace the culvert at Woodstock Road with a double 10′ x 6′ reinforced concrete box culvert (RCBC).

Increasing the size of the culvert at Woodstock Road from double 7′ x 4.5′ elliptical CMP to double 10′ x 6′ RCBC has the potential to impact downstream properties. Therefore, critical elevations (i.e., living space finished floor, garage/shed finished floor, lowest adjacent grade (LAG), HVAC units, crawl space vent, and deck elevations) were collected for approximately thirty (30) properties to determine the magnitude of these impacts. The locations of the surveyed properties are shown on the attached map (Maple Creek Tributary #2 Water Surface Elevation Index Map).

Scenario 1: Existing Conditions

As part of Scenario 1, the existing flows with the existing Woodstock Road culvert in place were evaluated to determine the current extent and type of flooding being experienced by properties located downstream of the crossing. It was determined that none of the living space finished floor elevations are below the calculated 100-year water surface elevations (WSELs). However, there were seven (7) properties with shed/ out building flooding that were identified, as well as three (3) with crawl space, five (5) with HVAC units, and twelve (12) with LAG flooding. The affected properties are listed in Table 1, along with the current level of service being provided for each respective type of flooding. Detailed maps for each of these identified locations are attached. These maps include the critical surveyed elevations and the 2-, 10-, 25-, 50-, and 100-year WSELs.

Table 1: Existing Conditions Flooding Locations

Address	Level of Service Provided (Year)			
	Shed/Out Building	Crawl Space	HVAC Units	LAG
3900 Gloucester Road (Map #1)	>100	>100	50	2
3904 Gloucester Road (Map #1)	>100	>100	50	>100
3908 Gloucester Road (Map #2)	>100	2	<2	<2
3912 Gloucester Road (Map #2)	2	N/A	>100	25**
5005 Netherwood Road (Map #1)	>100	>100	>100	10
5009 Netherwood Road (Map #2)	2	>100	>100	2**
5013 Netherwood Road (Map #3)	<2	>100	>100	<2**
5021 Netherwood Road (Map #3)	>100	>100	>100	25**
5041 Netherwood Road (Map #4)	10	>100	>100	2**
5049 Netherwood Road (Map #5)	25	>100	>100	2**
2900 Brassfield Drive (Map #8)	10	N/A	>100	50**
2904 Brassfield Drive (Map #8)	10	10	50	2
3000 Brassfield Drive (Map #8)	>100	25	50	25

*Shaded cell indicates flooding occurring in storm events less than the 100-year. **LAG flooding for shed/outbuilding.

Scenario 2: Existing Conditions with Proposed Culvert

As part of Scenario 2, the existing flows with the proposed Woodstock Road culvert were evaluated to determine the immediate impacts to downstream properties. It was determined that the WSELs downstream of Woodstock Road will increase due to the culvert replacement. The increases will be less than 0.05 feet. Under these conditions, there was no new structural flooding created as a result of the culvert replacement. The number and location of properties with shed, out building, crawl space, LAG, and HVAC flooding are identical to those shown in Table 1. The attached maps shows the calculated the 2-, 10-, 25-, 50-, and 100-year WSELs for Scenario 2.

Scenario 3: Future Conditions with Proposed Culvert

The final scenario evaluated was the future condition flows with the proposed Woodstock Road culvert. The future condition flows were developed assuming the watershed is fully built-out to its zoned land uses. Additionally, several attenuation areas were taken into account in the existing conditions scenarios that were removed as part of this scenario. Detailed information about the development of the future condition flows and locations of attenuation areas are contained in the report prepared as part of the Maple Creek Tributary #2 Drainage Basin Study.

As part of this analysis, it was determined that the increases in the WSELs downstream of Woodstock Road will increase much more radically due to the lack of assumed attenuation and future development in the upstream portion of the watershed. Consequently, the number and location of properties experiencing flooding will increase. An additional five (5) properties with shed/ out building flooding were identified, as well as an additional four (4) with crawl space, two (2) with HVAC unit, and five (5) with LAG flooding. The increased WSELs will also reduce the level of service currently being provided thereby increasing the frequency of flooding for residents already experiencing flooding. The affected properties are listed in Table 2, along with the level of service being provided.

The future conditions will gradually be reached. The timeline and extent of future development in the upper portion watershed is unknown. Therefore, it is difficult to state when or if the properties identified in Table 2 will experience the projected extent of flooding.

Table 2: Future Conditions Flooding Locations

Address	Level of Service Provided (Year)			
	Shed/Out Building	Crawl Space	HVAC Units	LAG
Previously Identified Flooding with Reduced Level of Service				
3900 Gloucester Road (Map #1)	>100	25	10	2
3904 Gloucester Road (Map #1)	25	10	10	10
3908 Gloucester Road (Map #2)	10	2	<2	<2
3912 Gloucester Road (Map #2)	2	N/A	>100	25**
5005 Netherwood Road (Map #1)	>100	>100	>100	2
5009 Netherwood Road (Map #2)	2	>100	>100	<2**
5013 Netherwood Road (Map #3)	<2	25	10	<2**
5021 Netherwood Road (Map #3)	25	>100	>100	2**
5041 Netherwood Road (Map #4)	2	>100	>100	2**
5049 Netherwood Road (Map #5)	10	>100	>100	2**
2900 Brassfield Drive (Map #8)	2	N/A	25	10**
2904 Brassfield Drive (Map #8)	2	2	10	2
3000 Brassfield Drive (Map #8)	10	2	10	2
New Flooding Issues				
5025 Netherwood Road	>100	>100	>100	50**
5037 Netherwood Road	>100	>100	>100	25**
5045 Netherwood Road	>100	>100	>100	25**
3004 Brassfield Drive	N/A	25	>100	10
3008 Brassfield Drive	25	>100	>100	>100
3020 Brassfield Drive	>100	>100	>100	25**

*Shaded cell indicates flooding occurring in storm events less than the 100-year. **LAG flooding for shed/out building.

Summary and Conclusions

As previously stated, immediate WSEL increases are projected to occur upon the replacement of the Woodstock Road culvert. These increases are estimated to range from 0.01 to 0.05 feet. The 2- and 100-year WSELs calculated as part of the analysis for Scenarios 1 and 2 were used to generate WSEL mapping. The WSEL maps prepared are attached and illustrate the differences between the two scenarios. There is no new flooding created as a result of the proposed culvert replacement under the existing conditions.

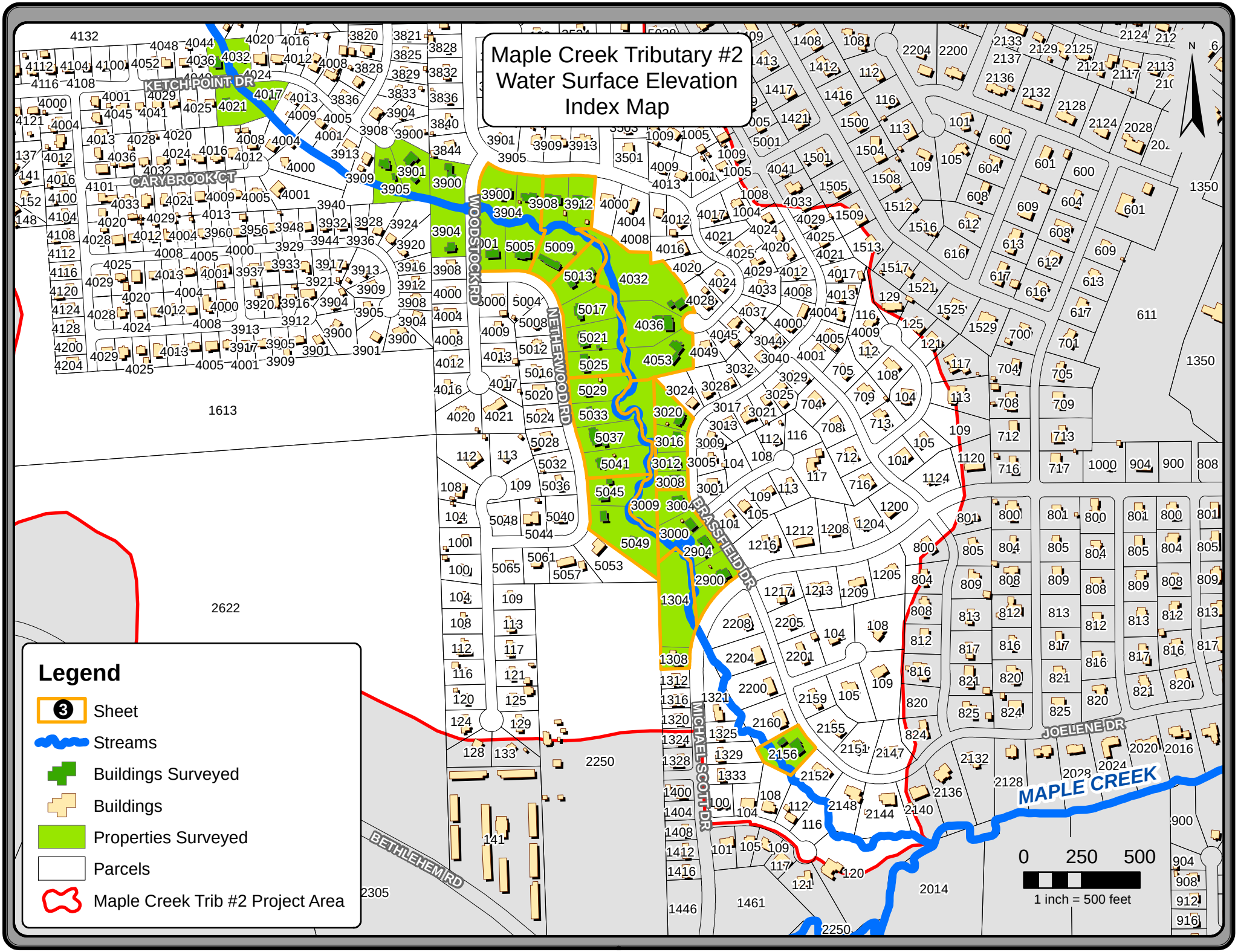
Under the future conditions (Scenario 3), existing flooding will be worsened. Additionally, there will be new flooding issues affecting sheds, out buildings, HVAC units, and crawl spaces. However, these changes are not caused by the proposed culvert replacement. Instead they can be attributed to the lack of assumed attenuation and future development in the upstream portion of the watershed. Findings indicate that no finished floor elevation (FFE) flooding is anticipated in the future conditions.

The findings from this analysis will be incorporated into the final report prepared for the Maple Creek Tributary #2 Drainage Basin Study.

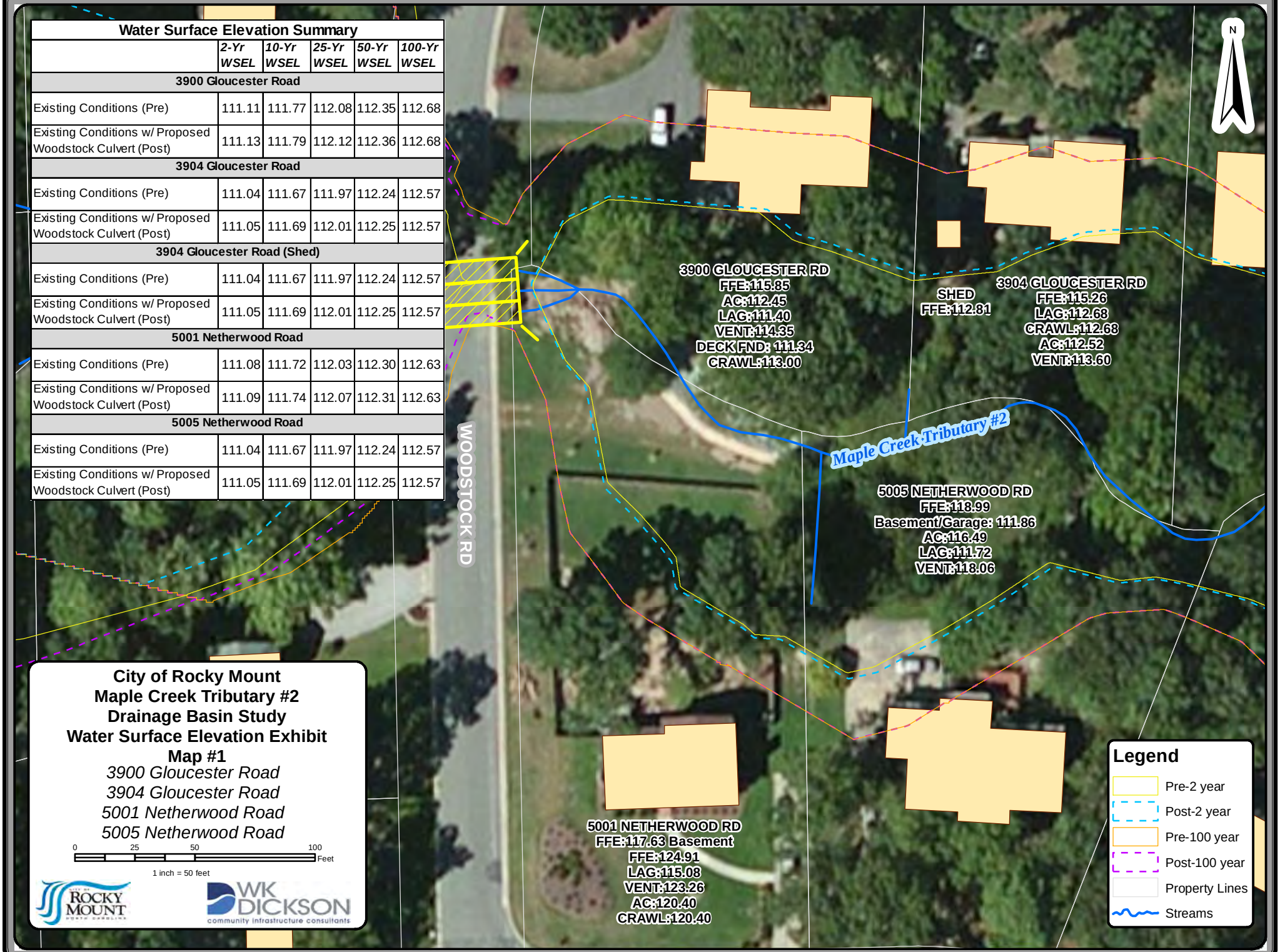
ATTACHMENTS

****ALL ELEVATIONS ON THE MAPS ARE REFERENCED TO NAVD 1988****

Maple Creek Tributary #2 Water Surface Elevation Index Map



Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
3900 Gloucester Road					
Existing Conditions (Pre)	111.11	111.77	112.08	112.35	112.68
Existing Conditions w/ Proposed Woodstock Culvert (Post)	111.13	111.79	112.12	112.36	112.68
3904 Gloucester Road					
Existing Conditions (Pre)	111.04	111.67	111.97	112.24	112.57
Existing Conditions w/ Proposed Woodstock Culvert (Post)	111.05	111.69	112.01	112.25	112.57
3904 Gloucester Road (Shed)					
Existing Conditions (Pre)	111.04	111.67	111.97	112.24	112.57
Existing Conditions w/ Proposed Woodstock Culvert (Post)	111.05	111.69	112.01	112.25	112.57
5001 Netherwood Road					
Existing Conditions (Pre)	111.08	111.72	112.03	112.30	112.63
Existing Conditions w/ Proposed Woodstock Culvert (Post)	111.09	111.74	112.07	112.31	112.63
5005 Netherwood Road					
Existing Conditions (Pre)	111.04	111.67	111.97	112.24	112.57
Existing Conditions w/ Proposed Woodstock Culvert (Post)	111.05	111.69	112.01	112.25	112.57



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #1
3900 Gloucester Road
3904 Gloucester Road
5001 Netherwood Road
5005 Netherwood Road

0 25 50 100 Feet

1 inch = 50 feet

ROCKY MOUNT

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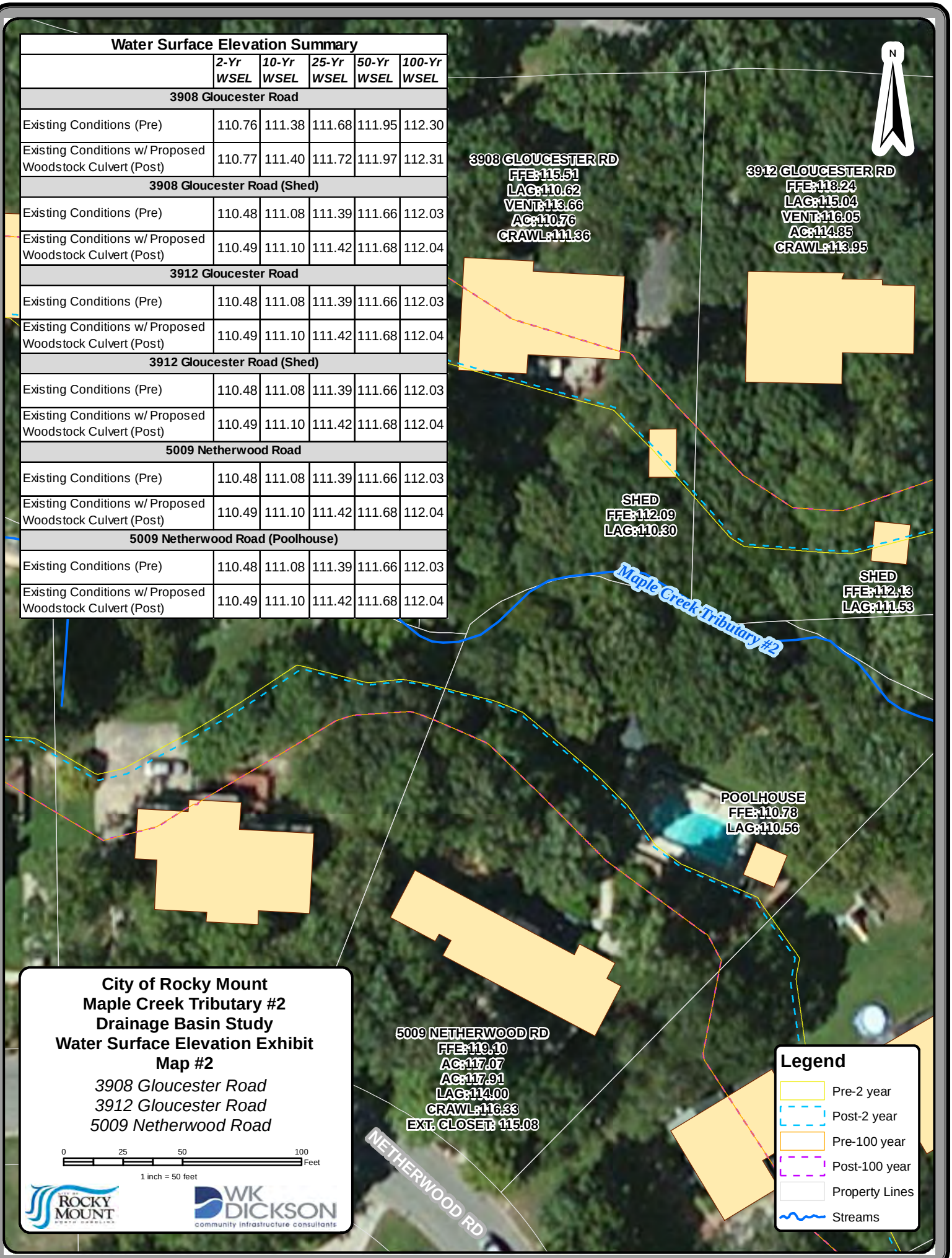
Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
3908 Gloucester Road					
Existing Conditions (Pre)	110.76	111.38	111.68	111.95	112.30
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.77	111.40	111.72	111.97	112.31
3908 Gloucester Road (Shed)					
Existing Conditions (Pre)	110.48	111.08	111.39	111.66	112.03
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.49	111.10	111.42	111.68	112.04
3912 Gloucester Road					
Existing Conditions (Pre)	110.48	111.08	111.39	111.66	112.03
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.49	111.10	111.42	111.68	112.04
3912 Gloucester Road (Shed)					
Existing Conditions (Pre)	110.48	111.08	111.39	111.66	112.03
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.49	111.10	111.42	111.68	112.04
5009 Netherwood Road					
Existing Conditions (Pre)	110.48	111.08	111.39	111.66	112.03
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.49	111.10	111.42	111.68	112.04
5009 Netherwood Road (Poolhouse)					
Existing Conditions (Pre)	110.48	111.08	111.39	111.66	112.03
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.49	111.10	111.42	111.68	112.04



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #2

3908 Gloucester Road
3912 Gloucester Road
5009 Netherwood Road

0 25 50 100 Feet

1 inch = 50 feet

ROCKY MOUNT NORTH CAROLINA

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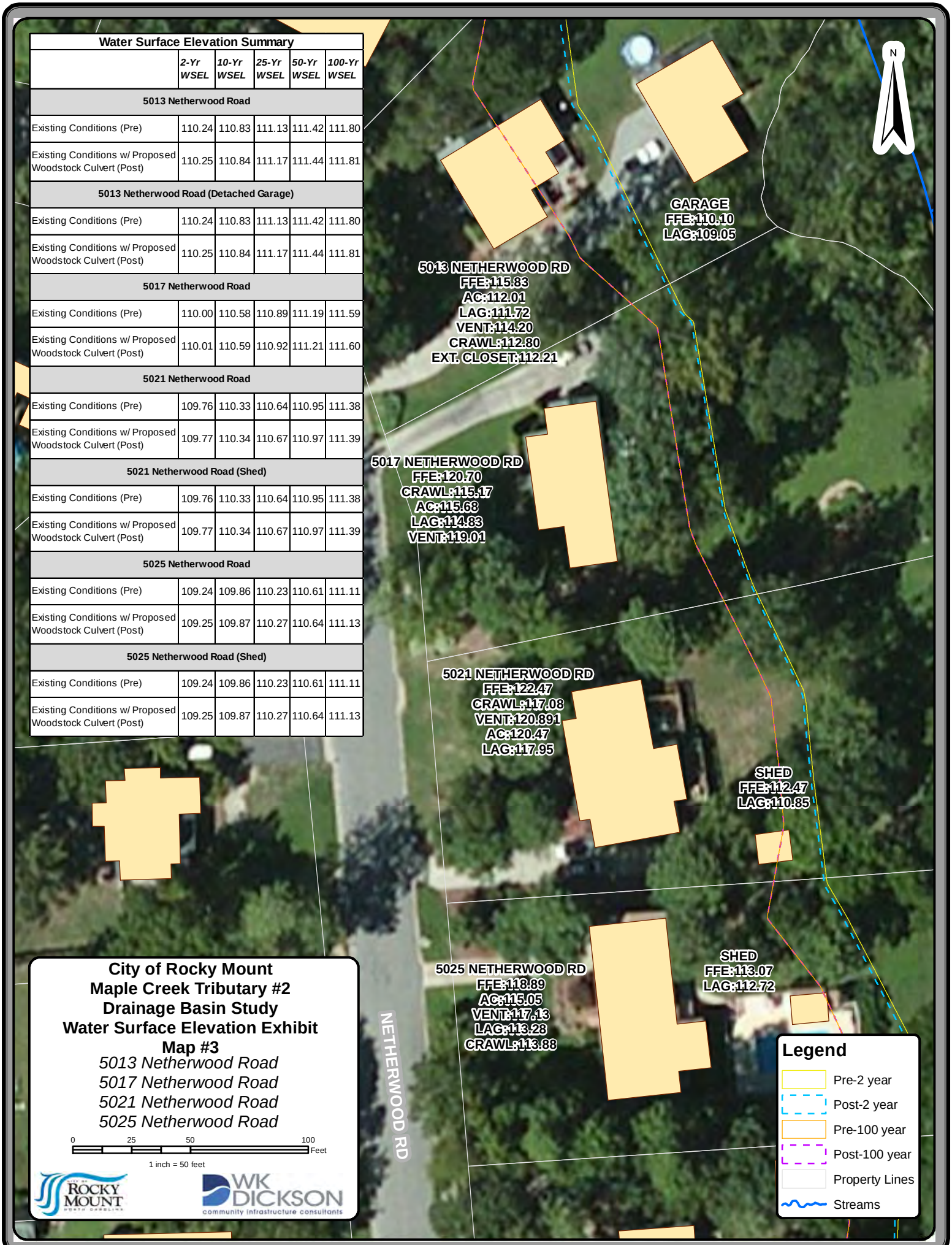
Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
5013 Netherwood Road					
Existing Conditions (Pre)	110.24	110.83	111.13	111.42	111.80
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.25	110.84	111.17	111.44	111.81
5013 Netherwood Road (Detached Garage)					
Existing Conditions (Pre)	110.24	110.83	111.13	111.42	111.80
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.25	110.84	111.17	111.44	111.81
5017 Netherwood Road					
Existing Conditions (Pre)	110.00	110.58	110.89	111.19	111.59
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.01	110.59	110.92	111.21	111.60
5021 Netherwood Road					
Existing Conditions (Pre)	109.76	110.33	110.64	110.95	111.38
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.77	110.34	110.67	110.97	111.39
5021 Netherwood Road (Shed)					
Existing Conditions (Pre)	109.76	110.33	110.64	110.95	111.38
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.77	110.34	110.67	110.97	111.39
5025 Netherwood Road					
Existing Conditions (Pre)	109.24	109.86	110.23	110.61	111.11
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.25	109.87	110.27	110.64	111.13
5025 Netherwood Road (Shed)					
Existing Conditions (Pre)	109.24	109.86	110.23	110.61	111.11
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.25	109.87	110.27	110.64	111.13



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #3

5013 Netherwood Road
5017 Netherwood Road
5021 Netherwood Road
5025 Netherwood Road

0 25 50 100 Feet

1 inch = 50 feet

ROCKY MOUNT

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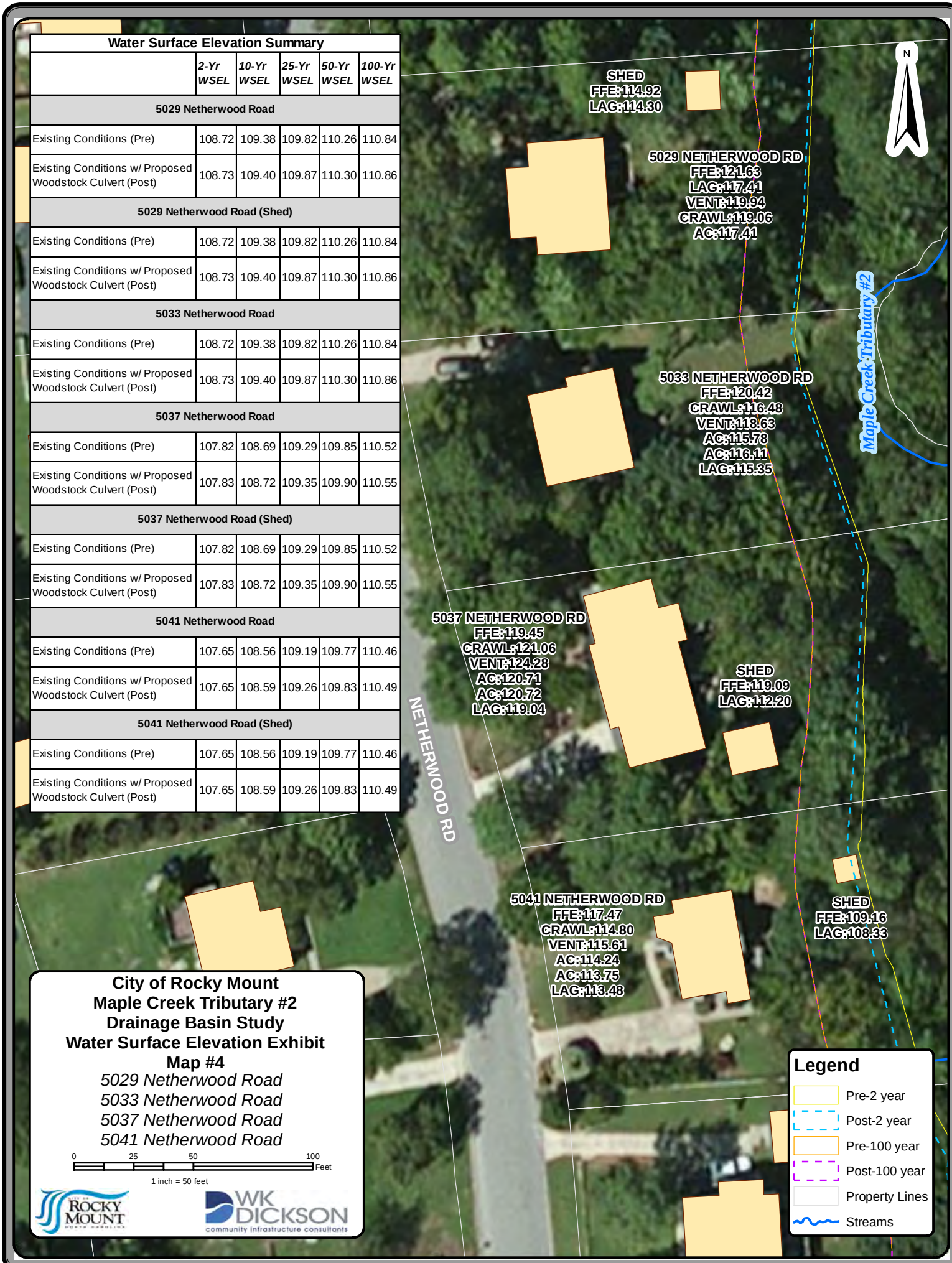
Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
5029 Netherwood Road					
Existing Conditions (Pre)	108.72	109.38	109.82	110.26	110.84
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.73	109.40	109.87	110.30	110.86
5029 Netherwood Road (Shed)					
Existing Conditions (Pre)	108.72	109.38	109.82	110.26	110.84
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.73	109.40	109.87	110.30	110.86
5033 Netherwood Road					
Existing Conditions (Pre)	108.72	109.38	109.82	110.26	110.84
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.73	109.40	109.87	110.30	110.86
5037 Netherwood Road					
Existing Conditions (Pre)	107.82	108.69	109.29	109.85	110.52
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.83	108.72	109.35	109.90	110.55
5037 Netherwood Road (Shed)					
Existing Conditions (Pre)	107.82	108.69	109.29	109.85	110.52
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.83	108.72	109.35	109.90	110.55
5041 Netherwood Road					
Existing Conditions (Pre)	107.65	108.56	109.19	109.77	110.46
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.65	108.59	109.26	109.83	110.49
5041 Netherwood Road (Shed)					
Existing Conditions (Pre)	107.65	108.56	109.19	109.77	110.46
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.65	108.59	109.26	109.83	110.49



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #4

5029 Netherwood Road
5033 Netherwood Road
5037 Netherwood Road
5041 Netherwood Road

0 25 50 100 Feet

1 inch = 50 feet

ROCKY MOUNT

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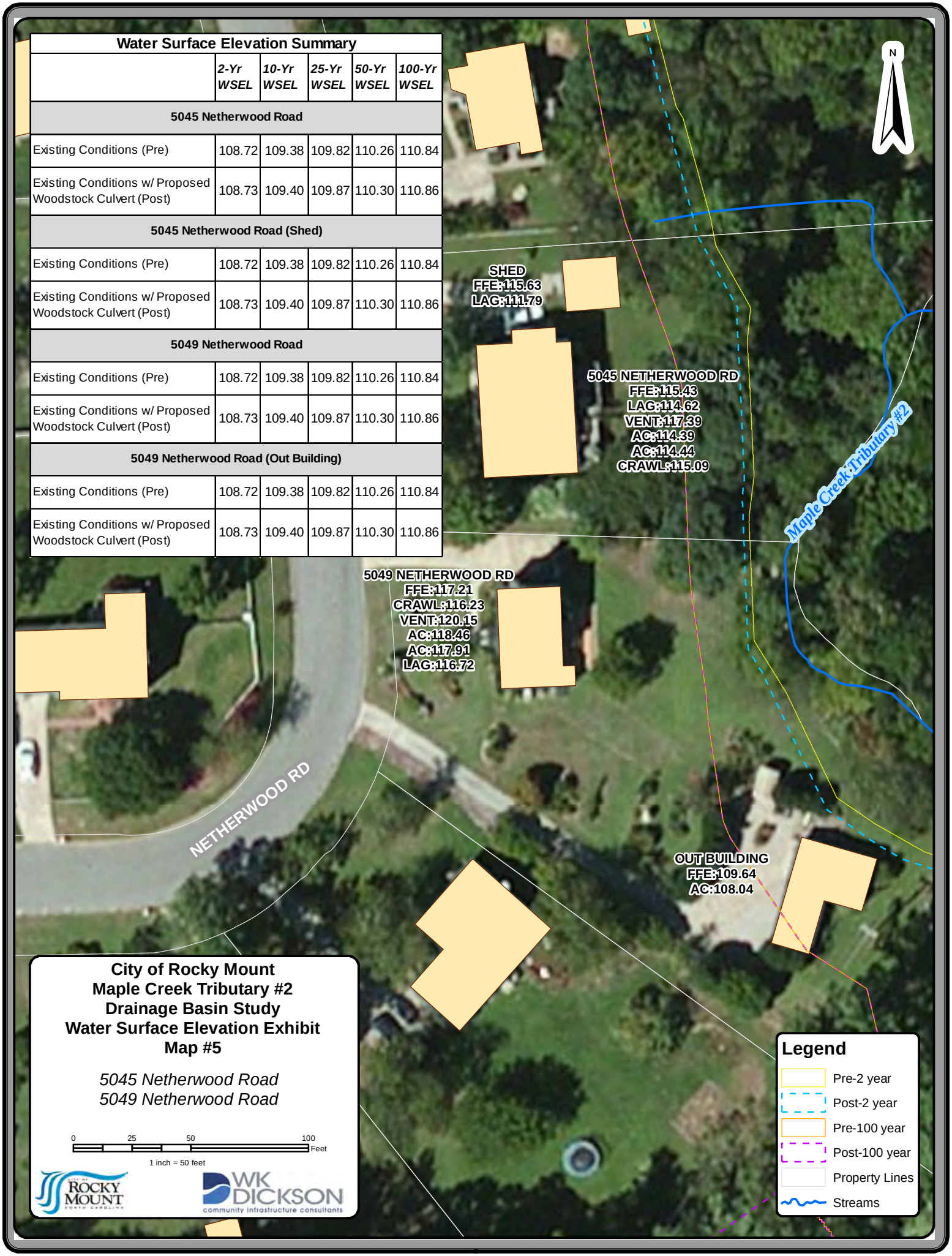
Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
5045 Netherwood Road					
Existing Conditions (Pre)	108.72	109.38	109.82	110.26	110.84
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.73	109.40	109.87	110.30	110.86
5045 Netherwood Road (Shed)					
Existing Conditions (Pre)	108.72	109.38	109.82	110.26	110.84
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.73	109.40	109.87	110.30	110.86
5049 Netherwood Road					
Existing Conditions (Pre)	108.72	109.38	109.82	110.26	110.84
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.73	109.40	109.87	110.30	110.86
5049 Netherwood Road (Out Building)					
Existing Conditions (Pre)	108.72	109.38	109.82	110.26	110.84
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.73	109.40	109.87	110.30	110.86



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #5

5045 Netherwood Road
5049 Netherwood Road

Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
4032 Gloucester Road					
Existing Conditions (Pre)	110.00	110.58	110.89	111.19	111.59
Existing Conditions w/ Proposed Woodstock Culvert (Post)	110.01	110.59	110.92	111.21	111.60
4036 Gloucester Road					
Existing Conditions (Pre)	109.76	110.33	110.64	110.95	111.38
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.77	110.34	110.67	110.97	111.39
4036 Gloucester Road (Shed)					
Existing Conditions (Pre)	109.76	110.33	110.64	110.95	111.38
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.77	110.34	110.67	110.97	111.39
4053 Gloucester Road					
Existing Conditions (Pre)	109.24	109.86	110.23	110.61	111.11
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.25	109.87	110.27	110.64	111.13
4053 Gloucester Road (Carport)					
Existing Conditions (Pre)	109.24	109.86	110.23	110.61	111.11
Existing Conditions w/ Proposed Woodstock Culvert (Post)	109.25	109.87	110.27	110.64	111.13

City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #6

4032 Gloucester Road
4036 Gloucester Road
4053 Gloucester Road

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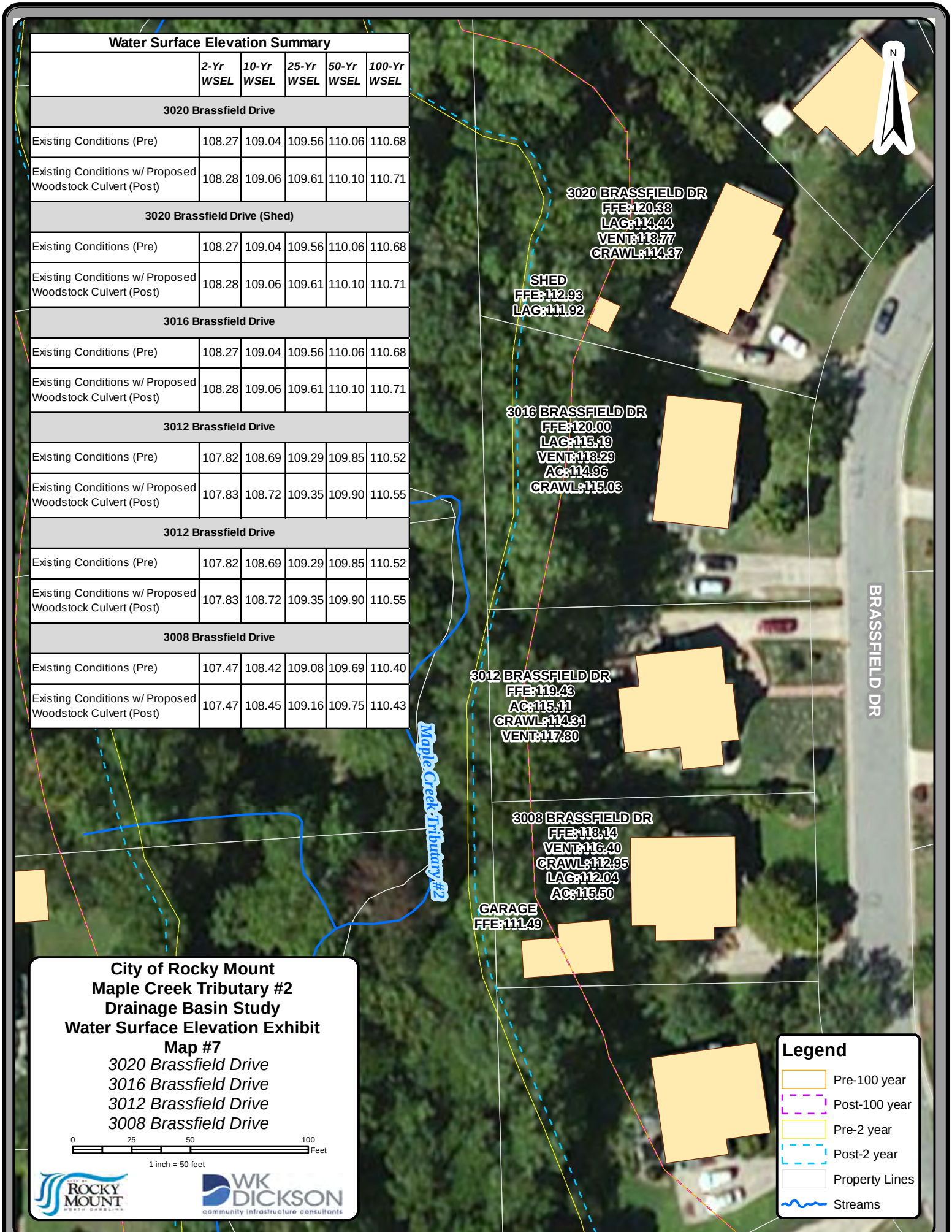
Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
3020 Brassfield Drive					
Existing Conditions (Pre)	108.27	109.04	109.56	110.06	110.68
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.28	109.06	109.61	110.10	110.71
3020 Brassfield Drive (Shed)					
Existing Conditions (Pre)	108.27	109.04	109.56	110.06	110.68
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.28	109.06	109.61	110.10	110.71
3016 Brassfield Drive					
Existing Conditions (Pre)	108.27	109.04	109.56	110.06	110.68
Existing Conditions w/ Proposed Woodstock Culvert (Post)	108.28	109.06	109.61	110.10	110.71
3012 Brassfield Drive					
Existing Conditions (Pre)	107.82	108.69	109.29	109.85	110.52
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.83	108.72	109.35	109.90	110.55
3012 Brassfield Drive					
Existing Conditions (Pre)	107.82	108.69	109.29	109.85	110.52
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.83	108.72	109.35	109.90	110.55
3008 Brassfield Drive					
Existing Conditions (Pre)	107.47	108.42	109.08	109.69	110.40
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.47	108.45	109.16	109.75	110.43



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #7

3020 Brassfield Drive
3016 Brassfield Drive
3012 Brassfield Drive
3008 Brassfield Drive

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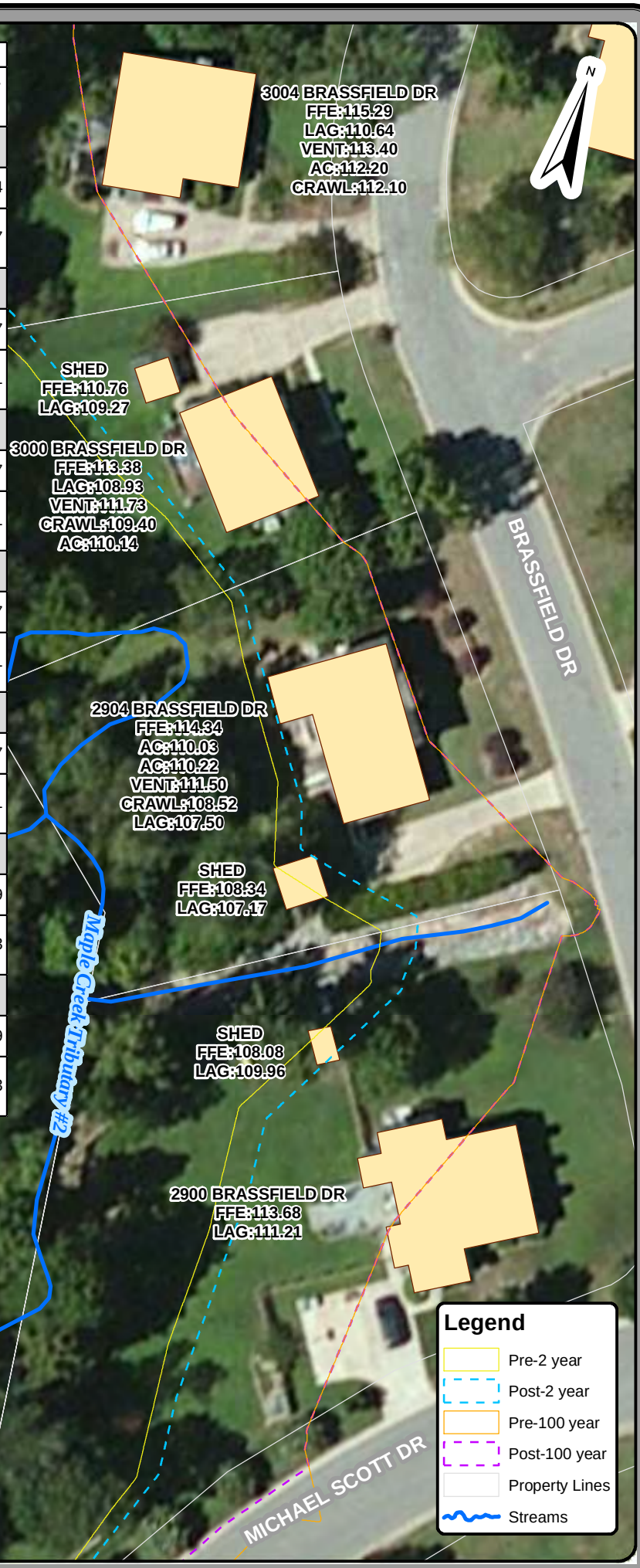
Water Surface Elevation Summary

	2-Yr WSEL	10-Yr WSEL	25-Yr WSEL	50-Yr WSEL	100-Yr WSEL
3004 Brassfield Drive					
Existing Conditions (Pre)	107.22	108.26	108.98	109.61	110.34
Existing Conditions w/ Proposed Woodstock Culvert (Post)	107.23	108.30	109.06	109.67	110.37
3000 Brassfield Drive					
Existing Conditions (Pre)	106.97	108.10	108.87	109.52	110.27
Existing Conditions w/ Proposed Woodstock Culvert (Post)	106.98	108.14	108.95	109.59	110.31
3000 Brassfield Drive (Shed)					
Existing Conditions (Pre)	106.97	108.10	108.87	109.52	110.27
Existing Conditions w/ Proposed Woodstock Culvert (Post)	106.98	108.14	108.95	109.59	110.31
2904 Brassfield Drive					
Existing Conditions (Pre)	106.97	108.10	108.87	109.52	110.27
Existing Conditions w/ Proposed Woodstock Culvert (Post)	106.98	108.14	108.95	109.59	110.31
2904 Brassfield Drive (Shed)					
Existing Conditions (Pre)	106.97	108.10	108.87	109.52	110.27
Existing Conditions w/ Proposed Woodstock Culvert (Post)	106.98	108.14	108.95	109.59	110.31
2900 Brassfield Drive					
Existing Conditions (Pre)	106.67	107.92	108.73	109.42	110.19
Existing Conditions w/ Proposed Woodstock Culvert (Post)	106.67	107.96	108.82	109.50	110.23
2900 Brassfield Drive (Shed)					
Existing Conditions (Pre)	106.67	107.92	108.73	109.42	110.19
Existing Conditions w/ Proposed Woodstock Culvert (Post)	106.67	107.96	108.82	109.50	110.23



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #8

3004 Brassfield Drive
3000 Brassfield Drive
2904 Brassfield Drive
2900 Brassfield Drive

0 25 50 100 Feet

1 inch = 50 feet

ROCKY MOUNT

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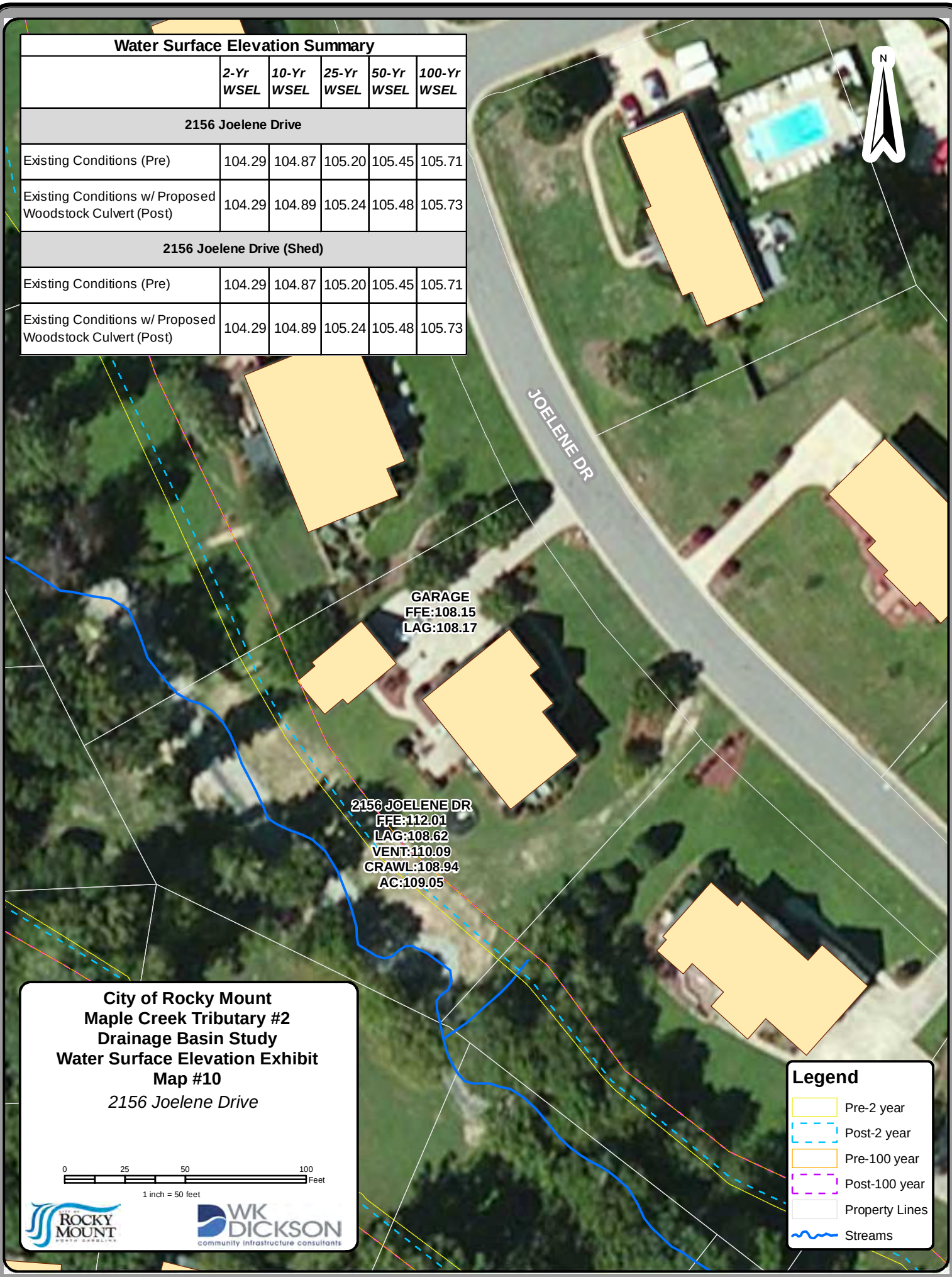
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #9
1308 Michael Scott Drive

Water Surface Elevation Summary					
	2-Yr WSEL	*10-Yr WSEL*	*25-Yr WSEL*	*50-Yr WSEL*	*100-Yr WSEL*
2156 Joelene Drive					
Existing Conditions (Pre)	104.29	104.87	105.20	105.45	105.71
Existing Conditions w/ Proposed Woodstock Culvert (Post)	104.29	104.89	105.24	105.48	105.73
2156 Joelene Drive (Shed)					
Existing Conditions (Pre)	104.29	104.87	105.20	105.45	105.71
Existing Conditions w/ Proposed Woodstock Culvert (Post)	104.29	104.89	105.24	105.48	105.73



City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Water Surface Elevation Exhibit
Map #10
2156 Joelene Drive

ROCKY MOUNT NORTH CAROLINA

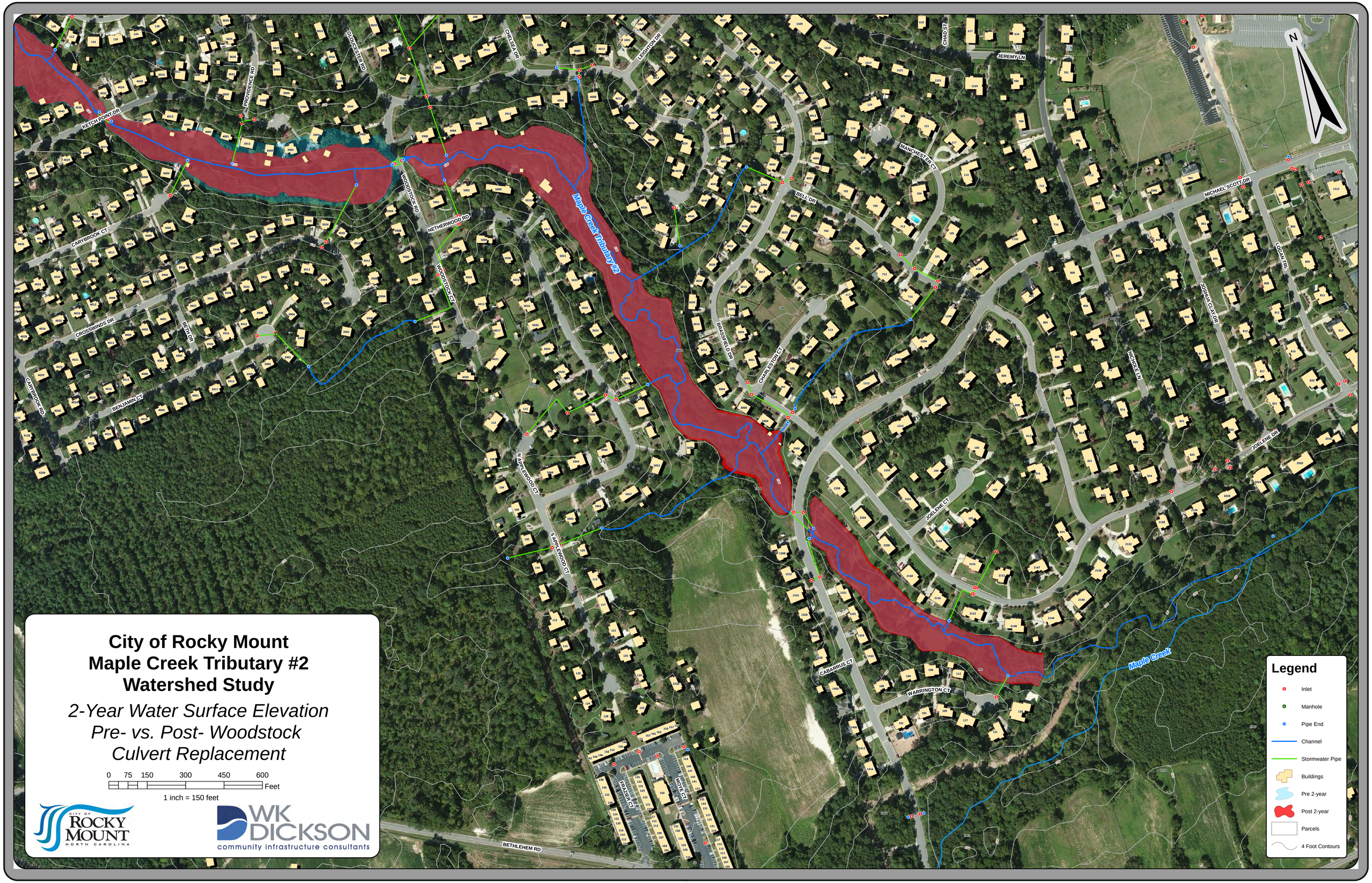
WK DICKSON community infrastructure consultants

City of Rocky Mount
Maple Creek Tributary #2
Watershed Study

2-Year Water Surface Elevation
Pre- vs. Post- Woodstock
Culvert Replacement

0 75 150 300 450 600 Feet

1 inch = 150 feet



CITY OF ROCKY MOUNT NORTH CAROLINA

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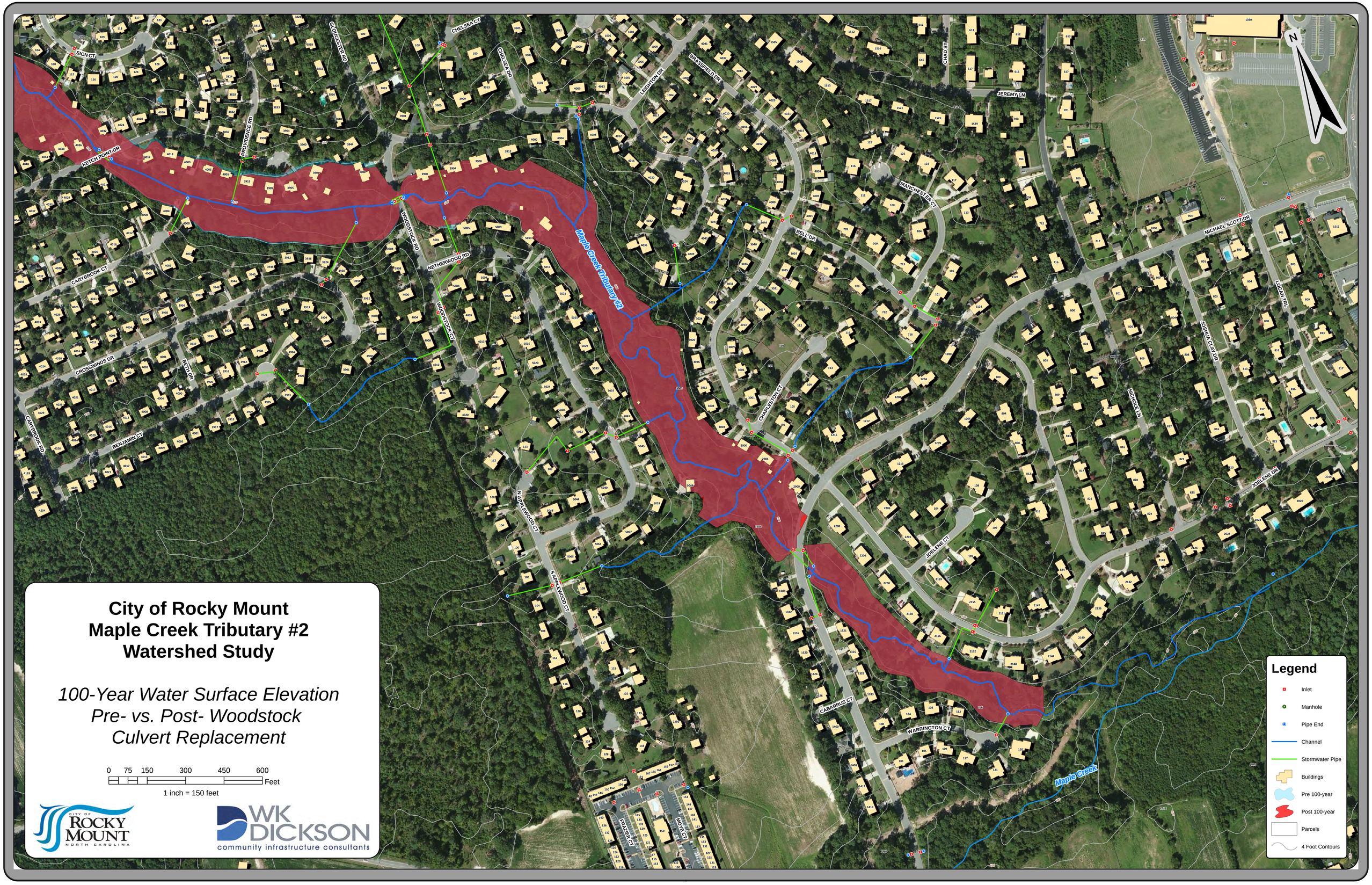
City of Rocky Mount
Maple Creek Tributary #2
Watershed Study
100-Year Water Surface Elevation
Pre- vs. Post- Woodstock
Culvert Replacement
0 75 150 300 450 600
Feet
1 inch = 150 feet
CITY OF ROCKY MOUNT NORTH CAROLINA
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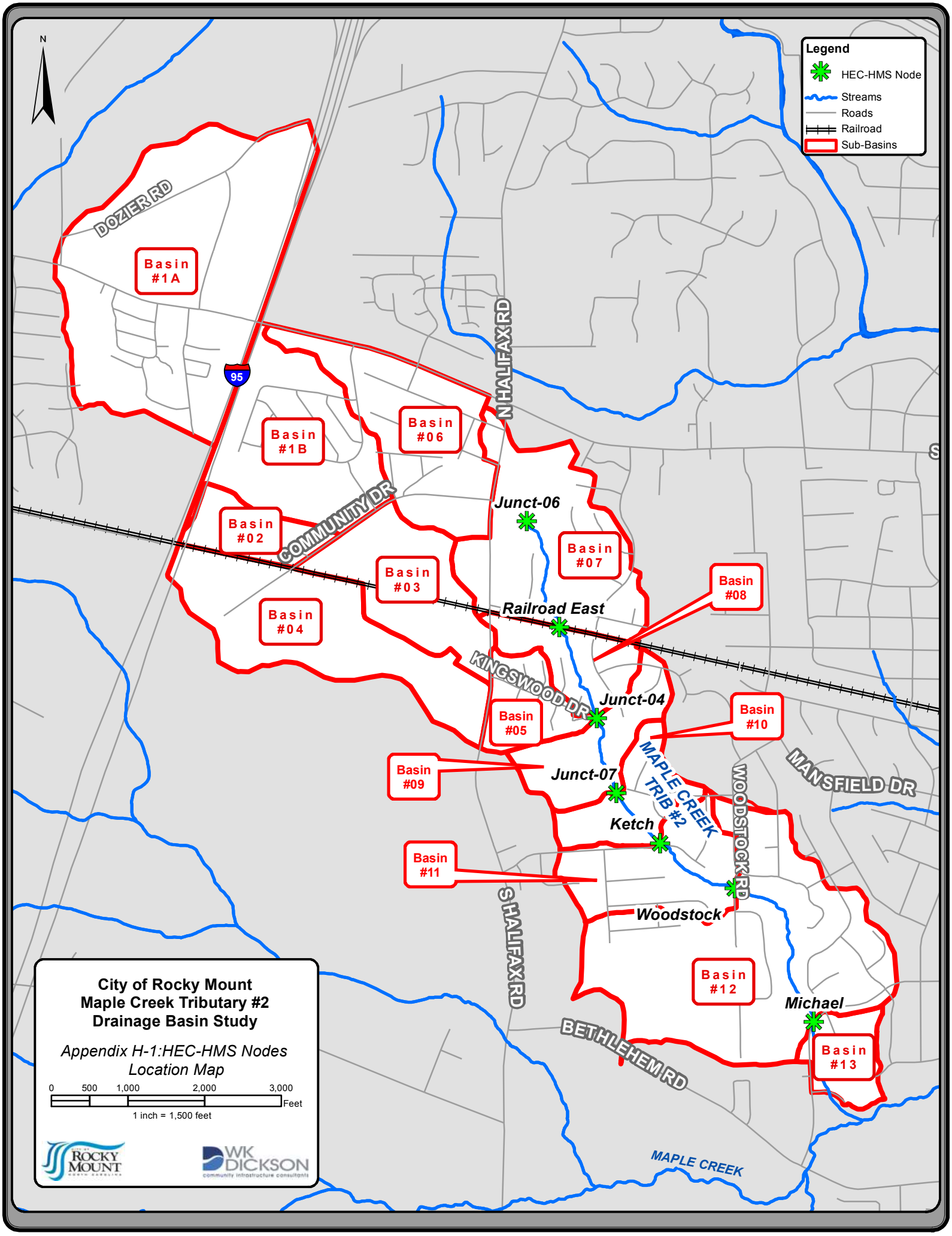
Legend
Inlet
Manhole
Pipe End
Channel
Stormwater Pipe
Buildings
Pre 100-year
Post 100-year
Parcels
4 Foot Contours
Maple Creek Tributary #2
Maple Creek
SION CT
KETCH POINT DR
PROVIDENCE RD
GLOUCESTER RD
CHELSEA CT
CHELSEA DR
LEIGHTON DR
BRASSFIELD DR
CHAD ST
JEREMY LN
MANCHESTER CT
BELL DR
MICHAEL SCOTT DR
LOGAN TRL
JOSHUA CLAY DR
NICHOLE LN
JOELENE DR
JOELENE CT
CARYBROOK CT
CROSSWINDS DR
BETH DR
CARYBROOK RD
BENJAMIN CT
WOODSTOCK RD
NETHERWOOD RD
WOODSTOCK CT
N APPLEWOOD CT
S APPLEWOOD CT
CHARLESTON CT
CABARRUS CT
WARRINGTON CT
FRAZIER CT
MOYE CT
N

Appendix H:
HEC-HMS Output

List of Contents:


N
Legend
HEC-HMS Node
Streams
Roads
Railroad
Sub-Basins
DOZIER RD
Basin #1A
95
Basin #1B
Basin #06
N HALIFAX RD
COMMUNITY DR
Basin #02
Junct-06
Basin #07
Basin #03
Basin #08
Basin #04
Railroad East
KINGSWOOD DR
Junct-04
Basin #05
Basin #10
MAPLE CREEK TRIB #2
Basin #09
Junct-07
MANSFIELD DR
WOODSTOCK RD
Ketch
Basin #11
S HALIFAX RD
Woodstock
Basin #12
Michael
BETHLEHEM RD
Basin #13
MAPLE CREEK
City of Rocky Mount
Maple Creek Tributary #2
Drainage Basin Study
Appendix H-1:HEC-HMS Nodes
Location Map
0 500 1,000 2,000 3,000 Feet
1 inch = 1,500 feet
ROCKY MOUNT
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2-YEAR EXISTING CONDITIONS				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	144.6	13:41	42.2
BSN1B	0.14	64.2	13:29	17.0
Community Drive	0.48	207.5	13:38	59.1
BSN2	0.04	29.6	12:51	5.1
Junct-01	0.52	221.1	13:34	64.3
through-3	0.52	221.1	13:41	64.2
BSN3	0.10	74.4	12:46	12.0
Junct-02	0.61	248.8	13:30	76.2
Railroad West	0.61	243.0	13:46	76.2
BSN4	0.15	52.1	13:35	14.2
Junct-03	0.77	294.1	13:43	90.4
through-5	0.77	294.1	14:03	90.0
BSN6	0.13	97.0	12:50	16.5
through-7	0.13	96.6	12:57	16.5
BSN7	0.16	126.4	12:35	16.3
Junct-06	0.29	199.7	12:42	32.8
Railroad East	0.29	133.3	13:12	32.7
through-8	0.29	132.8	13:27	32.6
BSN8	0.05	57.8	12:25	6.2
Junct-05	0.34	140.7	13:24	38.8
BSN5	0.04	80.3	12:16	7.0
Junct-04	1.15	425.6	13:54	135.8
through-9	1.15	425.4	13:59	135.6
BSN9	0.06	42.6	12:34	5.4
Junct-07	1.21	432.4	13:58	141.0
through-10	1.21	432.4	13:58	141.0
BSN10	0.05	61.0	12:16	4.8
Junct-08	1.27	437.5	13:58	145.8
Ketch	1.27	435.5	14:04	145.8
through-11	1.27	435.5	14:04	145.8
BSN11	0.09	53.4	12:42	7.8
Junct-09	1.35	446.5	14:03	153.6
Woodstock	1.35	441.0	14:14	153.6
through-12	1.35	441.0	14:14	153.6
BSN12	0.28	137.9	13:02	27.5
Junct-10	1.63	495.3	14:05	181.0
Michael	1.63	469.5	14:32	181.0
through-13	1.63	469.2	14:42	180.6
BSN13	0.04	32.3	12:28	3.6
Outfall	1.67	472.5	14:41	184.2

10-YEAR EXISTING CONDITIONS				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	231.4	13:40	70.0
BSN1B	0.14	105.3	13:28	28.8
Community Drive	0.48	334.6	13:38	98.8
BSN2	0.04	46.9	12:51	8.6
Junct-01	0.52	356.4	13:33	107.4
through-3	0.52	356.4	13:40	107.2
BSN3	0.10	117.5	12:46	20.1
Junct-02	0.61	403.1	13:26	127.3
Railroad West	0.61	355.8	14:06	127.3
BSN4	0.15	93.2	13:33	25.9
Junct-03	0.77	440.6	13:50	153.2
through-5	0.77	440.6	14:10	152.6
BSN6	0.13	151.5	12:49	27.3
through-7	0.13	151.1	12:57	27.3
BSN7	0.16	211.1	12:34	28.8
Junct-06	0.29	326.6	12:42	56.1
Railroad East	0.29	167.7	13:22	56.0
through-8	0.29	167.2	13:39	55.9
BSN8	0.05	88.7	12:25	10.3
Junct-05	0.34	178.1	13:36	66.2
BSN5	0.04	111.0	12:16	10.9
Junct-04	1.15	619.3	13:59	229.7
through-9	1.15	619.2	14:05	229.5
BSN9	0.06	75.6	12:34	10.1
Junct-07	1.21	630.9	14:04	239.5
through-10	1.21	630.9	14:04	239.5
BSN10	0.05	102.3	12:15	8.8
Junct-08	1.27	639.9	14:03	248.3
Ketch	1.27	638.7	14:10	248.3
through-11	1.27	638.7	14:10	248.3
BSN11	0.09	94.2	12:41	14.4
Junct-09	1.35	656.9	14:07	262.6
Woodstock	1.35	649.4	14:23	262.6
through-12	1.35	649.4	14:23	262.6
BSN12	0.28	240.0	13:02	49.3
Junct-10	1.63	778.5	13:00	311.9
Michael	1.63	719.5	14:33	311.8
through-13	1.63	719.4	14:39	311.2
BSN13	0.04	55.1	12:28	6.5
Outfall	1.67	725.4	14:39	317.8

25-YEAR EXISTING CONDITIONS				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	285.3	13:39	89.6
BSN1B	0.14	131.1	13:28	37.2
Community Drive	0.48	413.9	13:37	126.8
BSN2	0.04	57.7	12:51	11.1
Junct-01	0.52	441.1	13:33	137.9
through-3	0.52	441.1	13:40	137.6
BSN3	0.10	144.3	12:46	25.9
Junct-02	0.61	497.7	13:28	163.5
Railroad West	0.61	400.3	14:18	163.5
BSN4	0.15	120.4	13:32	34.5
Junct-03	0.77	501.0	13:48	198.0
through-5	0.77	501.0	14:08	197.0
BSN6	0.13	185.3	12:49	35.1
through-7	0.13	184.7	12:57	35.0
BSN7	0.16	265.4	12:34	38.0
Junct-06	0.29	406.6	12:41	73.1
Railroad East	0.29	251.4	13:14	72.9
through-8	0.29	247.2	13:28	72.7
BSN8	0.05	107.8	12:25	13.3
Junct-05	0.34	262.3	13:28	86.0
BSN5	0.04	129.5	12:16	13.6
Junct-04	1.15	735.2	13:37	296.7
through-9	1.15	734.8	13:43	296.4
BSN9	0.06	97.3	12:33	13.6
Junct-07	1.21	752.4	13:42	309.9
through-10	1.21	752.4	13:42	309.9
BSN10	0.05	128.8	12:15	11.8
Junct-08	1.27	763.8	13:42	321.7
Ketch	1.27	758.8	13:48	321.6
through-11	1.27	758.8	13:48	321.6
BSN11	0.09	121.0	12:41	19.3
Junct-09	1.35	787.9	13:47	340.9
Woodstock	1.35	765.7	14:02	340.8
through-12	1.35	765.7	14:02	340.8
BSN12	0.28	306.3	13:01	65.3
Junct-10	1.63	963.7	12:57	406.2
Michael	1.63	885.2	14:08	402.9
through-13	1.63	885.0	14:14	401.6
BSN13	0.04	69.8	12:27	8.7
Outfall	1.67	893.3	14:13	410.3

50-YEAR EXISTING CONDITIONS				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	323.8	13:39	102.1
BSN1B	0.14	149.4	13:28	42.5
Community Drive	0.48	470.4	13:37	144.6
BSN2	0.04	65.4	12:51	12.6
Junct-01	0.52	501.4	13:33	157.1
through-3	0.52	501.4	13:40	156.9
BSN3	0.10	163.6	12:46	29.5
Junct-02	0.61	566.0	13:28	186.4
Railroad West	0.61	497.6	14:06	186.4
BSN4	0.15	139.4	13:32	40.0
Junct-03	0.77	617.9	14:00	226.4
through-5	0.77	617.9	14:20	225.4
BSN6	0.13	209.7	12:49	39.9
through-7	0.13	209.3	12:55	39.8
BSN7	0.16	304.0	12:34	43.8
Junct-06	0.29	463.9	12:41	83.6
Railroad East	0.29	320.7	13:09	83.5
through-8	0.29	317.3	13:21	83.2
BSN8	0.05	121.7	12:25	15.2
Junct-05	0.34	336.8	13:20	98.4
BSN5	0.04	143.8	12:16	15.3
Junct-04	1.15	825.9	13:29	339.1
through-9	1.15	824.0	13:36	338.8
BSN9	0.06	112.7	12:33	15.8
Junct-07	1.21	846.7	13:35	354.5
through-10	1.21	846.7	13:35	354.5
BSN10	0.05	147.6	12:15	13.6
Junct-08	1.27	859.3	13:35	368.2
Ketch	1.27	851.9	13:41	368.0
through-11	1.27	851.9	13:41	368.0
BSN11	0.09	139.9	12:41	22.3
Junct-09	1.35	889.9	13:39	390.4
Woodstock	1.35	867.5	13:53	390.3
through-12	1.35	867.5	13:53	390.3
BSN12	0.28	353.0	13:01	75.4
Junct-10	1.63	1088.5	12:57	465.8
Michael	1.63	1026.4	13:58	462.1
through-13	1.63	1026.1	14:03	460.8
BSN13	0.04	80.2	12:27	10.1
Outfall	1.67	1035.9	14:03	470.9

100-YEAR EXISTING CONDITIONS				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	363.7	13:39	115.4
BSN1B	0.14	168.3	13:27	48.3
Community Drive	0.48	528.8	13:37	163.6
BSN2	0.04	73.3	12:50	14.3
Junct-01	0.52	563.9	13:32	177.9
through-3	0.52	563.9	13:39	177.6
BSN3	0.10	183.2	12:46	33.4
Junct-02	0.61	636.8	13:28	211.1
Railroad West	0.61	577.2	14:01	211.1
BSN4	0.15	159.3	13:31	45.9
Junct-03	0.77	720.0	13:55	257.0
through-5	0.77	720.0	14:15	255.8
BSN6	0.13	234.5	12:49	45.1
through-7	0.13	234.0	12:55	45.1
BSN7	0.16	343.4	12:34	50.1
Junct-06	0.29	526.5	12:42	95.2
Railroad East	0.29	386.5	13:05	95.1
through-8	0.29	383.3	13:15	94.8
BSN8	0.05	135.7	12:25	17.2
Junct-05	0.34	408.4	13:14	112.0
BSN5	0.04	157.9	12:16	17.1
Junct-04	1.15	943.7	13:58	384.9
through-9	1.15	943.0	14:04	384.5
BSN9	0.06	128.5	12:33	18.2
Junct-07	1.21	962.6	14:04	402.7
through-10	1.21	962.6	14:04	402.7
BSN10	0.05	166.9	12:15	15.7
Junct-08	1.27	977.3	14:04	418.4
Ketch	1.27	972.9	14:10	418.2
through-11	1.27	972.9	14:10	418.2
BSN11	0.09	159.4	12:40	25.7
Junct-09	1.35	1003.0	14:09	444.0
Woodstock	1.35	995.9	14:18	443.9
through-12	1.35	995.9	14:18	443.9
BSN12	0.28	401.4	13:01	86.5
Junct-10	1.63	1239.4	13:28	530.5
Michael	1.63	1184.4	13:49	523.9
through-13	1.63	1184.1	13:55	522.4
BSN13	0.04	90.9	12:27	11.6
Outfall	1.67	1195.8	13:55	534.0

2-YEAR FUTURE CONDITIONS - CITY DESIGN STANDARD				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	144.6	13:41	42.2
BSN1B	0.14	64.2	13:29	17.0
Community Drive	0.48	207.6	13:36	59.2
BSN2	0.04	29.6	12:51	5.1
Junct-01	0.52	221.7	13:32	64.3
through-3	0.52	221.7	13:39	64.2
BSN3	0.10	74.4	12:46	12.0
Junct-02	0.61	251.0	13:26	76.2
Railroad West	0.61	251.0	13:26	76.2
BSN4	0.15	52.1	13:35	14.2
Junct-03	0.77	302.7	13:29	90.4
through-5	0.77	302.7	13:49	90.0
BSN6	0.13	97.0	12:50	16.5
through-7	0.13	97.0	12:50	16.5
BSN7	0.16	126.4	12:35	16.3
Junct-06	0.29	213.0	12:39	32.8
Railroad East	0.29	213.0	12:39	32.8
through-8	0.29	213.0	12:39	32.8
BSN8	0.05	57.8	12:25	6.2
Junct-05	0.34	258.2	12:36	39.0
BSN5	0.04	80.3	12:16	7.0
Junct-04	1.15	380.1	13:24	136.0
through-9	1.15	380.1	13:24	136.0
BSN9	0.06	42.6	12:34	5.4
Junct-07	1.21	415.9	12:42	141.4
through-10	1.21	415.9	12:42	141.4
BSN10	0.05	61.0	12:16	4.8
Junct-08	1.27	435.9	12:36	146.2
Ketch	1.27	435.9	12:36	146.2
through-11	1.27	435.9	12:36	146.2
BSN11	0.09	53.4	12:42	7.8
Junct-09	1.35	488.4	12:38	154.0
Woodstock	1.35	488.4	12:38	154.0
through-12	1.35	488.4	12:38	154.0
BSN12	0.28	137.9	13:02	27.5
Junct-10	1.63	601.2	12:47	181.5
Michael	1.63	601.2	12:47	181.5
through-13	1.63	601.2	12:47	181.5
BSN13	0.04	32.3	12:28	3.6
Outfall	1.67	622.1	12:44	185.1

10-YEAR FUTURE CONDITIONS - CITY DESIGN STANDARD				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	231.4	13:40	70.0
BSN1B	0.14	105.3	13:28	28.8
Community Drive	0.48	334.9	13:35	98.8
BSN2	0.04	46.9	12:51	8.6
Junct-01	0.52	358.1	13:31	107.4
through-3	0.52	358.1	13:38	107.2
BSN3	0.10	117.5	12:46	20.1
Junct-02	0.61	407.0	13:25	127.3
Railroad West	0.61	407.0	13:25	127.3
BSN4	0.15	93.2	13:33	25.9
Junct-03	0.77	499.4	13:27	153.2
through-5	0.77	499.4	13:47	152.6
BSN6	0.13	151.5	12:49	27.3
through-7	0.13	151.5	12:49	27.3
BSN7	0.16	211.1	12:34	28.8
Junct-06	0.29	346.9	12:39	56.1
Railroad East	0.29	346.9	12:39	56.1
through-8	0.29	346.9	12:39	56.1
BSN8	0.05	88.7	12:25	10.3
Junct-05	0.34	418.2	12:35	66.4
BSN5	0.04	111.0	12:16	10.9
Junct-04	1.15	634.9	12:49	230.0
through-9	1.15	634.9	12:49	230.0
BSN9	0.06	75.6	12:34	10.1
Junct-07	1.21	701.0	12:42	240.0
through-10	1.21	701.0	12:42	240.0
BSN10	0.05	102.3	12:15	8.8
Junct-08	1.27	737.3	12:36	248.8
Ketch	1.27	737.3	12:36	248.8
through-11	1.27	737.3	12:36	248.8
BSN11	0.09	94.2	12:41	14.4
Junct-09	1.35	830.2	12:38	263.2
Woodstock	1.35	830.2	12:38	263.2
through-12	1.35	830.2	12:38	263.2
BSN12	0.28	240.0	13:02	49.3
Junct-10	1.63	1028.3	12:46	312.5
Michael	1.63	1028.3	12:46	312.5
through-13	1.63	1028.3	12:46	312.5
BSN13	0.04	55.1	12:28	6.5
Outfall	1.67	1065.7	12:43	319.0

25-YEAR FUTURE CONDITIONS - CITY DESIGN STANDARD				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	285.3	13:39	89.6
BSN1B	0.14	131.1	13:28	37.2
Community Drive	0.48	414.3	13:35	126.8
BSN2	0.04	57.7	12:51	11.1
Junct-01	0.52	443.2	13:30	137.9
through-3	0.52	443.2	13:37	137.6
BSN3	0.10	144.3	12:46	25.9
Junct-02	0.61	504.5	13:24	163.5
Railroad West	0.61	504.5	13:24	163.5
BSN4	0.15	120.4	13:32	34.5
Junct-03	0.77	623.9	13:26	198.0
through-5	0.77	623.9	13:46	197.1
BSN6	0.13	185.3	12:49	35.1
through-7	0.13	185.3	12:49	35.1
BSN7	0.16	265.4	12:34	38.0
Junct-06	0.29	431.3	12:39	73.1
Railroad East	0.29	431.3	12:39	73.1
through-8	0.29	431.3	12:39	73.1
BSN8	0.05	107.8	12:25	13.3
Junct-05	0.34	519.0	12:35	86.5
BSN5	0.04	129.5	12:16	13.6
Junct-04	1.15	798.7	12:48	297.2
through-9	1.15	798.7	12:48	297.2
BSN9	0.06	97.3	12:33	13.6
Junct-07	1.21	884.7	12:41	310.7
through-10	1.21	884.7	12:41	310.7
BSN10	0.05	128.8	12:15	11.8
Junct-08	1.27	932.1	12:36	322.5
Ketch	1.27	932.1	12:36	322.5
through-11	1.27	932.1	12:36	322.5
BSN11	0.09	121.0	12:41	19.3
Junct-09	1.35	1051.4	12:37	341.8
Woodstock	1.35	1051.4	12:37	341.8
through-12	1.35	1051.4	12:37	341.8
BSN12	0.28	306.3	13:01	65.3
Junct-10	1.63	1304.4	12:45	407.1
Michael	1.63	1304.4	12:45	407.1
through-13	1.63	1304.4	12:45	407.1
BSN13	0.04	69.8	12:27	8.7
Outfall	1.67	1353.0	12:43	415.9

50-YEAR FUTURE CONDITIONS - CITY DESIGN STANDARD				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	351.5	13:38	116.5
BSN1B	0.14	168.2	13:26	51.4
Community Drive	0.48	517.1	13:33	168.0
BSN2	0.04	72.0	12:50	14.9
Junct-01	0.52	553.8	13:28	182.9
through-3	0.52	553.8	13:35	182.7
BSN3	0.10	174.3	12:45	32.5
Junct-02	0.61	630.4	13:22	215.1
Railroad West	0.61	630.4	13:22	215.1
BSN4	0.15	166.0	13:30	49.3
Junct-03	0.77	795.2	13:24	264.5
through-5	0.77	795.2	13:24	264.5
BSN6	0.13	215.3	12:49	41.5
through-7	0.13	215.3	12:49	41.5
BSN7	0.16	320.3	12:34	46.7
Junct-06	0.29	512.9	12:38	88.1
Railroad East	0.29	512.9	12:38	88.1
through-8	0.29	512.9	12:38	88.1
BSN8	0.05	121.7	12:25	15.2
Junct-05	0.34	613.0	12:35	103.3
BSN5	0.04	143.8	12:16	15.3
Junct-04	1.15	1217.3	12:44	383.1
through-9	1.15	1217.3	12:44	383.1
BSN9	0.06	110.2	12:33	15.4
Junct-07	1.21	1317.4	12:42	398.5
through-10	1.21	1317.4	12:42	398.5
BSN10	0.05	147.6	12:15	13.6
Junct-08	1.27	1367.7	12:39	412.1
Ketch	1.27	1367.7	12:39	412.1
through-11	1.27	1367.7	12:39	412.1
BSN11	0.09	139.9	12:41	22.3
Junct-09	1.35	1507.3	12:39	434.4
Woodstock	1.35	1507.3	12:39	434.4
through-12	1.35	1507.3	12:39	434.4
BSN12	0.28	353.0	13:01	75.4
Junct-10	1.63	1800.9	12:44	509.9
Michael	1.63	1800.9	12:44	509.9
through-13	1.63	1800.9	12:44	509.9
BSN13	0.04	80.2	12:27	10.1
Outfall	1.67	1858.5	12:42	520.0

100-YEAR FUTURE CONDITIONS - CITY DESIGN STANDARD				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	390.1	13:38	130.1
BSN1B	0.14	186.3	13:26	57.4
Community Drive	0.48	573.5	13:33	187.5
BSN2	0.04	79.5	12:50	16.6
Junct-01	0.52	614.3	13:28	204.1
through-3	0.52	614.3	13:35	203.9
BSN3	0.10	193.4	12:45	36.5
Junct-02	0.61	699.8	13:22	240.3
Railroad West	0.61	699.8	13:22	240.3
BSN4	0.15	185.5	13:30	55.6
Junct-03	0.77	884.0	13:24	295.9
through-5	0.77	884.0	13:24	295.9
BSN6	0.13	239.9	12:49	46.8
through-7	0.13	239.9	12:49	46.8
BSN7	0.16	359.5	12:34	53.1
Junct-06	0.29	574.1	12:38	99.9
Railroad East	0.29	574.1	12:38	99.9
through-8	0.29	574.1	12:38	99.9
BSN8	0.05	135.7	12:25	17.2
Junct-05	0.34	686.2	12:35	117.1
BSN5	0.04	157.9	12:16	17.1
Junct-04	1.15	1360.4	12:44	430.2
through-9	1.15	1360.4	12:44	430.2
BSN9	0.06	126.0	12:33	17.8
Junct-07	1.21	1475.1	12:41	448.0
through-10	1.21	1475.1	12:41	448.0
BSN10	0.05	166.9	12:15	15.7
Junct-08	1.27	1533.2	12:38	463.7
Ketch	1.27	1533.2	12:38	463.7
through-11	1.27	1533.2	12:38	463.7
BSN11	0.09	159.4	12:40	25.7
Junct-09	1.35	1692.2	12:39	489.4
Woodstock	1.35	1692.2	12:39	489.4
through-12	1.35	1692.2	12:39	489.4
BSN12	0.28	401.4	13:01	86.5
Junct-10	1.63	2026.2	12:44	576.0
Michael	1.63	2026.2	12:44	576.0
through-13	1.63	2026.2	12:44	576.0
BSN13	0.04	90.9	12:27	11.6
Outfall	1.67	2092.1	12:42	587.6

2-YEAR - ALTERNATIVE #1				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	144.6	13:41	42.2
BSN1B	0.14	64.2	13:29	17.0
Community Drive	0.48	207.6	13:36	59.2
BSN2	0.04	29.6	12:51	5.1
Junct-01	0.52	221.7	13:32	64.3
through-3	0.52	221.7	13:39	64.2
BSN3	0.10	74.4	12:46	12.0
Junct-02	0.61	251.0	13:26	76.2
Railroad West	0.61	251.0	13:26	76.2
BSN4	0.15	52.1	13:35	14.2
Junct-03	0.77	302.7	13:29	90.4
through-8	0.77	302.7	13:29	90.4
BSN6	0.13	97.0	12:50	16.5
through-7	0.13	97.0	12:50	16.5
BSN7	0.16	126.4	12:35	16.3
Junct-06	0.29	213.0	12:39	32.8
Railroad East	0.29	213.0	12:39	32.8
through-5	0.29	213.0	12:39	32.8
BSN8	0.05	57.8	12:25	6.2
Junct-05	0.34	258.2	12:36	39.0
BSN5	0.04	80.3	12:16	7.0
Junct-04	1.15	475.6	12:44	136.4
through-9	1.15	475.6	12:44	136.4
Hampton Detention	1.15	418.0	13:17	133.0
BSN9	0.06	42.6	12:34	5.4
Junct-07	1.21	431.8	13:13	138.4
through-10	1.21	431.8	13:13	138.4
BSN10	0.05	61.0	12:16	4.8
Junct-08	1.27	437.1	13:13	143.2
Ketch	1.27	437.1	13:13	143.2
through-11	1.27	437.1	13:13	143.2
BSN11	0.09	53.4	12:42	7.8
Junct-09	1.35	469.1	13:03	151.1
Woodstock	1.35	469.1	13:03	151.1
through-12	1.35	469.1	13:03	151.1
BSN12	0.28	137.9	13:02	27.5
Junct-10	1.63	607.0	13:03	178.5
Michael	1.63	607.0	13:03	178.5
through-13	1.63	607.0	13:03	178.5
BSN13	0.04	32.3	2:28	3.6
Outfall	1.67	617.7	13:01	182.1

10-YEAR - ALTERNATIVE #1				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	231.4	13:40	70.0
BSN1B	0.14	105.3	13:28	28.8
Community Drive	0.48	334.9	13:35	98.8
BSN2	0.04	46.9	12:51	8.6
Junct-01	0.52	358.1	13:31	107.4
through-3	0.52	358.1	13:38	107.2
BSN3	0.10	117.5	12:46	20.1
Junct-02	0.61	407.0	13:25	127.3
Railroad West	0.61	407.0	13:25	127.3
BSN4	0.15	93.2	13:33	25.9
Junct-03	0.77	499.4	13:27	153.2
through-8	0.77	499.4	13:27	153.2
BSN6	0.13	151.5	12:49	27.3
through-7	0.13	151.5	12:49	27.3
BSN7	0.16	211.1	12:34	28.8
Junct-06	0.29	346.9	12:39	56.1
Railroad East	0.29	346.9	12:39	56.1
through-5	0.29	346.9	12:39	56.1
BSN8	0.05	88.7	12:25	10.3
Junct-05	0.34	418.2	12:35	66.4
BSN5	0.04	111.0	12:16	10.9
Junct-04	1.15	785.4	12:44	230.5
through-9	1.15	785.4	12:44	230.5
Hampton Detention	1.15	705.7	13:13	225.6
BSN9	0.06	75.6	12:34	10.1
Junct-07	1.21	735.1	13:07	235.6
through-10	1.21	735.1	13:07	235.6
BSN10	0.05	102.3	12:15	8.8
Junct-08	1.27	744.9	13:06	244.4
Ketch	1.27	744.9	13:06	244.4
through-11	1.27	744.9	13:06	244.4
BSN11	0.09	94.2	12:41	14.4
Junct-09	1.35	815.4	12:57	258.8
Woodstock	1.35	815.4	12:57	258.8
through-12	1.35	815.4	12:57	258.8
BSN12	0.28	240.0	13:02	49.3
Junct-10	1.63	1053.9	12:59	308.1
Michael	1.63	1053.9	12:59	308.1
through-13	1.63	1053.9	12:59	308.1
BSN13	0.04	55.1	12:28	6.5
Outfall	1.67	1076.3	12:57	314.6

25-YEAR - ALTERNATIVE #1				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	285.3	13:39	89.6
BSN1B	0.14	131.1	13:28	37.2
Community Drive	0.48	414.3	13:35	126.8
BSN2	0.04	57.7	12:51	11.1
Junct-01	0.52	443.2	13:30	137.9
through-3	0.52	443.2	13:37	137.6
BSN3	0.10	144.3	12:46	25.9
Junct-02	0.61	504.5	13:24	163.5
Railroad West	0.61	504.5	13:24	163.5
BSN4	0.15	120.4	13:32	34.5
Junct-03	0.77	623.9	13:26	198.0
through-8	0.77	623.9	13:26	198.0
BSN6	0.13	185.3	2:49	35.1
through-7	0.13	185.3	12:49	35.1
BSN7	0.16	265.4	12:34	38.0
Junct-06	0.29	431.3	12:39	73.1
Railroad East	0.29	431.3	12:39	73.1
through-5	0.29	431.3	12:39	73.1
BSN8	0.05	107.8	12:25	13.3
Junct-05	0.34	519.0	12:35	86.5
BSN5	0.04	129.5	12:16	13.6
Junct-04	1.15	982.6	12:44	298.1
through-9	1.15	982.6	12:44	298.1
Hampton Detention	1.15	881.2	13:12	291.2
BSN9	0.06	97.3	12:33	13.6
Junct-07	1.21	919.7	13:06	304.8
through-10	1.21	919.7	13:06	304.8
BSN10	0.05	128.8	12:15	11.8
Junct-08	1.27	932.5	13:04	316.6
Ketch	1.27	932.5	13:04	316.6
through-11	1.27	932.5	13:04	316.6
BSN11	0.09	121.0	12:41	19.3
Junct-09	1.35	1027.5	12:54	335.8
Woodstock	1.35	1027.5	12:54	335.8
through-12	1.35	1027.5	12:54	335.8
BSN12	0.28	306.3	13:01	65.3
Junct-10	1.63	1330.3	12:57	401.2
Michael	1.63	1330.3	12:57	401.2
through-13	1.63	1330.3	12:57	401.2
BSN13	0.04	69.8	12:27	8.7
Outfall	1.67	1360.6	12:55	409.9

50-YEAR - ALTERNATIVE #1				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	351.5	13:38	116.5
BSN1B	0.14	168.2	13:26	51.4
Community Drive	0.48	517.1	13:33	168.0
BSN2	0.04	72.0	12:50	14.9
Junct-01	0.52	553.8	13:28	182.9
through-3	0.52	553.8	13:35	182.7
BSN3	0.10	174.3	12:45	32.5
Junct-02	0.61	630.4	13:22	215.1
Railroad West	0.61	630.4	13:22	215.1
BSN4	0.15	166.0	13:30	49.3
Junct-03	0.77	795.2	13:24	264.5
through-8	0.77	795.2	13:24	264.5
BSN6	0.13	215.3	12:49	41.5
through-7	0.13	215.3	12:49	41.5
BSN7	0.16	320.3	12:34	46.7
Junct-06	0.29	512.9	12:38	88.1
Railroad East	0.29	512.9	12:38	88.1
through-5	0.29	512.9	12:38	88.1
BSN8	0.05	121.7	12:25	15.2
Junct-05	0.34	613.0	12:35	103.3
BSN5	0.04	143.8	12:16	15.3
Junct-04	1.15	1217.3	12:44	383.1
through-9	1.15	1217.3	12:44	383.1
Hampton Detention	1.15	1093.9	13:13	376.1
BSN9	0.06	110.2	12:33	15.4
Junct-07	1.21	1135.9	13:08	391.5
through-10	1.21	1135.9	13:08	391.5
BSN10	0.05	147.6	12:15	13.6
Junct-08	1.27	1150.1	13:06	405.1
Ketch	1.27	1150.1	13:06	405.1
through-11	1.27	1150.1	13:06	405.1
BSN11	0.09	139.9	12:41	22.3
Junct-09	1.35	1254.2	12:56	427.5
Woodstock	1.35	1254.2	12:56	427.5
through-12	1.35	1254.2	12:56	427.5
BSN12	0.28	353.0	13:01	75.4
Junct-10	1.63	1605.2	12:58	502.9
Michael	1.63	1605.2	12:58	502.9
through-13	1.63	1605.2	12:58	502.9
BSN13	0.04	80.2	12:27	10.1
Outfall	1.67	1638.7	12:56	513.0

100-YEAR - ALTERNATIVE #1				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	390.1	13:38	130.1
BSN1B	0.14	186.3	13:26	57.4
Community Drive	0.48	573.5	13:33	187.5
BSN2	0.04	79.5	12:50	16.6
Junct-01	0.52	614.3	13:28	204.1
through-3	0.52	614.3	13:35	203.9
BSN3	0.10	193.4	12:45	36.5
Junct-02	0.61	699.8	13:22	240.3
Railroad West	0.61	699.8	13:22	240.3
BSN4	0.15	185.5	13:30	55.6
Junct-03	0.77	884.0	13:24	295.9
through-8	0.77	884.0	13:24	295.9
BSN6	0.13	239.9	12:49	46.8
through-7	0.13	239.9	12:49	46.8
BSN7	0.16	359.5	12:34	53.1
Junct-06	0.29	574.1	12:38	99.9
Railroad East	0.29	574.1	12:38	99.9
through-5	0.29	574.1	12:38	99.9
BSN8	0.05	135.7	12:25	17.2
Junct-05	0.34	686.2	12:35	117.1
BSN5	0.04	157.9	12:16	17.1
Junct-04	1.15	1360.4	12:44	430.2
through-9	1.15	1360.4	12:44	430.2
Hampton Detention	1.15	1220.6	13:13	422.8
BSN9	0.06	126.0	12:33	17.8
Junct-07	1.21	1269.1	13:07	440.7
through-10	1.21	1269.1	13:07	440.7
BSN10	0.05	166.9	12:15	15.7
Junct-08	1.27	1285.5	13:06	456.4
Ketch	1.27	1285.5	13:06	456.4
through-11	1.27	1285.5	13:06	456.4
BSN11	0.09	159.4	12:40	25.7
Junct-09	1.35	1405.4	12:56	482.1
Woodstock	1.35	1405.4	12:56	482.1
through-12	1.35	1405.4	12:56	482.1
BSN12	0.28	401.4	13:01	86.5
Junct-10	1.63	1804.3	12:58	568.6
Michael	1.63	1804.3	12:58	568.6
through-13	1.63	1804.3	12:58	568.6
BSN13	0.04	90.9	12:27	11.6
Outfall	1.67	1842.9	12:56	580.2

2-YEAR - ALTERNATIVE #1A				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	144.6	13:41	42.2
BSN1B	0.14	64.2	13:29	17.0
Community Drive	0.48	207.5	13:38	59.1
BSN2	0.04	29.6	12:51	5.1
Junct-01	0.52	221.1	13:34	64.3
through-3	0.52	221.1	13:41	64.2
BSN3	0.10	74.4	12:46	12.0
Junct-02	0.61	248.8	13:30	76.2
Railroad West	0.61	243.0	13:46	76.2
BSN4	0.15	52.1	13:35	14.2
Junct-03	0.77	294.1	13:43	90.4
through-5	0.77	294.1	14:03	90.0
BSN6	0.13	97.0	12:50	16.5
through-7	0.13	97.0	12:50	16.5
BSN7	0.16	126.4	12:35	16.3
Junct-06	0.29	213.0	12:39	32.8
Railroad East	0.29	213.0	12:39	32.8
through-8	0.29	213.0	12:39	32.8
BSN8	0.05	57.8	12:25	6.2
Junct-05	0.34	258.2	12:36	39.0
BSN5	0.04	80.3	12:16	7.0
Junct-04	1.15	377.3	12:49	136.0
through-9	1.15	377.3	12:49	136.0
BSN9	0.06	42.6	12:34	5.4
Junct-07	1.21	414.3	12:42	141.4
through-10	1.21	414.3	12:42	141.4
BSN10	0.05	61.0	12:16	4.8
Junct-08	1.27	434.7	12:36	146.2
Ketch	1.27	434.7	12:36	146.2
through-11	1.27	434.7	12:36	146.2
BSN11	0.09	53.4	12:42	7.8
Junct-09	1.35	487.0	12:38	154.0
Woodstock	1.35	487.0	12:38	154.0
through-12	1.35	487.0	12:38	154.0
BSN12	0.28	137.9	13:02	27.5
Junct-10	1.63	599.5	12:47	181.5
Michael	1.63	599.5	12:47	181.5
through-13	1.63	599.5	12:47	181.5
BSN13	0.04	32.3	12:28	3.6
Outfall	1.67	620.4	12:44	185.1

10-YEAR - ALTERNATIVE #1A				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	231.4	13:40	70.0
BSN1B	0.14	105.3	13:28	28.8
Community Drive	0.48	334.6	13:38	98.8
BSN2	0.04	46.9	12:51	8.6
Junct-01	0.52	356.4	13:33	107.4
through-3	0.52	356.4	13:40	107.2
BSN3	0.10	117.5	12:46	20.1
Junct-02	0.61	403.1	13:26	127.3
Railroad West	0.61	355.8	14:06	127.3
BSN4	0.15	93.2	13:33	25.9
Junct-03	0.77	440.6	13:50	153.2
through-5	0.77	440.6	14:10	152.6
BSN6	0.13	151.5	12:49	27.3
through-7	0.13	151.5	12:49	27.3
BSN7	0.16	211.1	12:34	28.8
Junct-06	0.29	346.9	12:39	56.1
Railroad East	0.29	346.9	12:39	56.1
through-8	0.29	346.9	12:39	56.1
BSN8	0.05	88.7	12:25	10.3
Junct-05	0.34	418.2	12:35	66.4
BSN5	0.04	111.0	12:16	10.9
Junct-04	1.15	622.2	12:42	229.9
through-9	1.15	622.2	12:42	229.9
BSN9	0.06	75.6	12:34	10.1
Junct-07	1.21	692.1	12:42	240.0
through-10	1.21	692.1	12:42	240.0
BSN10	0.05	102.3	12:15	8.8
Junct-08	1.27	723.9	12:34	248.8
Ketch	1.27	723.9	12:34	248.8
through-11	1.27	723.9	12:34	248.8
BSN11	0.09	94.2	12:41	14.4
Junct-09	1.35	816.9	12:42	263.2
Woodstock	1.35	816.9	12:42	263.2
through-12	1.35	816.9	12:42	263.2
BSN12	0.28	240.0	13:02	49.3
Junct-10	1.63	1014.9	12:42	312.5
Michael	1.63	1014.9	12:42	312.5
through-13	1.63	1014.9	12:42	312.5
BSN13	0.04	55.1	12:28	6.5
Outfall	1.67	1056.2	12:42	319.0

25-YEAR - ALTERNATIVE #1A				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	285.3	13:39	89.6
BSN1B	0.14	131.1	13:28	37.2
Community Drive	0.48	413.9	13:37	126.8
BSN2	0.04	57.7	12:51	11.1
Junct-01	0.52	441.1	13:33	137.9
through-3	0.52	441.1	13:40	137.6
BSN3	0.10	144.3	12:46	25.9
Junct-02	0.61	497.7	13:28	163.5
Railroad West	0.61	400.3	14:18	163.5
BSN4	0.15	120.4	13:32	34.5
Junct-03	0.77	501.0	13:48	198.0
through-5	0.77	501.0	14:08	197.0
BSN6	0.13	185.3	12:49	35.1
through-7	0.13	185.3	12:49	35.1
BSN7	0.16	265.4	12:34	38.0
Junct-06	0.29	431.3	12:39	73.1
Railroad East	0.29	431.3	12:39	73.1
through-8	0.29	431.3	12:39	73.1
BSN8	0.05	107.8	12:25	13.3
Junct-05	0.34	519.0	12:35	86.5
BSN5	0.04	129.5	12:16	13.6
Junct-04	1.15	769.9	12:35	297.1
through-9	1.15	769.9	12:35	297.1
BSN9	0.06	97.3	12:33	13.6
Junct-07	1.21	866.9	12:35	310.7
through-10	1.21	866.9	12:35	310.7
BSN10	0.05	128.8	12:15	11.8
Junct-08	1.27	926.5	12:34	322.5
Ketch	1.27	926.5	12:34	322.5
through-11	1.27	926.5	12:34	322.5
BSN11	0.09	121.0	12:41	19.3
Junct-09	1.35	1042.6	12:34	341.8
Woodstock	1.35	1042.6	12:34	341.8
through-12	1.35	1042.6	12:34	341.8
BSN12	0.28	306.3	13:01	65.3
Junct-10	1.63	1259.2	12:38	407.1
Michael	1.63	1259.2	12:38	407.1
through-13	1.63	1259.2	12:38	407.1
BSN13	0.04	69.8	12:27	8.7
Outfall	1.67	1320.2	12:36	415.8

50-YEAR - ALTERNATIVE #1A				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	351.5	13:38	116.5
BSN1B	0.14	149.4	13:28	42.5
Community Drive	0.48	498.5	13:36	159.0
BSN2	0.04	72.0	12:50	14.9
Junct-01	0.52	532.5	13:32	174.0
through-3	0.52	532.5	13:39	173.7
BSN3	0.10	179.8	12:45	34.9
Junct-02	0.61	604.1	13:26	208.6
Railroad West	0.61	542.0	14:01	208.6
BSN4	0.15	166.0	13:30	49.3
Junct-03	0.77	688.8	13:54	257.9
through-5	0.77	688.8	14:14	257.0
BSN6	0.13	215.3	12:49	41.5
through-7	0.13	215.3	12:49	41.5
BSN7	0.16	320.3	12:34	46.7
Junct-06	0.29	512.9	12:38	88.1
Railroad East	0.29	512.9	12:38	88.1
through-8	0.29	512.9	12:38	88.1
BSN8	0.05	121.7	12:25	15.2
Junct-05	0.34	613.0	12:35	103.3
BSN5	0.04	143.8	12:16	15.3
Junct-04	1.15	904.0	12:34	375.6
through-9	1.15	904.0	12:34	375.6
BSN9	0.06	112.7	12:33	15.8
Junct-07	1.21	1016.5	12:34	391.3
through-10	1.21	1016.5	12:34	391.3
BSN10	0.05	147.6	12:15	13.6
Junct-08	1.27	1091.6	12:31	405.0
Ketch	1.27	1091.6	12:31	405.0
through-11	1.27	1091.6	12:31	405.0
BSN11	0.09	139.9	12:41	22.3
Junct-09	1.35	1221.9	12:33	427.3
Woodstock	1.35	1221.9	12:33	427.3
through-12	1.35	1221.9	12:33	427.3
BSN12	0.28	353.0	13:01	75.4
Junct-10	1.63	1472.8	12:38	502.7
Michael	1.63	1472.8	12:38	502.7
through-13	1.63	1472.8	12:38	502.7
BSN13	0.04	80.2	12:27	10.1
Outfall	1.67	1541.9	12:37	512.8

100-YEAR - ALTERNATIVE #1A				
Hydrologic Element	**Drainage Area (mi^2)**	**Peak Discharge (CFS)**	**Time of Peak**	**Volume (AC-FT)**
BSN1A	0.33	390.1	13:38	130.1
BSN1B	0.14	168.3	13:27	48.3
Community Drive	0.48	555.7	13:36	178.4
BSN2	0.04	79.5	12:50	16.6
Junct-01	0.52	593.6	13:31	195.0
through-3	0.52	593.6	13:38	194.7
BSN3	0.10	198.5	12:45	38.9
Junct-02	0.61	673.3	13:26	233.7
Railroad West	0.61	616.2	13:58	233.7
BSN4	0.15	185.5	13:30	55.6
Junct-03	0.77	784.4	13:51	289.3
through-5	0.77	784.4	14:11	288.1
BSN6	0.13	239.9	12:49	46.8
through-7	0.13	239.9	12:49	46.8
BSN7	0.16	359.5	12:34	53.1
Junct-06	0.29	574.1	12:38	99.9
Railroad East	0.29	574.1	12:38	99.9
through-8	0.29	574.1	12:38	99.9
BSN8	0.05	135.7	12:25	17.2
Junct-05	0.34	686.2	12:35	117.1
BSN5	0.04	157.9	12:16	17.1
Junct-04	1.15	1000.1	12:34	422.3
through-9	1.15	1000.1	12:34	422.3
BSN9	0.06	128.5	12:33	18.2
Junct-07	1.21	1128.5	12:34	440.5
through-10	1.21	1128.5	12:34	440.5
BSN10	0.05	166.9	12:15	15.7
Junct-08	1.27	1214.7	12:30	456.2
Ketch	1.27	1214.7	12:30	456.2
through-11	1.27	1214.7	12:30	456.2
BSN11	0.09	159.4	12:40	25.7
Junct-09	1.35	1362.3	12:32	482.0
Woodstock	1.35	1362.3	12:32	482.0
through-12	1.35	1362.3	12:32	482.0
BSN12	0.28	401.4	13:01	86.5
Junct-10	1.63	1664.0	12:42	568.5
Michael	1.63	1664.0	12:42	568.5
through-13	1.63	1664.0	12:42	568.5
BSN13	0.04	90.9	12:27	11.6
Outfall	1.67	1735.3	12:40	580.1

Appendix I:
Hydrology Calculations

List of Contents:

SCS Runoff Curve Number - Existing Conditons

Project: Maple Creek Tributary #2
Prepared by: EVH/RWH
Checked by: DJK/JPK
Date: April 11, 2011

Basin: 1A

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	A	72	20.77	0.03245	1495
Agricultural	B	81	3.62	0.00566	293
Agricultural	B/D	91	1.23	0.00192	112
Commercial Corridor	B	97	6.37	0.00995	618
Commercial Corridor	B/D	98	9.67	0.01511	948
Commercial Corridor	D	98	1.11	0.00173	109
Heavy Industrial	B	98	43.33	0.06770	4246
Heavy Industrial	B/D	98	17.06	0.02666	1672
Heavy Industrial	D	98	7.29	0.01139	714
Open Space/Park (Fair Condition)	B	69	13.14	0.02053	907
Open Space/Park (Fair Condition)	B/D	84	1.78	0.00278	150
Open Space/Park (Fair Condition)	D	84	4.36	0.00681	366
Mobile Home Park	B	94	26.58	0.04153	2499
Mobile Home Park	D	97	12.81	0.02002	1243
Office and Institutional	B	97	3.81	0.00595	370
Office and Institutional	D	98	0.15	0.00023	15
Medium Density Multi-Family Residential	B	85	1.75	0.00273	149
Medium Density Multi-Family Residential	B/D	92	0.98	0.00153	90
Medium Density Multi-Family Residential	D	92	0.04	0.00006	4
Woods	B	55	9.13	0.01427	502
Woods	B/D	77	7.47	0.01167	575
Woods	D	77	1.19	0.00186	92
Right of Way	A	83	2.38	0.00372	198
Right of Way	B	89	12.05	0.01883	1072
Right of Way	B/D	93	4.95	0.00773	460
		Totals =	213.02	0.33284	18897

Total (weighted) RCN = total product/total area = 88.71

RCN used = 89

Basin: 1B

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Mobile Home Park Conditional Use	B	94	4.44	0.00694	418
Mobile Home Park Conditional Use	B/D	97	36.99	0.05780	3588
Manufactured Residential	B/D	92	1.36	0.00213	125
Manufactured Residential	D	92	0.16	0.00025	15
Open Space/Park (Fair Condition)	B	69	7.13	0.01114	492
Right of Way	B	89	1.68	0.00262	149
Right of Way	B/D	93	8.63	0.01349	803
Right of Way	D	93	0.04	0.00006	4
Woods	B/D	77	31.66	0.04947	2438
		Totals =	92.10	0.14390	8031

Total (weighted) RCN = total product/total area = 87.21

RCN used = 87

SCS Runoff Curve Number - Existing Conditons

Project: Maple Creek Tributary #2
Prepared by: EVH/RWH
Checked by: DJK/JPK

Basin: 2

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Heavy Industrial	B	98	1.19	0.00186	117
Heavy Industrial	B/D	98	8.11	0.01267	795
Right of Way	B	89	0.22	0.00034	20
Right of Way	B/D	93	5.04	0.00788	469
Woods	B	55	0.01	0.00002	1
Woods	B/D	77	11.91	0.01861	917
		Totals =	26.48	0.04138	2317

Total (weighted) RCN = total product/total area = 87.51

RCN used = 88

Basin: 3

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	6.80	0.01063	551
Agricultural	B/D	91	2.06	0.00322	188
Business Service (Commercial)	B	97	5.82	0.00910	565
Business Service (Commercial)	B/D	98	12.69	0.01983	1244
Business Service (Commercial)	B	98	0.79	0.00124	78
Light Industrial	B	98	0.17	0.00026	16
Light Industrial	D	98	0.04	0.00007	4
Heavy Industrial	B	98	0.03	0.00005	3
Heavy Industrial	B/D	98	11.27	0.01761	1104
Right of Way	B	89	1.38	0.00215	122
Right of Way	B/D	93	3.56	0.00556	331
Right of Way	D	93	0.52	0.00081	48
Woods	B	55	3.09	0.00482	170
Woods	B/D	77	13.67	0.02136	1053
		Totals =	61.90	0.09672	5477

Total (weighted) RCN = total product/total area = 88.49

RCN used = 88

Basin: 4

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Business Service (Commercial)	B	97	0.80	0.00124	77
Business Service (Commercial)	B/D	98	0.52	0.00082	51
Business Service (Commercial)	D	98	0.50	0.00078	49
Heavy Industrial	B	98	7.37	0.01152	723
Heavy Industrial	B/D	98	0.46	0.00072	45
Open Space/Park (Fair Condition)	B	69	21.44	0.03350	1479
Open Space/Park (Fair Condition)	B/D	84	39.04	0.06100	3279
Right of Way	B	89	1.36	0.00213	121
Right of Way	B/D	93	6.65	0.01039	618
Right of Way	D	93	0.01	0.00002	1
Woods	B	55	0.41	0.00064	23
Woods	B/D	77	16.57	0.02589	1276
Woods	D	77	3.61	0.00564	278
		Totals =	98.75	0.15429	8021

Total (weighted) RCN = total product/total area = 81.23

RCN used = 81

SCS Runoff Curve Number - Existing Conditons

Project: Maple Creek Tributary #2
Prepared by: EVH/RWH
Checked by: DJK/JPK

Basin: 5

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	0.10	0.00016	8
Agricultural	B/D	91	0.09	0.00014	8
Light Industrial	B	98	0.39	0.00062	39
Light Industrial	D	98	0.31	0.00049	31
Mobile Home Park	B	94	18.65	0.02913	1753
Mobile Home Park	B/D	97	0.23	0.00036	22
Mobile Home Park	D	97	7.43	0.01162	721
Right of Way	B	89	0.42	0.00066	38
Right of Way	D	93	0.31	0.00049	29
		Totals =	27.94	0.04366	2648

Total (weighted) RCN = total product/total area = 94.78

RCN used = 95

Basin: 6

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	2.87	0.00448	232
Commercial Corridor Conditional Use	B	97	0.15	0.00024	15
Commercial Corridor Conditional Use	D	98	0.27	0.00042	26
Mobile Home Park Conditional Use	B	94	0.37	0.00057	34
Mobile Home Park Conditional Use	B/D	97	2.12	0.00331	206
Office and Institutional	B	97	0.21	0.00033	21
Office and Institutional	D	98	0.58	0.00090	56
Open Space/Park (Fair Condition)	B	69	5.69	0.00889	393
Low Density Residential	B	75	2.27	0.00355	170
Low Density Residential	D	87	21.67	0.03386	1885
Multi-Family Residential	B	90	1.32	0.00207	119
Multi-Family Residential	B/D	96	0.64	0.00100	61
Multi-Family Residential	D	96	19.33	0.03020	1856
Manufactured Residential	B	80	0.24	0.00037	19
Manufactured Residential	B/D	92	0.70	0.00109	64
Manufactured Residential	D	92	5.10	0.00798	470
Right of Way	B	89	4.62	0.00722	411
Right of Way	B/D	93	1.33	0.00208	124
Right of Way	D	93	9.46	0.01478	880
Woods	B/D	77	3.22	0.00503	248
		Totals =	82.16	0.12837	7290

Total (weighted) RCN = total product/total area = 88.74

RCN used = 89

SCS Runoff Curve Number - Existing Conditons

Project: Maple Creek Tributary #2
Prepared by: EVH/RWH
Checked by: DJK/JPK

Basin: 7

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	3.05	0.00477	247
Agricultural	B/D	91	4.25	0.00664	387
Commercial Corridor Conditional Use	B	97	0.85	0.00133	82
Commercial Corridor Conditional Use	D	98	0.15	0.00023	15
Office and Institutional	B	97	1.44	0.00225	140
Office and Institutional	B/D	98	0.61	0.00095	60
Open Space/Park (Fair Condition)	B	69	7.82	0.01222	540
Low Density Residential	B	75	0.83	0.00130	62
Very Low Density Residential	B	75	23.33	0.03645	1750
Very Low Density Residential	B/D	87	3.60	0.00563	313
Multi-Family Residential	B	90	13.48	0.02106	1213
Multi-Family Residential	B/D	96	13.44	0.02100	1290
Multi-Family Residential	D	96	2.69	0.00420	258
Right of Way	B	89	8.89	0.01389	791
Right of Way	B/D	93	3.70	0.00578	344
Right of Way	D	93	0.58	0.00091	54
Woods	B	55	2.51	0.00392	138
Woods	B/D	77	10.56	0.01650	813
		Totals =	101.78	0.15903	8497

Total (weighted) RCN = total product/total area = 83.49

RCN used = 83

Basin: 8

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Light Industrial	B	98	7.34	0.01147	720
Light Industrial	B/D	98	0.04	0.00006	4
Light Industrial	D	98	0.12	0.00019	12
Mobile Home Park	B	94	4.17	0.00652	392
Mobile Home Park	D	97	2.13	0.00333	207
Very Low Density Residential	B	75	8.77	0.01370	657
Very Low Density Residential	B/D	87	0.91	0.00143	79
Very Low Density Residential	D	87	3.22	0.00503	280
Right of Way	B	89	3.34	0.00523	298
Right of Way	B/D	93	1.01	0.00157	94
Right of Way	D	93	0.45	0.00071	42
Woods	B	55	0.13	0.00020	7
Woods	B/D	77	0.10	0.00016	8
		Totals =	31.73	0.04959	2799

Total (weighted) RCN = total product/total area = 88.20

RCN used = 88

SCS Runoff Curve Number - Existing Conditons

Project: Maple Creek Tributary #2
Prepared by: EVH/RWH
Checked by: DJK/JPK

Basin: 9

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	20.67	0.03230	1674
Agricultural	B/D	91	0.77	0.00120	70
Agricultural	C	88	0.23	0.00037	21
Agricultural	D	91	1.55	0.00242	141
Mobile Home Park	B	94	0.26	0.00040	24
Mobile Home Park	D	97	0.15	0.00024	15
Low Density Residential	B	75	0.02	0.00003	1
Very Low Density Residential	B	75	3.84	0.00599	288
Very Low Density Residential	B/D	87	2.90	0.00453	252
Very Low Density Residential	D	87	0.49	0.00076	43
Right of Way	B	89	1.01	0.00158	90
Right of Way	B/D	93	0.39	0.00062	37
Woods	B	55	3.91	0.00611	215
Woods	B/D	77	0.57	0.00089	44
Woods	C	70	2.21	0.00345	155
Woods	D	77	1.16	0.00181	89
		Totals =	40.13	0.06271	3159

Total (weighted) RCN = total product/total area = 78.70

RCN used = 79

Basin: 10

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	7.69	0.01202	623
Agricultural	B/D	91	1.06	0.00166	96
Agricultural	D	91	2.45	0.00383	223
Low Density Residential	B	75	6.32	0.00987	474
Low Density Residential	B/D	87	0.67	0.00105	58
Low Density Residential	C	83	6.16	0.00962	511
Low Density Residential	D	87	2.50	0.00391	218
Right of Way	B	89	0.88	0.00138	79
Right of Way	C	92	1.35	0.00211	124
Right of Way	D	93	0.05	0.00009	5
Woods	B	55	3.19	0.00498	175
Woods	C	70	1.46	0.00228	102
		Totals =	33.79	0.05279	2689

Total (weighted) RCN = total product/total area = 79.58

RCN used = 80

SCS Runoff Curve Number - Existing Conditons

Project: Maple Creek Tributary #2
Prepared by: EVH/RWH
Checked by: DJK/JPK

Basin: 11

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	1.50	0.00234	121
Low Density Residential	B	75	31.67	0.04948	2375
Low Density Residential	B/D	87	2.36	0.00369	205
Low Density Residential	C	83	0.34	0.00053	28
Low Density Residential	D	87	9.39	0.01467	817
Very Low Density Residential	B	75	1.30	0.00203	97
Very Low Density Residential	D	87	1.32	0.00207	115
Right of Way	B	89	5.44	0.00851	485
Right of Way	B/D	93	0.56	0.00088	53
Right of Way	C	92	0.01	0.00001	1
Right of Way	D	93	1.74	0.00272	162
		Totals =	55.64	0.08694	4459

Total (weighted) RCN = total product/total area = 80.15

RCN used = 80

Basin: 12

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	25.77	0.04026	2087
Agricultural	B/D	91	30.26	0.04729	2754
Agricultural	D	91	1.42	0.00221	129
Low Density Residential	B	75	51.35	0.08024	3851
Low Density Residential	B/D	87	10.42	0.01627	906
Low Density Residential	C	83	5.66	0.00885	470
Low Density Residential	D	87	13.59	0.02123	1182
Very Low Density Residential	B	75	19.37	0.03026	1453
Very Low Density Residential	B/D	87	2.13	0.00333	185
Very Low Density Residential	D	87	4.57	0.00715	398
Right of Way	B	89	12.51	0.01955	1113
Right of Way	B/D	93	1.48	0.00231	138
Right of Way	C	92	0.00	0.00001	0
Right of Way	D	93	2.08	0.00325	194
		Totals =	180.61	0.28221	14861

Total (weighted) RCN = total product/total area = 82.28

RCN used = 82

Basin: 13

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Low Density Residential	B	75	0.01	0.00002	1
Very Low Density Residential	B	75	12.17	0.01902	913
Very Low Density Residential	C	83	1.07	0.00166	88
Very Low Density Residential	D	87	8.29	0.01295	721
Right of Way	B	89	1.56	0.00244	139
Right of Way	C	92	0.44	0.00068	40
Right of Way	D	93	0.93	0.00145	86
		Totals =	24.46	0.03823	1989

Total (weighted) RCN = total product/total area = 81.29

RCN used = 81

SCS Runoff Curve Number - Future Conditons

Project: Maple Creek Tributary #2
Prepared by: ERB
Checked by: EVH
Date: April 11, 2011

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	A	72	1.56	0.00244	112
Agricultural	B	81	1.91	0.00298	155
Commercial Corridor	A	96	0.41	0.00064	39
Commercial Corridor	B	97	16.25	0.02539	1576
Commercial Corridor	B/D	98	9.67	0.01511	948
Commercial Corridor	D	98	1.11	0.00173	109
Business Service (Commercial)	B	97	3.13	0.00489	304
Business Service (Commercial)	B/D	98	1.30	0.00203	127
Business Service (Commercial)	D	98	1.15	0.00180	113
Heavy Industrial	A	98	19.68	0.03075	1929
Heavy Industrial	B	98	43.33	0.06770	4246
Heavy Industrial	B/D	98	17.06	0.02666	1672
Heavy Industrial	D	98	12.04	0.01881	1180
Mobile Home Park	B	94	18.59	0.02905	1747
Mobile Home Park	B/D	97	26.58	0.04153	2578
Mobile Home Park	D	97	12.91	0.02017	1252
Office and Institutional	B	97	3.81	0.00595	370
Office and Institutional	D	98	0.26	0.00041	25
Medium Density Multi-Family Residential	B	85	1.75	0.00273	149
Medium Density Multi-Family Residential	B/D	92	0.98	0.00153	90
Medium Density Multi-Family Residential	D	92	0.16	0.00025	15
Right of Way	A	83	2.38	0.00372	198
Right of Way	B	89	12.05	0.01883	1072
Right of Way	B/D	93	4.95	0.00773	460
		Totals =	213.02	0.33284	20467

Total (weighted) RCN = total product/total area = 96.08

RCN used = 96

Basin: 1B

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial Corridor	B	97	5.96	0.00931	578
Commercial Corridor	B/D	98	1.49	0.00233	146
Heavy Industrial	B/D	98	31.25	0.04883	3063
Mobile Home Park	B	94	4.44	0.00694	418
Mobile Home Park	B/D	97	36.99	0.05780	3588
Manufactured Residential	B/D	92	1.41	0.00220	130
Manufactured Residential	D	92	0.20	0.00031	18
Right of Way	B	89	1.68	0.00262	149
Right of Way	B/D	93	8.63	0.01349	803
Right of Way	D	93	0.04	0.00006	4
		Totals =	92.10	0.14390	8897

Total (weighted) RCN = total product/total area = 96.60

RCN used = 97

SCS Runoff Curve Number - Future Conditons

Project: Maple Creek Tributary #2
Prepared by: ERB
Checked by: EVH

Basin: 2

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Heavy Industrial	B	98	1.20	0.00188	118
Heavy Industrial	B/D	98	20.01	0.03127	1961
Right of Way	B	89	0.22	0.00034	20
Right of Way	B/D	93	5.04	0.00788	469
		Totals =	26.47	0.04136	2567

Total (weighted) RCN = total product/total area = 96.97

RCN used = 97

Basin: 3

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	9.90	0.01547	802
Agricultural	B/D	91	15.73	0.02458	1431
Business Service (Commercial)	B	97	5.82	0.00910	565
Business Service (Commercial)	B/D	98	12.69	0.01983	1244
Business Service (Commercial)	B	98	0.80	0.00125	78
Light Industrial	B	98	0.17	0.00026	16
Light Industrial	D	98	0.04	0.00007	4
Heavy Industrial	B	98	0.03	0.00005	3
Heavy Industrial	B/D	98	11.27	0.01761	1104
Right of Way	B	89	1.38	0.00215	122
Right of Way	B/D	93	3.56	0.00556	331
Right of Way	D	93	0.52	0.00081	48
		Totals =	61.91	0.09674	5750

Total (weighted) RCN = total product/total area = 92.88

RCN used = 93

Basin: 4

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B/D	81	20.59	0.03217	1668
Agricultural	D	91	38.30	0.05984	3485
Business Service (Commercial)	B	97	0.80	0.00124	77
Business Service (Commercial)	B/D	98	0.52	0.00082	51
Business Service (Commercial)	D	98	0.50	0.00078	49
Heavy Industrial	B	98	11.04	0.01725	1082
Heavy Industrial	B/D	98	18.96	0.02963	1858
Right of Way	B	89	1.36	0.00213	121
Right of Way	B/D	93	6.65	0.01039	618
Right of Way	D	93	0.01	0.00002	1
		Totals =	98.73	0.15427	9012

Total (weighted) RCN = total product/total area = 91.27

RCN used = 91

SCS Runoff Curve Number - Future Conditons

Project: Maple Creek Tributary #2
Prepared by: ERB
Checked by: EVH

Basin: 5

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	0.10	0.00016	8
Agricultural	B/D	91	0.09	0.00014	8
Light Industrial	B	98	0.39	0.00062	39
Light Industrial	D	98	0.31	0.00049	31
Mobile Home Park	B	94	18.65	0.02913	1753
Mobile Home Park	B/D	97	0.23	0.00036	22
Mobile Home Park	D	97	7.43	0.01162	721
Right of Way	B	89	0.42	0.00066	38
Right of Way	D	93	0.31	0.00049	29
		Totals =	27.94	0.04366	2648

Total (weighted) RCN = total product/total area = 94.78

RCN used = 95

Basin: 6

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	2.87	0.00448	232
Agricultural	B/D	91	3.22	0.00503	293
Commercial Corridor	B	97	5.83	0.00911	566
Commercial Corridor	B/D	98	0.01	0.00002	1
Commercial Corridor	D	98	0.27	0.00042	26
Mobile Home Park	B	94	0.37	0.00057	34
Mobile Home Park	B/D	97	2.12	0.00331	206
Office and Institutional	B	97	0.21	0.00033	21
Office and Institutional	D	98	0.58	0.00090	56
Low Density Residential	B	75	2.27	0.00355	170
Low Density Residential	D	87	21.67	0.03386	1885
Multi-Family Residential	B	90	1.32	0.00207	119
Multi-Family Residential	B/D	96	0.64	0.00100	61
Multi-Family Residential	D	96	19.33	0.03020	1856
Manufactured Residential	B	80	0.24	0.00037	19
Manufactured Residential	B/D	92	0.70	0.00109	64
Manufactured Residential	D	92	5.10	0.00798	470
Right of Way	B	89	4.62	0.00722	411
Right of Way	B/D	93	1.33	0.00208	124
Right of Way	D	93	9.46	0.01478	880
		Totals =	82.16	0.12837	7495

Total (weighted) RCN = total product/total area = 91.22

RCN used = 91

SCS Runoff Curve Number - Future Conditons

Project: Maple Creek Tributary #2
Prepared by: ERB
Checked by: EVH

Basin: 7

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Commercial Corridor	B	97	1.44	0.00225	140
Commercial Corridor	D	98	0.15	0.00023	15
Heavy Industrial	B	98	0.17	0.00027	17
Low Density Residential	B	75	8.51	0.01330	638
Low Density Residential	B/D	87	0.93	0.00145	81
Very Low Density Residential	B	75	23.33	0.03645	1750
Very Low Density Residential	B/D	87	8.48	0.01325	738
Multi-Family Residential	B	90	20.45	0.03195	1841
Multi-Family Residential	B/D	96	20.83	0.03255	2000
Multi-Family Residential	D	96	2.69	0.00420	258
Right of Way	B	89	8.89	0.01389	791
Right of Way	B/D	93	3.70	0.00578	344
Right of Way	D	93	0.58	0.00091	54
Woods	B	55	0.85	0.00133	47
Woods	B/D	77	0.78	0.00122	60
		Totals =	101.78	0.15903	8772

Total (weighted) RCN = total product/total area = 86.19

RCN used = 86

Basin: 8

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Light Industrial	B	98	7.34	0.01147	720
Light Industrial	B/D	98	0.04	0.00006	4
Light Industrial	D	98	0.12	0.00019	12
Mobile Home Park	B	94	4.17	0.00652	392
Mobile Home Park	D	97	2.13	0.00333	207
Very Low Density Residential	B	75	8.77	0.01370	657
Very Low Density Residential	B/D	87	0.91	0.00143	79
Very Low Density Residential	D	87	3.22	0.00503	280
Right of Way	B	89	3.34	0.00523	298
Right of Way	B/D	93	1.01	0.00157	94
Right of Way	D	93	0.45	0.00071	42
Woods	B	55	0.13	0.00020	7
Woods	B/D	77	0.10	0.00016	8
		Totals =	31.73	0.04959	2799

Total (weighted) RCN = total product/total area = 88.20

RCN used = 88

SCS Runoff Curve Number - Future Conditons

Project: Maple Creek Tributary #2
Prepared by: ERB
Checked by: EVH

Basin: 9

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Mobile Home Park	B	94	0.26	0.00040	24
Mobile Home Park	D	97	0.15	0.00024	15
Low Density Residential	B	75	23.96	0.03744	1797
Low Density Residential	B/D	87	1.81	0.00283	157
Low Density Residential	C	83	3.97	0.00620	330
Low Density Residential	D	87	1.35	0.00211	117
Very Low Density Residential	B	75	3.84	0.00599	288
Very Low Density Residential	B/D	87	2.90	0.00453	252
Very Low Density Residential	D	87	0.49	0.00076	43
Right of Way	B	89	1.01	0.00158	90
Right of Way	B/D	93	0.39	0.00062	37
		Totals =	40.13	0.06270	3150

Total (weighted) RCN = total product/total area = 78.48

RCN used = 78

Basin: 10

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Low Density Residential	B	75	16.92	0.02644	1269
Low Density Residential	B/D	87	1.83	0.00286	159
Low Density Residential	C	83	7.32	0.01144	608
Low Density Residential	D	87	5.43	0.00848	472
Right of Way	B	89	0.88	0.00138	79
Right of Way	C	92	1.35	0.00211	124
Right of Way	D	93	0.05	0.00009	5
		Totals =	33.79	0.05280	2716

Total (weighted) RCN = total product/total area = 80.39

RCN used = 80

Basin: 11

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	1.50	0.00234	121
Low Density Residential	B	75	31.67	0.04948	2375
Low Density Residential	B/D	87	2.36	0.00369	205
Low Density Residential	C	83	0.34	0.00053	28
Low Density Residential	D	87	9.39	0.01467	817
Very Low Density Residential	B	75	1.30	0.00203	97
Very Low Density Residential	D	87	1.32	0.00207	115
Right of Way	B	89	5.44	0.00851	485
Right of Way	B/D	93	0.56	0.00088	53
Right of Way	C	92	0.01	0.00001	1
Right of Way	D	93	1.74	0.00272	162
		Totals =	55.64	0.08694	4459

Total (weighted) RCN = total product/total area = 80.15

RCN used = 80

SCS Runoff Curve Number - Future Conditons

Project: Maple Creek Tributary #2
Prepared by: ERB
Checked by: EVH

Basin: 12

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Agricultural	B	81	25.77	0.04026	2087
Agricultural	B/D	91	30.26	0.04729	2754
Agricultural	D	91	1.42	0.00221	129
Low Density Residential	B	75	51.35	0.08024	3851
Low Density Residential	B/D	87	10.42	0.01627	906
Low Density Residential	C	83	5.66	0.00884	470
Low Density Residential	D	87	13.59	0.02123	1182
Very Low Density Residential	B	75	19.37	0.03026	1453
Very Low Density Residential	B/D	87	2.13	0.00333	185
Very Low Density Residential	D	87	4.57	0.00715	398
Right of Way	B	89	12.51	0.01955	1113
Right of Way	B/D	93	1.48	0.00231	138
Right of Way	C	92	0.00	0.00001	0
Right of Way	D	93	2.08	0.00325	194
		Totals =	180.61	0.28221	14860

Total (weighted) RCN = total product/total area = 82.28

RCN used = 82

Basin: 13

Landuse	Soil Group	RCN	Area (Acres)	Area (Sq. Mi.)	Product of RCN and Area
Low Density Residential	B	75	0.01	0.00002	1
Very Low Density Residential	B	75	12.17	0.01902	913
Very Low Density Residential	C	83	1.07	0.00166	88
Very Low Density Residential	D	87	8.29	0.01295	721
Right of Way	B	89	1.56	0.00244	139
Right of Way	C	92	0.44	0.00068	40
Right of Way	D	93	0.93	0.00145	86
		Totals =	24.46	0.03823	1989

Total (weighted) RCN = total product/total area = 81.29

RCN used = 81

Project: Maple Creek Trib #2
Prepared by: RWH/EVH
Checked by: DJK
Date: March 14, 2012

Time of Concentration Calculations

BASIN	Sheet Flow						Shallow Concentration					Channel Flow									
	Description Grass/Woods/ Pavement	n	Flow Length (ft)	P-2 (in)	Land Slope (ft/ft)	Tt (min)	Surface Description 0--Unpaved/1-Paved	Flow Length (ft)	Slope (ft/ft)	Velocity (ft/s)	Tt (min)	Channel Area (ft2)	Channel Perimeter (ft)	Hydraulic Radius (ft)	Slope (ft/ft)	n	Velocity (ft/s)	Flow Length (ft)	Tt (min)	Tc (min)	Lag (min)
1A	Grass	0.24	112	3.60	0.009	20.34	0 1 0 1 0	433 60 231 127 427	0.005 0.017 0.017 0.004 0.011	1.10 2.62 2.12 1.28 1.66	6.58 0.38 1.81 1.66 4.30	Pipe 14.00	11.94	1.17	0.031 0.002	0.013 0.06	5.00 1.07	65 3882	0.22 60.48	95.77	57.46
1B	Woods	0.40	300	3.60	0.013	57.34	0	872	0.003	0.95	15.36	14.00	11.94	1.17	0.005	0.045	2.52	1714	11.35	84.05	50.43
2	Woods	0.40	276	3.60	0.008	65.31	0	587	0.009	1.49	6.57	14.00	11.94	1.17	0.005	0.045	2.58	1173	7.58	79.46	47.68
3	Woods	0.40	230	3.60	0.009	55.01	0	280	0.018	2.16	2.16	14.00	11.94	1.17	0.005	0.045	2.61	2292	14.64	71.81	43.09
4	Woods	0.40	192	3.60	0.005	58.44	0	833	0.006	1.25	11.11	14.00	11.94	1.17	0.006	0.035	3.70	3845	17.31	86.86	52.11
5	Grass	0.24	150	3.60	0.023	17.50						14.00	11.94	1.17	0.006	0.035	3.70	1635	7.36	24.86	14.91
6	Woods	0.40	195	3.60	0.010	45.12	0 1	1025 483	0.014 0.006	1.89 1.60	9.06 5.02	Pipe 14.00 Pipe	11.94	1.17	0.015 0.006 0.002	0.013 0.06 0.013	5.00 2.12 5.00	136 2032 535	0.45 15.96 1.78	77.40	46.44
7	Grass	0.24	150	3.60	0.003	38.11	0	209	0.012	1.76	1.97	27.00	16.42	1.64	0.006	0.045	3.67	2541	11.55	51.63	30.98
8	Grass	0.24	150	3.60	0.007	28.88	0	368	0.018	2.14	2.86	27.00	16.42	1.64	0.006	0.045	3.49	1399	6.67	38.41	23.05
9	Woods	0.40	190	3.60	0.011	43.74	0	600	0.028	2.72	3.68	27.00	16.42	1.64	0.005	0.04	3.74	580	2.59	50.00	30.00
10	Grass	0.24	150	3.60	0.027	16.59	0	112	0.018	2.16	0.87	27.00	16.42	1.64	0.004	0.04	3.08	853	4.61	22.06	13.24
11	Woods	0.40	229	3.60	0.013	46.53	0 1	138 1356	0.007 0.009	1.37 1.91	1.67 11.82	Pipe 27.00	16.42	1.64	0.060 0.005	0.013 0.045	5.00 3.14	251 216	0.84 1.14	62.00	37.20
12	Woods	0.40	247	3.60	0.010	54.80	0	585	0.014	1.89	5.17	14.00 Pipe 27.00	11.94 16.42	1.17 1.64	0.007 0.006 0.002	0.045 0.013 0.045	3.11 5.00 2.16	1402 2084 2752	7.51 6.95 21.26	95.69	57.41
13	Woods	0.40	210	3.60	0.029	31.78	0 1 0	274 81 273	0.026 0.012 0.024	2.58 2.26 2.49	1.77 0.60 1.83	Pipe 27.00	16.42	1.64	0.015 0.008	0.013 0.045	5.00 4.04	365 916	1.22 3.78	40.97	24.58

Appendix J:
HEC-RAS Output

List of Contents:

EXISTING CONDITIONS ANALYSIS

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	10365	2-yr	470.00	96.44	101.70	101.15	101.92	0.005001	5.10	172.61	125.47	0.42
Alignment - (1)	10365	10-yr	720.00	96.44	102.24	101.61	102.47	0.005003	5.50	246.01	143.70	0.43
Alignment - (1)	10365	25-yr	885.00	96.44	102.53	101.81	102.76	0.005002	5.71	288.60	151.00	0.43
Alignment - (1)	10365	50-yr	1026.00	96.44	102.75	102.01	103.00	0.005005	5.87	323.52	157.48	0.44
Alignment - (1)	10365	100-yr	1184.00	96.44	102.99	102.15	103.24	0.005002	6.03	361.21	164.18	0.44
Alignment - (1)	10638.24	2-yr	470.00	98.77	103.13		103.28	0.004883	4.62	209.95	149.35	0.42
Alignment - (1)	10638.24	10-yr	720.00	98.77	103.65		103.81	0.004738	4.96	289.89	159.62	0.42
Alignment - (1)	10638.24	25-yr	885.00	98.77	103.93		104.10	0.004742	5.18	336.42	165.84	0.43
Alignment - (1)	10638.24	50-yr	1026.00	98.77	104.16		104.33	0.004704	5.33	374.30	169.71	0.43
Alignment - (1)	10638.24	100-yr	1184.00	98.77	104.39		104.57	0.004715	5.50	413.60	173.70	0.43
Alignment - (1)	10849.17	2-yr	470.00	98.54	103.93		104.07	0.002935	4.13	202.34	113.98	0.34
Alignment - (1)	10849.17	10-yr	720.00	98.54	104.47		104.64	0.003333	4.74	267.57	124.51	0.37
Alignment - (1)	10849.17	25-yr	885.00	98.54	104.78		104.96	0.003516	5.05	306.33	130.09	0.38
Alignment - (1)	10849.17	50-yr	1026.00	98.54	105.01		105.22	0.003667	5.31	337.60	135.40	0.39
Alignment - (1)	10849.17	100-yr	1184.00	98.54	105.25		105.47	0.003807	5.56	371.16	140.66	0.40
Alignment - (1)	11152.11	2-yr	470.00	98.92	104.64		104.71	0.001576	3.22	281.71	138.11	0.25
Alignment - (1)	11152.11	10-yr	720.00	98.92	105.27		105.36	0.001745	3.66	374.50	152.41	0.27
Alignment - (1)	11152.11	25-yr	885.00	98.92	105.62		105.72	0.001828	3.90	429.15	159.85	0.28
Alignment - (1)	11152.11	50-yr	1026.00	98.92	105.89		106.00	0.001882	4.07	473.29	165.32	0.28
Alignment - (1)	11152.11	100-yr	1184.00	98.92	106.17		106.29	0.001948	4.27	520.31	171.87	0.29
Alignment - (1)	11531.01	2-yr	470.00	100.12	105.31		105.48	0.002517	3.96	203.05	119.77	0.35
Alignment - (1)	11531.01	10-yr	720.00	100.12	105.99		106.18	0.002531	4.41	289.03	132.70	0.36
Alignment - (1)	11531.01	25-yr	885.00	100.12	106.36		106.57	0.002551	4.66	339.52	139.23	0.37
Alignment - (1)	11531.01	50-yr	1026.00	100.12	106.65		106.86	0.002571	4.85	379.98	144.24	0.37
Alignment - (1)	11531.01	100-yr	1184.00	100.12	106.94		107.17	0.002594	5.05	423.53	150.10	0.37
Alignment - (1)	11640	2-yr	470.00	101.11	105.61	104.47	105.96	0.005454	4.75	98.89	106.39	0.49
Alignment - (1)	11640	10-yr	720.00	101.11	106.23	105.10	106.79	0.006728	6.00	119.93	117.72	0.56
Alignment - (1)	11640	25-yr	885.00	101.11	106.56	105.46	107.26	0.007589	6.76	130.92	123.62	0.61
Alignment - (1)	11640	50-yr	1026.00	101.11	106.80	105.75	107.64	0.008338	7.38	139.09	128.23	0.64
Alignment - (1)	11640	100-yr	1184.00	101.11	107.04	106.05	108.04	0.009185	8.04	147.23	133.33	0.68
Alignment - (1)	11700		Culvert									

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	11775	2-yr	470.00	100.19	106.21	103.81	106.42	0.001776	3.64	129.21	51.37	0.31
Alignment - (1)	11775	10-yr	720.00	100.19	107.41	104.47	107.71	0.001864	4.38	164.48	65.33	0.33
Alignment - (1)	11775	25-yr	885.00	100.19	108.20	104.86	108.54	0.001817	4.72	187.59	74.78	0.33
Alignment - (1)	11775	50-yr	1026.00	100.19	108.86	105.17	109.24	0.001760	4.96	206.97	83.07	0.33
Alignment - (1)	11775	100-yr	1184.00	100.19	109.59	105.51	110.01	0.001681	5.18	228.65	89.70	0.33
Alignment - (1)	11835	2-yr	441.00	100.00	106.43		106.54	0.001541	3.44	228.66	104.92	0.26
Alignment - (1)	11835	10-yr	649.00	100.00	107.78		107.85	0.000895	3.02	377.25	116.09	0.20
Alignment - (1)	11835	25-yr	766.00	100.00	108.63		108.69	0.000647	2.78	479.42	123.18	0.18
Alignment - (1)	11835	50-yr	868.00	100.00	109.34		109.39	0.000519	2.63	568.61	129.05	0.16
Alignment - (1)	11835	100-yr	996.00	100.00	110.12		110.17	0.000432	2.55	672.07	136.23	0.15
Alignment - (1)	11974.42	2-yr	441.00	100.50	106.67		106.77	0.001680	3.42	240.08	114.56	0.25
Alignment - (1)	11974.42	10-yr	649.00	100.50	107.92		107.99	0.001057	3.09	407.40	153.59	0.21
Alignment - (1)	11974.42	25-yr	766.00	100.50	108.73		108.79	0.000735	2.78	543.67	179.29	0.18
Alignment - (1)	11974.42	50-yr	868.00	100.50	109.42		109.47	0.000555	2.56	674.81	200.94	0.15
Alignment - (1)	11974.42	100-yr	996.00	100.50	110.19		110.23	0.000429	2.38	838.92	226.51	0.14
Alignment - (1)	12143.18	2-yr	441.00	101.50	106.97		107.02	0.001249	2.69	350.94	184.23	0.21
Alignment - (1)	12143.18	10-yr	649.00	101.50	108.10		108.14	0.000719	2.34	576.85	215.55	0.17
Alignment - (1)	12143.18	25-yr	766.00	101.50	108.87		108.89	0.000480	2.07	745.23	227.45	0.14
Alignment - (1)	12143.18	50-yr	868.00	101.50	109.52		109.54	0.000361	1.91	898.38	238.31	0.12
Alignment - (1)	12143.18	100-yr	996.00	101.50	110.27		110.29	0.000276	1.78	1085.09	278.34	0.11
Alignment - (1)	12518.55	2-yr	441.00	101.50	107.47		107.55	0.001568	3.22	267.73	134.57	0.24
Alignment - (1)	12518.55	10-yr	649.00	101.50	108.42		108.49	0.001185	3.12	407.07	157.22	0.22
Alignment - (1)	12518.55	25-yr	766.00	101.50	109.08		109.14	0.000888	2.88	516.30	171.58	0.19
Alignment - (1)	12518.55	50-yr	868.00	101.50	109.69		109.73	0.000691	2.68	623.87	184.27	0.17
Alignment - (1)	12518.55	100-yr	996.00	101.50	110.40		110.44	0.000545	2.53	760.50	201.99	0.15
Alignment - (1)	12742.17	2-yr	441.00	101.89	107.82		107.89	0.001513	3.15	318.79	177.25	0.24
Alignment - (1)	12742.17	10-yr	649.00	101.89	108.69		108.75	0.001120	2.99	482.14	195.48	0.21
Alignment - (1)	12742.17	25-yr	766.00	101.89	109.29		109.33	0.000847	2.76	602.04	205.40	0.19
Alignment - (1)	12742.17	50-yr	868.00	101.89	109.85		109.88	0.000662	2.57	719.64	214.46	0.17
Alignment - (1)	12742.17	100-yr	996.00	101.89	110.52		110.55	0.000512	2.40	868.21	224.74	0.15
Alignment - (1)	13161.24	2-yr	441.00	103.59	108.72		108.92	0.004160	4.68	203.72	142.77	0.38
Alignment - (1)	13161.24	10-yr	649.00	103.59	109.38		109.55	0.003518	4.70	304.25	162.22	0.36

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	13161.24	25-yr	766.00	103.59	109.82		109.96	0.002871	4.48	378.46	176.04	0.33
Alignment - (1)	13161.24	50-yr	868.00	103.59	110.26		110.37	0.002260	4.18	459.62	189.39	0.30
Alignment - (1)	13161.24	100-yr	996.00	103.59	110.84		110.93	0.001681	3.82	574.04	206.21	0.26
Alignment - (1)	13456.23	2-yr	441.00	104.41	109.76		109.88	0.002573	3.80	245.40	138.42	0.30
Alignment - (1)	13456.23	10-yr	649.00	104.41	110.33		110.45	0.002683	4.18	326.94	148.86	0.32
Alignment - (1)	13456.23	25-yr	766.00	104.41	110.64		110.76	0.002610	4.28	374.34	153.91	0.31
Alignment - (1)	13456.23	50-yr	868.00	104.41	110.95		111.07	0.002430	4.28	422.56	159.56	0.31
Alignment - (1)	13456.23	100-yr	996.00	104.41	111.38		111.49	0.002119	4.18	493.31	167.89	0.29
Alignment - (1)	13752.12	2-yr	441.00	104.47	110.24		110.27	0.000778	2.21	396.51	197.92	0.17
Alignment - (1)	13752.12	10-yr	649.00	104.47	110.83		110.86	0.000823	2.44	518.89	216.63	0.18
Alignment - (1)	13752.12	25-yr	766.00	104.47	111.13		111.17	0.000824	2.52	586.94	226.37	0.18
Alignment - (1)	13752.12	50-yr	868.00	104.47	111.42		111.46	0.000797	2.55	652.43	235.70	0.18
Alignment - (1)	13752.12	100-yr	996.00	104.47	111.80		111.84	0.000737	2.55	746.04	249.84	0.17
Alignment - (1)	13993.89	2-yr	441.00	104.65	110.48		110.59	0.002207	3.66	262.74	151.88	0.28
Alignment - (1)	13993.89	10-yr	649.00	104.65	111.08		111.19	0.002226	3.96	359.33	168.53	0.29
Alignment - (1)	13993.89	25-yr	766.00	104.65	111.39		111.50	0.002197	4.07	412.33	177.17	0.29
Alignment - (1)	13993.89	50-yr	868.00	104.65	111.66		111.77	0.002113	4.11	462.08	184.91	0.29
Alignment - (1)	13993.89	100-yr	996.00	104.65	112.03		112.14	0.001942	4.09	531.69	195.31	0.28
Alignment - (1)	14297.17	2-yr	441.00	104.50	111.04		111.14	0.001513	3.38	266.13	127.53	0.24
Alignment - (1)	14297.17	10-yr	649.00	104.50	111.67		111.78	0.001709	3.84	351.81	144.30	0.26
Alignment - (1)	14297.17	25-yr	766.00	104.50	111.97		112.09	0.001733	3.98	397.17	152.37	0.27
Alignment - (1)	14297.17	50-yr	868.00	104.50	112.24		112.36	0.001725	4.07	437.19	154.48	0.27
Alignment - (1)	14297.17	100-yr	996.00	104.50	112.57		112.69	0.001677	4.13	488.75	156.52	0.26
Alignment - (1)	14362.99	2-yr	441.00	105.43	111.11		111.30	0.002864	4.18	194.45	145.52	0.36
Alignment - (1)	14362.99	10-yr	649.00	105.43	111.77		111.93	0.002399	4.22	302.69	183.52	0.34
Alignment - (1)	14362.99	25-yr	766.00	105.43	112.08		112.23	0.002212	4.22	362.55	200.15	0.33
Alignment - (1)	14362.99	50-yr	868.00	105.43	112.35		112.48	0.002034	4.19	416.60	211.12	0.32
Alignment - (1)	14362.99	100-yr	996.00	105.43	112.68		112.80	0.001808	4.11	488.83	224.94	0.30
Alignment - (1)	14499.92	2-yr	441.00	107.01	111.48	109.61	111.67	0.002547	3.48	126.60	39.16	0.34
Alignment - (1)	14499.92	10-yr	649.00	107.01	112.09	110.14	112.37	0.003230	4.31	150.77	49.42	0.39
Alignment - (1)	14499.92	25-yr	766.00	107.01	112.36	110.42	112.71	0.003583	4.73	162.02	57.18	0.42
Alignment - (1)	14499.92	50-yr	868.00	107.01	112.59	110.64	112.99	0.003859	5.07	171.25	68.11	0.44

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	14499.92	100-yr	996.00	107.01	112.87	110.91	113.33	0.004104	5.46	182.74	90.81	0.45
Alignment - (1)	14500		Culvert									
Alignment - (1)	14563.55	2-yr	441.00	107.47	114.49	110.76	114.61	0.000825	2.78	158.52	112.21	0.21
Alignment - (1)	14563.55	10-yr	649.00	107.47	115.62	111.41	115.70	0.000580	2.43	388.24	169.93	0.18
Alignment - (1)	14563.55	25-yr	766.00	107.47	115.80	111.74	115.89	0.000703	2.73	419.45	184.35	0.19
Alignment - (1)	14563.55	50-yr	868.00	107.47	115.98	111.99	116.09	0.000779	2.93	454.95	199.48	0.21
Alignment - (1)	14563.55	100-yr	996.00	107.47	116.12	112.28	116.24	0.000923	3.24	481.98	210.27	0.22
Alignment - (1)	14666.23	2-yr	436.00	108.44	114.66		114.66	0.000064	0.80	938.61	251.31	0.06
Alignment - (1)	14666.23	10-yr	639.00	108.44	115.73		115.74	0.000062	0.88	1220.82	282.76	0.06
Alignment - (1)	14666.23	25-yr	759.00	108.44	115.93		115.94	0.000076	1.00	1278.51	291.22	0.07
Alignment - (1)	14666.23	50-yr	852.00	108.44	116.13		116.14	0.000084	1.08	1337.87	297.28	0.07
Alignment - (1)	14666.23	100-yr	973.00	108.44	116.29		116.30	0.000099	1.19	1386.03	301.13	0.08
Alignment - (1)	14953.25	2-yr	436.00	108.74	114.68		114.71	0.000587	1.97	450.85	209.54	0.15
Alignment - (1)	14953.25	10-yr	639.00	108.74	115.76		115.77	0.000381	1.79	696.90	246.00	0.12
Alignment - (1)	14953.25	25-yr	759.00	108.74	115.96		115.99	0.000441	1.96	748.53	252.37	0.13
Alignment - (1)	14953.25	50-yr	852.00	108.74	116.17		116.19	0.000462	2.05	800.90	259.36	0.14
Alignment - (1)	14953.25	100-yr	973.00	108.74	116.34		116.36	0.000521	2.21	844.77	265.19	0.15
Alignment - (1)	15162.55	2-yr	436.00	108.90	114.82		114.85	0.000780	2.23	383.79	169.03	0.17
Alignment - (1)	15162.55	10-yr	639.00	108.90	115.85		115.87	0.000546	2.09	568.02	193.25	0.15
Alignment - (1)	15162.55	25-yr	759.00	108.90	116.07		116.10	0.000629	2.30	611.37	200.33	0.16
Alignment - (1)	15162.55	50-yr	852.00	108.90	116.27		116.31	0.000661	2.41	654.20	208.75	0.16
Alignment - (1)	15162.55	100-yr	973.00	108.90	116.46		116.50	0.000741	2.59	692.50	216.00	0.17
Alignment - (1)	15355.4	2-yr	436.00	110.34	115.04		115.18	0.004445	4.44	198.59	165.01	0.39
Alignment - (1)	15355.4	10-yr	639.00	110.34	115.99		116.06	0.001743	3.20	363.67	181.82	0.25
Alignment - (1)	15355.4	25-yr	759.00	110.34	116.23		116.30	0.001770	3.33	407.62	189.07	0.26
Alignment - (1)	15355.4	50-yr	852.00	110.34	116.44		116.51	0.001695	3.34	449.07	199.03	0.25
Alignment - (1)	15355.4	100-yr	973.00	110.34	116.64		116.72	0.001743	3.47	489.09	208.19	0.26
Alignment - (1)	15557.79	2-yr	436.00	110.42	115.70		115.98	0.003183	4.42	131.23	70.23	0.39
Alignment - (1)	15557.79	10-yr	639.00	110.42	116.28		116.65	0.003747	5.24	180.63	108.06	0.43
Alignment - (1)	15557.79	25-yr	759.00	110.42	116.51		116.93	0.004158	5.71	205.83	110.54	0.46
Alignment - (1)	15557.79	50-yr	852.00	110.42	116.70		117.14	0.004317	5.97	226.99	112.58	0.47

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	15557.79	100-yr	973.00	110.42	116.89		117.38	0.004645	6.35	249.24	121.33	0.49
Alignment - (1)	15700	2-yr	436.00	111.23	116.03	114.04	116.22	0.000873	3.46	126.01	37.51	0.33
Alignment - (1)	15700	10-yr	639.00	111.23	116.65	114.59	116.93	0.001101	4.27	149.80	44.14	0.38
Alignment - (1)	15700	25-yr	759.00	111.23	116.90	114.88	117.25	0.001270	4.76	159.72	61.66	0.42
Alignment - (1)	15700	50-yr	852.00	111.23	117.08	115.10	117.48	0.001382	5.10	175.16	74.43	0.44
Alignment - (1)	15700	100-yr	973.00	111.23	117.27	115.36	117.74	0.001550	5.54	191.20	98.39	0.47
Alignment - (1)	15735		Culvert									
Alignment - (1)	15770	2-yr	436.00	111.24	116.82	114.24	116.99	0.000675	3.31	131.82	49.82	0.28
Alignment - (1)	15770	10-yr	639.00	111.24	117.68	114.81	117.88	0.000677	3.63	210.24	100.53	0.29
Alignment - (1)	15770	25-yr	759.00	111.24	117.94	115.11	118.18	0.000774	4.02	237.58	112.75	0.32
Alignment - (1)	15770	50-yr	852.00	111.24	118.10	115.33	118.38	0.000862	4.33	256.14	126.00	0.34
Alignment - (1)	15770	100-yr	973.00	111.24	118.25	115.61	118.58	0.000996	4.75	276.27	138.94	0.36
Alignment - (1)	15898.43	2-yr	432.00	111.19	116.93		117.17	0.002349	4.03	136.38	97.44	0.37
Alignment - (1)	15898.43	10-yr	631.00	111.19	117.81		118.02	0.001793	4.07	236.01	130.93	0.34
Alignment - (1)	15898.43	25-yr	752.00	111.19	118.11		118.34	0.001847	4.32	276.84	142.97	0.35
Alignment - (1)	15898.43	50-yr	847.00	111.19	118.30		118.54	0.001913	4.51	305.64	151.54	0.36
Alignment - (1)	15898.43	100-yr	963.00	111.19	118.52		118.78	0.001991	4.73	339.32	160.98	0.37
Alignment - (1)	16116.29	2-yr	432.00	111.00	117.32		117.39	0.000483	2.24	316.53	191.37	0.18
Alignment - (1)	16116.29	10-yr	631.00	111.00	118.15		118.20	0.000424	2.33	498.40	245.72	0.17
Alignment - (1)	16116.29	25-yr	752.00	111.00	118.46		118.52	0.000435	2.45	578.23	258.32	0.18
Alignment - (1)	16116.29	50-yr	847.00	111.00	118.68		118.74	0.000448	2.55	634.30	266.82	0.18
Alignment - (1)	16116.29	100-yr	963.00	111.00	118.91		118.98	0.000463	2.66	698.44	276.22	0.19
Alignment - (1)	16367.71	2-yr	432.00	111.92	117.46		117.57	0.000990	2.91	220.71	137.04	0.25
Alignment - (1)	16367.71	10-yr	631.00	111.92	118.26		118.37	0.000860	3.05	347.32	175.70	0.24
Alignment - (1)	16367.71	25-yr	752.00	111.92	118.58		118.69	0.000873	3.20	404.91	186.67	0.25
Alignment - (1)	16367.71	50-yr	847.00	111.92	118.79		118.91	0.000892	3.33	445.98	194.12	0.25
Alignment - (1)	16367.71	100-yr	963.00	111.92	119.03		119.16	0.000915	3.47	493.39	202.37	0.26
Alignment - (1)	16711.97	2-yr	432.00	113.98	117.90		118.43	0.007419	5.81	74.39	28.93	0.64
Alignment - (1)	16711.97	10-yr	631.00	113.98	118.56	117.76	119.15	0.006606	6.33	126.15	92.14	0.62
Alignment - (1)	16711.97	25-yr	752.00	113.98	118.87	118.44	119.47	0.006282	6.56	155.46	98.23	0.62
Alignment - (1)	16711.97	50-yr	847.00	113.98	119.09		119.70	0.006119	6.74	176.98	102.47	0.62

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	16711.97	100-yr	963.00	113.98	119.33		119.96	0.005962	6.94	202.27	107.24	0.61
Alignment - (1)	16903.85	2-yr	426.00	113.99	118.93		119.16	0.002169	3.88	129.98	79.12	0.36
Alignment - (1)	16903.85	10-yr	619.00	113.99	119.59		119.88	0.002302	4.49	192.11	108.91	0.39
Alignment - (1)	16903.85	25-yr	735.00	113.99	119.89		120.21	0.002421	4.82	226.63	122.37	0.40
Alignment - (1)	16903.85	50-yr	826.00	113.99	120.10		120.45	0.002491	5.04	253.37	129.59	0.41
Alignment - (1)	16903.85	100-yr	944.00	113.99	120.34		120.71	0.002592	5.31	284.84	134.99	0.42
Alignment - (1)	17391.26	2-yr	426.00	115.95	120.27		120.60	0.004076	4.69	109.63	109.67	0.48
Alignment - (1)	17391.26	10-yr	619.00	115.95	120.92		121.23	0.003355	4.86	186.39	128.47	0.45
Alignment - (1)	17391.26	25-yr	735.00	115.95	121.24		121.54	0.003085	4.93	229.06	137.82	0.44
Alignment - (1)	17391.26	50-yr	826.00	115.95	121.46		121.76	0.002937	5.00	260.87	144.39	0.43
Alignment - (1)	17391.26	100-yr	944.00	115.95	121.73		122.03	0.002789	5.08	300.81	152.27	0.43
Alignment - (1)	17750.27	2-yr	426.00	118.46	122.12	121.42	122.62	0.007653	5.73	87.09	136.02	0.65
Alignment - (1)	17750.27	10-yr	619.00	118.46	122.51	122.47	123.06	0.007818	6.39	142.39	149.10	0.67
Alignment - (1)	17750.27	25-yr	735.00	118.46	122.71	122.64	123.27	0.007585	6.60	173.87	156.09	0.67
Alignment - (1)	17750.27	50-yr	826.00	118.46	122.87	122.78	123.42	0.007309	6.70	198.70	161.39	0.66
Alignment - (1)	17750.27	100-yr	944.00	118.46	123.06		123.60	0.006923	6.78	230.92	167.95	0.65
Alignment - (1)	17947.72	2-yr	426.00	119.60	124.73	124.73	125.11	0.010885	6.89	160.50	191.10	0.65
Alignment - (1)	17947.72	10-yr	619.00	119.60	124.95	124.95	125.38	0.012974	7.84	205.19	207.80	0.71
Alignment - (1)	17947.72	25-yr	735.00	119.60	125.06	125.06	125.51	0.014048	8.32	228.66	215.54	0.75
Alignment - (1)	17947.72	50-yr	826.00	119.60	125.14	125.14	125.61	0.014820	8.66	245.80	220.73	0.77
Alignment - (1)	17947.72	100-yr	944.00	119.60	125.24	125.24	125.73	0.015638	9.04	267.49	227.33	0.79
Alignment - (1)	18316.06	2-yr	133.00	120.45	125.95		125.95	0.000289	1.18	313.80	227.31	0.10
Alignment - (1)	18316.06	10-yr	168.00	120.45	126.30		126.31	0.000252	1.16	398.32	248.61	0.10
Alignment - (1)	18316.06	25-yr	251.00	120.45	126.54		126.55	0.000386	1.49	459.91	261.85	0.12
Alignment - (1)	18316.06	50-yr	321.00	120.45	126.72		126.73	0.000491	1.72	505.98	271.24	0.14
Alignment - (1)	18316.06	100-yr	387.00	120.45	126.90		126.91	0.000555	1.87	556.27	281.14	0.15
Alignment - (1)	18612.92	2-yr	133.00	122.00	126.09		126.17	0.002591	2.94	108.40	131.82	0.30
Alignment - (1)	18612.92	10-yr	168.00	122.00	126.43		126.48	0.001894	2.70	157.10	157.59	0.26
Alignment - (1)	18612.92	25-yr	251.00	122.00	126.73		126.80	0.002243	3.11	208.91	181.40	0.29
Alignment - (1)	18612.92	50-yr	321.00	122.00	126.95		127.02	0.002414	3.36	250.60	198.41	0.30
Alignment - (1)	18612.92	100-yr	387.00	122.00	127.16		127.23	0.002418	3.49	293.37	213.42	0.31

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	18841.01	2-yr	133.00	124.23	127.85	127.85	128.29	0.012922	5.71	45.70	97.59	0.65
Alignment - (1)	18841.01	10-yr	168.00	124.23	128.12	128.12	128.46	0.010057	5.41	82.72	156.79	0.58
Alignment - (1)	18841.01	25-yr	251.00	124.23	128.36	128.36	128.72	0.011519	6.13	121.98	172.75	0.63
Alignment - (1)	18841.01	50-yr	321.00	124.23	128.50	128.50	128.89	0.012948	6.71	147.47	182.37	0.68
Alignment - (1)	18841.01	100-yr	387.00	124.23	128.65	128.65	129.04	0.013313	7.01	173.83	191.81	0.69
Alignment - (1)	19025	2-yr	133.00	126.51	129.82	129.62	129.98	0.006704	4.10	95.64	152.24	0.48
Alignment - (1)	19025	10-yr	168.00	126.51	129.92		130.11	0.007927	4.59	111.73	163.10	0.52
Alignment - (1)	19025	25-yr	251.00	126.51	130.24		130.41	0.007392	4.82	167.29	180.53	0.52
Alignment - (1)	19025	50-yr	321.00	126.51	130.47		130.63	0.007061	4.98	209.20	189.14	0.51
Alignment - (1)	19025	100-yr	387.00	126.51	130.64		130.80	0.007121	5.19	242.11	195.63	0.52
Alignment - (1)	19146.14	2-yr	133.00	126.07	130.32	128.53	130.50	0.002861	3.37	40.80	116.54	0.33
Alignment - (1)	19146.14	10-yr	168.00	126.07	130.53	128.86	130.77	0.003688	3.99	43.70	122.84	0.38
Alignment - (1)	19146.14	25-yr	251.00	126.07	130.90	129.50	131.34	0.005783	5.35	48.91	133.36	0.49
Alignment - (1)	19146.14	50-yr	321.00	126.07	131.13	129.93	131.76	0.007727	6.44	52.15	139.95	0.57
Alignment - (1)	19146.14	100-yr	387.00	126.07	131.30	130.29	132.14	0.009708	7.43	54.61	144.95	0.64
Alignment - (1)	19187		Culvert									
Alignment - (1)	19207	2-yr	133.00	126.60	133.80	129.20	133.92	0.000647	2.77	47.93	153.87	0.19
Alignment - (1)	19207	10-yr	168.00	126.60	135.08	129.57	135.08	0.000023	0.56	834.48	164.42	0.04
Alignment - (1)	19207	25-yr	251.00	126.60	135.39	130.37	135.40	0.000043	0.79	886.79	167.03	0.05
Alignment - (1)	19207	50-yr	321.00	126.60	135.56	130.97	135.56	0.000065	0.98	914.87	168.42	0.06
Alignment - (1)	19207	100-yr	387.00	126.60	135.66	131.52	135.67	0.000089	1.16	932.09	169.26	0.07
Alignment - (1)	19262	2-yr	200.00	128.06	133.96		133.96	0.000045	0.62	971.34	293.13	0.05
Alignment - (1)	19262	10-yr	327.00	128.06	135.08		135.08	0.000050	0.74	1311.31	314.07	0.05
Alignment - (1)	19262	25-yr	407.00	128.06	135.40		135.40	0.000062	0.86	1411.84	320.00	0.06
Alignment - (1)	19262	50-yr	464.00	128.06	135.57		135.57	0.000072	0.94	1466.36	323.17	0.06
Alignment - (1)	19262	100-yr	527.00	128.06	135.67		135.67	0.000087	1.04	1500.18	325.12	0.07
Alignment - (1)	19445.34	2-yr	200.00	127.97	133.97		133.97	0.000114	0.84	757.84	302.15	0.06
Alignment - (1)	19445.34	10-yr	327.00	127.97	135.09		135.09	0.000097	0.87	1120.98	344.25	0.06
Alignment - (1)	19445.34	25-yr	407.00	127.97	135.41		135.41	0.000114	0.98	1232.98	357.01	0.06
Alignment - (1)	19445.34	50-yr	464.00	127.97	135.58		135.59	0.000129	1.06	1295.13	366.19	0.07
Alignment - (1)	19445.34	100-yr	527.00	127.97	135.69		135.69	0.000153	1.16	1334.88	371.19	0.08

HEC-RAS Plan: Ex - Att River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	19799.72	2-yr	200.00	129.96	134.04		134.06	0.000640	1.71	257.84	173.03	0.16
Alignment - (1)	19799.72	10-yr	327.00	129.96	135.14		135.15	0.000350	1.51	487.06	246.87	0.12
Alignment - (1)	19799.72	25-yr	407.00	129.96	135.47		135.48	0.000376	1.63	573.21	279.42	0.13
Alignment - (1)	19799.72	50-yr	464.00	129.96	135.65		135.66	0.000400	1.72	624.80	297.36	0.13
Alignment - (1)	19799.72	100-yr	527.00	129.96	135.77		135.78	0.000453	1.86	661.03	309.37	0.14
Alignment - (1)	20189.88	2-yr	200.00	132.20	135.19	135.19	135.52	0.015554	6.67	77.75	109.08	0.73
Alignment - (1)	20189.88	10-yr	327.00	132.20	135.45	135.45	135.85	0.019187	7.90	108.29	123.62	0.83
Alignment - (1)	20189.88	25-yr	407.00	132.20	135.68		136.03	0.016741	7.77	138.75	140.44	0.78
Alignment - (1)	20189.88	50-yr	464.00	132.20	135.92		136.19	0.012504	7.07	174.98	157.76	0.68
Alignment - (1)	20189.88	100-yr	527.00	132.20	136.10		136.34	0.011246	6.94	204.12	172.53	0.65
Alignment - (1)	20618.31	2-yr	200.00	135.89	139.34	138.93	139.48	0.006055	4.65	110.33	110.14	0.47
Alignment - (1)	20618.31	10-yr	327.00	135.89	139.82	139.27	139.95	0.005657	4.96	169.03	131.75	0.46
Alignment - (1)	20618.31	25-yr	407.00	135.89	140.01	139.45	140.16	0.006184	5.37	194.50	140.61	0.49
Alignment - (1)	20618.31	50-yr	464.00	135.89	140.08		140.26	0.007417	5.95	204.63	149.66	0.54
Alignment - (1)	20618.31	100-yr	527.00	135.89	140.19		140.38	0.007949	6.28	221.10	156.11	0.56
Alignment - (1)	20968.95	2-yr	200.00	137.93	141.17	140.80	141.24	0.004193	3.69	187.74	244.90	0.39
Alignment - (1)	20968.95	10-yr	327.00	137.93	141.54	141.02	141.60	0.003931	3.88	290.15	302.74	0.38
Alignment - (1)	20968.95	25-yr	407.00	137.93	141.75	141.12	141.80	0.003642	3.89	354.66	331.21	0.37
Alignment - (1)	20968.95	50-yr	464.00	137.93	141.89		141.94	0.003319	3.82	403.55	350.61	0.36
Alignment - (1)	20968.95	100-yr	527.00	137.93	142.03		142.08	0.003203	3.85	455.25	384.60	0.35

CITY DESIGN STANDARD ANALYSIS

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	10365	2-yr	601.00	96.44	102.01	101.42	102.23	0.005001	5.33	213.31	137.84	0.43
Alignment - (1)	10365	10-yr	1028.00	96.44	102.76	102.01	103.00	0.005005	5.87	324.01	157.57	0.44
Alignment - (1)	10365	25-yr	1304.00	96.44	103.15	102.26	103.41	0.005001	6.14	388.89	168.94	0.44
Alignment - (1)	10365	50-yr	1801.00	96.44	103.77	102.62	104.05	0.005000	6.55	497.86	187.39	0.45
Alignment - (1)	10365	100-yr	2026.00	96.44	104.02	102.81	104.30	0.005003	6.72	545.52	195.89	0.45
Alignment - (1)	10638.24	2-yr	601.00	98.77	103.42		103.57	0.004751	4.79	254.10	155.07	0.42
Alignment - (1)	10638.24	10-yr	1028.00	98.77	104.16		104.34	0.004704	5.33	374.81	169.76	0.43
Alignment - (1)	10638.24	25-yr	1304.00	98.77	104.55		104.75	0.004731	5.63	442.53	176.99	0.44
Alignment - (1)	10638.24	50-yr	1801.00	98.77	105.16		105.38	0.004754	6.08	554.45	187.98	0.45
Alignment - (1)	10638.24	100-yr	2026.00	98.77	105.41		105.64	0.004742	6.24	601.02	191.08	0.45
Alignment - (1)	10849.17	2-yr	601.00	98.54	104.23		104.38	0.003168	4.47	237.79	120.08	0.35
Alignment - (1)	10849.17	10-yr	1028.00	98.54	105.01		105.22	0.003669	5.31	338.04	135.47	0.39
Alignment - (1)	10849.17	25-yr	1304.00	98.54	105.43		105.66	0.003874	5.71	395.65	143.36	0.40
Alignment - (1)	10849.17	50-yr	1801.00	98.54	106.06		106.33	0.004109	6.28	489.40	153.34	0.42
Alignment - (1)	10849.17	100-yr	2026.00	98.54	106.31		106.60	0.004215	6.51	528.61	157.82	0.43
Alignment - (1)	11152.11	2-yr	601.00	98.92	104.99		105.07	0.001673	3.47	332.23	146.36	0.26
Alignment - (1)	11152.11	10-yr	1028.00	98.92	105.90		106.00	0.001883	4.08	473.90	165.39	0.28
Alignment - (1)	11152.11	25-yr	1304.00	98.92	106.37		106.49	0.002001	4.41	554.40	176.89	0.30
Alignment - (1)	11152.11	50-yr	1801.00	98.92	107.08		107.23	0.002168	4.90	687.36	195.30	0.31
Alignment - (1)	11152.11	100-yr	2026.00	98.92	107.37		107.52	0.002222	5.08	743.91	202.22	0.32
Alignment - (1)	11531.01	2-yr	601.00	100.12	105.69		105.87	0.002519	4.21	249.92	126.98	0.35
Alignment - (1)	11531.01	10-yr	1028.00	100.12	106.65		106.87	0.002571	4.85	380.54	144.30	0.37
Alignment - (1)	11531.01	25-yr	1304.00	100.12	107.15		107.39	0.002609	5.19	455.31	154.10	0.38
Alignment - (1)	11531.01	50-yr	1801.00	100.12	107.91		108.17	0.002673	5.70	576.85	167.55	0.39
Alignment - (1)	11531.01	100-yr	2026.00	100.12	108.21		108.48	0.002697	5.89	627.32	171.67	0.40
Alignment - (1)	11640	2-yr	601.00	101.11	105.96	104.83	106.42	0.006116	5.43	110.74	112.78	0.53
Alignment - (1)	11640	10-yr	1028.00	101.11	106.80	105.75	107.65	0.008348	7.39	139.20	128.30	0.64
Alignment - (1)	11640	25-yr	1304.00	101.11	107.20	106.28	108.33	0.009854	8.54	152.76	136.95	0.71
Alignment - (1)	11640	50-yr	1801.00	101.11	107.73	107.14	109.46	0.012991	10.55	170.66	148.76	0.83
Alignment - (1)	11640	100-yr	2026.00	101.11	107.90	107.50	109.95	0.014714	11.48	176.43	152.21	0.89
Alignment - (1)	11700		Culvert									

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	11775	2-yr	601.00	100.19	106.73	104.16	107.00	0.002000	4.16	144.50	57.42	0.33
Alignment - (1)	11775	10-yr	1028.00	100.19	108.38	105.18	108.82	0.002231	5.33	192.97	77.08	0.37
Alignment - (1)	11775	25-yr	1304.00	100.19	109.55	105.75	110.06	0.002074	5.73	227.51	89.36	0.36
Alignment - (1)	11775	50-yr	1801.00	100.19	110.24	106.70	111.06	0.002978	7.27	247.73	95.35	0.44
Alignment - (1)	11775	100-yr	2026.00	100.19	111.89	107.10	112.13	0.000922	4.47	648.90	136.77	0.25
Alignment - (1)	11835	2-yr	488.00	100.00	107.07		107.14	0.000961	2.91	297.07	110.20	0.21
Alignment - (1)	11835	10-yr	830.00	100.00	108.94		109.00	0.000613	2.77	518.28	125.77	0.17
Alignment - (1)	11835	25-yr	1051.00	100.00	110.20		110.26	0.000460	2.64	683.71	137.59	0.15
Alignment - (1)	11835	50-yr	1507.00	100.00	111.28		111.36	0.000658	3.40	844.87	179.44	0.19
Alignment - (1)	11835	100-yr	1692.00	100.00	112.16		112.23	0.000550	3.28	1013.40	206.33	0.17
Alignment - (1)	11974.42	2-yr	488.00	100.50	107.21		107.29	0.001160	3.02	307.51	131.32	0.21
Alignment - (1)	11974.42	10-yr	830.00	100.50	109.04		109.09	0.000677	2.74	600.43	189.10	0.17
Alignment - (1)	11974.42	25-yr	1051.00	100.50	110.29		110.32	0.000452	2.46	859.59	230.17	0.14
Alignment - (1)	11974.42	50-yr	1507.00	100.50	111.40		111.44	0.000427	2.58	1127.62	256.09	0.14
Alignment - (1)	11974.42	100-yr	1692.00	100.50	112.26		112.29	0.000324	2.37	1363.30	301.62	0.12
Alignment - (1)	12143.18	2-yr	488.00	100.50	107.42		107.45	0.000770	2.29	445.08	194.82	0.16
Alignment - (1)	12143.18	10-yr	830.00	100.50	109.16		109.18	0.000419	1.99	822.74	232.33	0.12
Alignment - (1)	12143.18	25-yr	1051.00	100.50	110.36		110.38	0.000279	1.78	1121.45	289.87	0.10
Alignment - (1)	12143.18	50-yr	1507.00	100.50	111.48		111.50	0.000274	1.91	1464.84	329.31	0.10
Alignment - (1)	12143.18	100-yr	1692.00	100.50	112.32		112.33	0.000212	1.76	1755.16	367.66	0.09
Alignment - (1)	12518.55	2-yr	488.00	100.50	107.75		107.82	0.001205	2.97	315.88	141.50	0.20
Alignment - (1)	12518.55	10-yr	830.00	100.50	109.35		109.40	0.000779	2.76	572.38	177.19	0.17
Alignment - (1)	12518.55	25-yr	1051.00	100.50	110.49		110.53	0.000547	2.52	789.16	204.65	0.15
Alignment - (1)	12518.55	50-yr	1507.00	100.50	111.60		111.65	0.000574	2.78	1036.07	239.02	0.15
Alignment - (1)	12518.55	100-yr	1692.00	100.50	112.41		112.45	0.000447	2.58	1237.37	254.78	0.14
Alignment - (1)	12742.17	2-yr	488.00	100.89	108.02		108.09	0.001242	2.98	365.22	184.20	0.21
Alignment - (1)	12742.17	10-yr	830.00	100.89	109.53		109.57	0.000748	2.66	661.84	209.33	0.17
Alignment - (1)	12742.17	25-yr	1051.00	100.89	110.62		110.65	0.000511	2.39	898.98	226.06	0.14
Alignment - (1)	12742.17	50-yr	1507.00	100.89	111.73		111.77	0.000509	2.58	1160.27	241.69	0.14
Alignment - (1)	12742.17	100-yr	1692.00	100.89	112.52		112.55	0.000417	2.45	1354.16	255.72	0.13
Alignment - (1)	13161.24	2-yr	488.00	102.59	108.77		108.97	0.003767	4.66	219.74	144.09	0.35
Alignment - (1)	13161.24	10-yr	830.00	102.59	109.99		110.12	0.002482	4.32	418.50	181.42	0.29

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	13161.24	25-yr	1051.00	102.59	110.93		111.02	0.001607	3.79	601.69	208.76	0.24
Alignment - (1)	13161.24	50-yr	1507.00	102.59	112.03		112.11	0.001367	3.82	848.91	240.94	0.23
Alignment - (1)	13161.24	100-yr	1692.00	102.59	112.76		112.82	0.001049	3.52	1032.06	264.82	0.20
Alignment - (1)	13456.23	2-yr	488.00	103.41	109.76		109.89	0.002603	3.96	254.75	138.38	0.29
Alignment - (1)	13456.23	10-yr	830.00	103.41	110.72		110.86	0.002496	4.30	396.92	155.27	0.29
Alignment - (1)	13456.23	25-yr	1051.00	103.41	111.44		111.56	0.002052	4.17	513.73	169.13	0.27
Alignment - (1)	13456.23	50-yr	1507.00	103.41	112.48		112.59	0.001866	4.34	698.64	188.22	0.26
Alignment - (1)	13456.23	100-yr	1692.00	103.41	113.10		113.20	0.001533	4.13	819.89	199.72	0.24
Alignment - (1)	13752.12	2-yr	488.00	103.47	110.27		110.30	0.000824	2.34	411.72	198.83	0.17
Alignment - (1)	13752.12	10-yr	830.00	103.47	111.22		111.26	0.000831	2.58	615.69	229.05	0.17
Alignment - (1)	13752.12	25-yr	1051.00	103.47	111.87		111.91	0.000739	2.58	771.53	252.18	0.16
Alignment - (1)	13752.12	50-yr	1507.00	103.47	112.87		112.91	0.000686	2.70	1040.15	282.08	0.16
Alignment - (1)	13752.12	100-yr	1692.00	103.47	113.43		113.47	0.000581	2.59	1202.89	296.25	0.15
Alignment - (1)	13993.89	2-yr	488.00	103.50	110.51		110.63	0.002051	3.67	279.88	152.62	0.26
Alignment - (1)	13993.89	10-yr	830.00	103.50	111.47		111.58	0.002062	4.04	438.93	179.33	0.26
Alignment - (1)	13993.89	25-yr	1051.00	103.50	112.09		112.20	0.001843	4.03	555.89	197.08	0.25
Alignment - (1)	13993.89	50-yr	1507.00	103.50	113.08		113.18	0.001668	4.15	765.30	227.44	0.24
Alignment - (1)	13993.89	100-yr	1692.00	103.50	113.61		113.70	0.001421	3.98	890.26	243.78	0.23
Alignment - (1)	14297.17	2-yr	488.00	103.50	111.06		111.17	0.001560	3.48	277.78	127.98	0.23
Alignment - (1)	14297.17	10-yr	830.00	103.50	112.04		112.16	0.001742	4.02	415.87	153.25	0.25
Alignment - (1)	14297.17	25-yr	1051.00	103.50	112.61		112.73	0.001671	4.13	504.90	156.78	0.25
Alignment - (1)	14297.17	50-yr	1507.00	103.50	113.56		113.69	0.001642	4.39	666.59	191.48	0.25
Alignment - (1)	14297.17	100-yr	1692.00	103.50	114.03		114.15	0.001487	4.31	761.75	214.95	0.24
Alignment - (1)	14362.99	2-yr	488.00	104.43	111.13		111.33	0.002626	4.24	207.03	146.19	0.34
Alignment - (1)	14362.99	10-yr	830.00	104.43	112.14		112.30	0.002082	4.28	384.34	202.41	0.31
Alignment - (1)	14362.99	25-yr	1051.00	104.43	112.72		112.85	0.001727	4.16	508.05	226.48	0.29
Alignment - (1)	14362.99	50-yr	1507.00	104.43	113.68		113.79	0.001372	4.07	745.34	266.64	0.26
Alignment - (1)	14362.99	100-yr	1692.00	104.43	114.14		114.24	0.001158	3.89	872.49	285.62	0.25
Alignment - (1)	14499.92	2-yr	488.00	105.41	111.47	108.97	111.63	0.001778	3.20	152.62	39.28	0.29
Alignment - (1)	14499.92	10-yr	830.00	105.41	112.39	109.81	112.68	0.002626	4.37	192.36	57.87	0.36
Alignment - (1)	14499.92	25-yr	1051.00	105.41	112.90	110.28	113.28	0.002971	4.96	216.43	91.99	0.39
Alignment - (1)	14499.92	50-yr	1507.00	105.41	113.76	111.13	114.26	0.003295	5.80	297.95	122.62	0.42

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	14499.92	100-yr	1692.00	105.41	114.20	111.45	114.66	0.002937	5.73	382.48	143.45	0.40
Alignment - (1)	14500		Culvert									
Alignment - (1)	14563.55	2-yr	488.00	105.87	111.10	110.12	111.65	0.009772	5.91	82.62	28.17	0.61
Alignment - (1)	14563.55	10-yr	830.00	105.87	111.96	111.18	112.88	0.013222	7.69	107.95	31.18	0.73
Alignment - (1)	14563.55	25-yr	1051.00	105.87	112.69	111.75	113.68	0.012110	7.98	131.72	33.75	0.71
Alignment - (1)	14563.55	50-yr	1507.00	105.87	114.51	112.75	115.34	0.006700	7.42	216.75	112.95	0.56
Alignment - (1)	14563.55	100-yr	1692.00	105.87	115.22	113.17	115.81	0.004480	6.59	345.94	141.95	0.47
Alignment - (1)	14666.23	2-yr	436.00	106.84	112.00		112.05	0.001023	2.50	342.69	201.67	0.21
Alignment - (1)	14666.23	10-yr	737.00	106.84	113.28		113.32	0.000575	2.23	623.24	235.21	0.17
Alignment - (1)	14666.23	25-yr	932.00	106.84	114.07		114.10	0.000425	2.10	816.12	248.35	0.15
Alignment - (1)	14666.23	50-yr	1368.00	106.84	115.64		115.66	0.000276	1.96	1217.75	278.84	0.12
Alignment - (1)	14666.23	100-yr	1533.00	106.84	116.03		116.06	0.000269	2.00	1330.80	294.85	0.12
Alignment - (1)	14953.25	2-yr	436.00	106.99	112.72	112.72	113.23	0.010712	6.77	125.99	128.63	0.54
Alignment - (1)	14953.25	10-yr	737.00	106.99	113.48		113.82	0.008280	6.54	239.54	167.59	0.48
Alignment - (1)	14953.25	25-yr	932.00	106.99	114.25		114.42	0.004131	5.03	377.87	190.76	0.35
Alignment - (1)	14953.25	50-yr	1368.00	106.99	115.76		115.84	0.001633	3.64	710.18	246.02	0.23
Alignment - (1)	14953.25	100-yr	1533.00	106.99	116.15		116.22	0.001445	3.53	808.49	258.62	0.22
Alignment - (1)	15162.55	2-yr	436.00	107.15	114.01		114.10	0.002037	3.35	263.77	159.50	0.24
Alignment - (1)	15162.55	10-yr	737.00	107.15	114.61		114.72	0.002504	3.96	362.12	166.60	0.27
Alignment - (1)	15162.55	25-yr	932.00	107.15	114.98		115.10	0.002571	4.16	424.92	170.96	0.28
Alignment - (1)	15162.55	50-yr	1368.00	107.15	116.11		116.21	0.001838	3.88	632.50	201.93	0.24
Alignment - (1)	15162.55	100-yr	1533.00	107.15	116.46		116.56	0.001725	3.87	706.70	216.20	0.23
Alignment - (1)	15355.4	2-yr	436.00	108.34	114.41		114.61	0.003177	3.79	157.07	145.33	0.35
Alignment - (1)	15355.4	10-yr	737.00	108.34	115.09		115.31	0.003304	4.34	263.50	165.82	0.37
Alignment - (1)	15355.4	25-yr	932.00	108.34	115.46		115.68	0.003171	4.50	327.04	172.45	0.37
Alignment - (1)	15355.4	50-yr	1368.00	108.34	116.44		116.62	0.002232	4.30	506.14	198.96	0.32
Alignment - (1)	15355.4	100-yr	1533.00	108.34	116.77		116.94	0.002029	4.26	574.33	214.33	0.31
Alignment - (1)	15557.79	2-yr	436.00	108.42	114.97		115.11	0.001875	3.00	149.49	57.06	0.29
Alignment - (1)	15557.79	10-yr	737.00	108.42	115.67		115.93	0.002768	4.14	194.19	69.69	0.36
Alignment - (1)	15557.79	25-yr	932.00	108.42	116.03		116.37	0.003264	4.75	221.14	86.69	0.40
Alignment - (1)	15557.79	50-yr	1368.00	108.42	116.82		117.27	0.003674	5.62	305.55	114.83	0.43

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	15557.79	100-yr	1533.00	108.42	117.10		117.58	0.003709	5.84	340.78	138.77	0.44
Alignment - (1)	15700	2-yr	436.00	109.23	115.12	112.54	115.30	0.000838	3.42	127.65	35.53	0.32
Alignment - (1)	15700	10-yr	737.00	109.23	115.89	113.75	116.23	0.001300	4.73	155.73	37.57	0.41
Alignment - (1)	15700	25-yr	932.00	109.23	116.28	114.21	116.74	0.001573	5.46	170.65	38.60	0.46
Alignment - (1)	15700	50-yr	1368.00	109.23	117.07	115.11	117.78	0.001995	6.76	210.04	73.90	0.53
Alignment - (1)	15700	100-yr	1533.00	109.23	117.33	115.42	118.12	0.002111	7.17	233.26	109.56	0.55
Alignment - (1)	15735		Culvert									
Alignment - (1)	15770	2-yr	436.00	109.24	115.06	113.29	115.32	0.001536	4.10	106.46	31.92	0.40
Alignment - (1)	15770	10-yr	737.00	109.24	115.79	114.17	116.29	0.002333	5.64	130.66	33.94	0.51
Alignment - (1)	15770	25-yr	932.00	109.24	116.17	114.66	116.82	0.002788	6.49	143.71	34.99	0.56
Alignment - (1)	15770	50-yr	1368.00	109.24	116.91	115.62	117.91	0.003504	8.02	173.24	56.87	0.65
Alignment - (1)	15770	100-yr	1533.00	109.24	117.16	115.95	118.28	0.003693	8.52	189.36	75.24	0.68
Alignment - (1)	15898.43	2-yr	416.00	109.19	115.29		115.74	0.005286	5.34	77.96	24.33	0.53
Alignment - (1)	15898.43	10-yr	701.00	109.19	116.15		116.91	0.007623	7.00	100.49	37.08	0.65
Alignment - (1)	15898.43	25-yr	885.00	109.19	116.60	115.58	117.51	0.008019	7.71	128.71	78.81	0.67
Alignment - (1)	15898.43	50-yr	1317.00	109.19	117.76	117.25	118.54	0.005690	7.67	251.06	128.84	0.59
Alignment - (1)	15898.43	100-yr	1475.00	109.19	118.33	117.51	118.94	0.004213	7.07	330.96	152.55	0.52
Alignment - (1)	16116.29	2-yr	416.00	109.00	116.01		116.13	0.000800	2.75	164.84	75.27	0.22
Alignment - (1)	16116.29	10-yr	701.00	109.00	117.23		117.36	0.000786	3.18	337.53	184.51	0.23
Alignment - (1)	16116.29	25-yr	885.00	109.00	117.83		117.96	0.000736	3.29	462.57	230.41	0.23
Alignment - (1)	16116.29	50-yr	1317.00	109.00	118.81		118.94	0.000694	3.50	708.84	272.07	0.23
Alignment - (1)	16116.29	100-yr	1475.00	109.00	119.16		119.28	0.000655	3.51	807.14	285.52	0.22
Alignment - (1)	16367.71	2-yr	416.00	110.92	116.25		116.48	0.002179	3.84	115.23	68.67	0.36
Alignment - (1)	16367.71	10-yr	701.00	110.92	117.44		117.68	0.001808	4.25	237.54	135.95	0.34
Alignment - (1)	16367.71	25-yr	885.00	110.92	118.02		118.26	0.001613	4.33	326.56	167.60	0.33
Alignment - (1)	16367.71	50-yr	1317.00	110.92	118.98		119.21	0.001453	4.59	502.85	200.65	0.32
Alignment - (1)	16367.71	100-yr	1475.00	110.92	119.32		119.54	0.001380	4.64	573.13	216.68	0.32
Alignment - (1)	16711.97	2-yr	416.00	112.98	117.24		117.72	0.005990	5.52	75.37	26.35	0.58
Alignment - (1)	16711.97	10-yr	701.00	112.98	118.21	117.17	118.91	0.006921	6.76	114.04	85.15	0.64
Alignment - (1)	16711.97	25-yr	885.00	112.98	118.65	117.72	119.42	0.006754	7.23	153.73	93.92	0.64
Alignment - (1)	16711.97	50-yr	1317.00	112.98	119.46	119.05	120.33	0.006548	8.06	235.70	109.84	0.65

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	16711.97	100-yr	1475.00	112.98	119.75	119.29	120.62	0.006261	8.20	268.35	115.57	0.64
Alignment - (1)	16903.85	2-yr	380.00	113.99	118.32		118.61	0.003456	4.31	90.71	46.94	0.45
Alignment - (1)	16903.85	10-yr	635.00	113.99	119.43		119.78	0.002846	4.86	175.30	101.72	0.43
Alignment - (1)	16903.85	25-yr	799.00	113.99	119.90		120.28	0.002832	5.22	227.92	122.84	0.43
Alignment - (1)	16903.85	50-yr	1217.00	113.99	120.75		121.20	0.002989	6.01	341.29	144.11	0.46
Alignment - (1)	16903.85	100-yr	1360.00	113.99	121.00		121.48	0.003001	6.22	379.34	150.98	0.46
Alignment - (1)	17391.26	2-yr	380.00	115.95	120.12		120.44	0.004062	4.52	93.38	105.26	0.48
Alignment - (1)	17391.26	10-yr	635.00	115.95	120.96		121.27	0.003317	4.87	192.24	129.79	0.45
Alignment - (1)	17391.26	25-yr	799.00	115.95	121.40		121.70	0.002971	4.98	251.77	142.54	0.44
Alignment - (1)	17391.26	50-yr	1217.00	115.95	122.27		122.57	0.002586	5.29	386.81	167.45	0.42
Alignment - (1)	17391.26	100-yr	1360.00	115.95	122.53		122.83	0.002500	5.38	430.68	174.54	0.42
Alignment - (1)	17750.27	2-yr	380.00	118.46	121.97	121.25	122.45	0.007753	5.54	68.79	55.45	0.65
Alignment - (1)	17750.27	10-yr	635.00	118.46	122.54	122.48	123.09	0.007789	6.42	146.83	150.10	0.67
Alignment - (1)	17750.27	25-yr	799.00	118.46	122.82	122.72	123.38	0.007401	6.67	191.24	159.82	0.66
Alignment - (1)	17750.27	50-yr	1217.00	118.46	123.49		124.00	0.006118	6.90	305.56	183.80	0.62
Alignment - (1)	17750.27	100-yr	1360.00	118.46	123.70		124.19	0.005763	6.94	344.55	191.49	0.61
Alignment - (1)	17947.72	2-yr	380.00	119.60	124.68	124.68	125.03	0.009834	6.49	151.59	187.59	0.61
Alignment - (1)	17947.72	10-yr	635.00	119.60	124.97	124.97	125.40	0.013129	7.91	208.55	209.00	0.72
Alignment - (1)	17947.72	25-yr	799.00	119.60	125.12	125.12	125.58	0.014595	8.56	240.82	219.24	0.76
Alignment - (1)	17947.72	50-yr	1217.00	119.60	125.43	125.43	125.97	0.017417	9.84	312.89	241.50	0.84
Alignment - (1)	17947.72	100-yr	1360.00	119.60	125.55	125.55	126.09	0.017039	9.93	343.62	250.30	0.84
Alignment - (1)	18316.06	2-yr	213.00	120.45	125.97		125.99	0.000713	1.86	318.95	229.15	0.16
Alignment - (1)	18316.06	10-yr	347.00	120.45	126.51		126.53	0.000772	2.10	451.85	260.17	0.17
Alignment - (1)	18316.06	25-yr	431.00	120.45	126.78		126.80	0.000807	2.22	523.82	274.79	0.18
Alignment - (1)	18316.06	50-yr	513.00	120.45	127.24		127.26	0.000621	2.07	656.36	296.26	0.16
Alignment - (1)	18316.06	100-yr	574.00	120.45	127.38		127.40	0.000649	2.15	698.08	298.46	0.16
Alignment - (1)	18612.92	2-yr	213.00	122.00	126.32		126.43	0.003886	3.78	140.28	149.09	0.37
Alignment - (1)	18612.92	10-yr	347.00	122.00	126.88		126.97	0.003257	3.85	235.53	192.50	0.35
Alignment - (1)	18612.92	25-yr	431.00	122.00	127.15		127.24	0.003041	3.90	291.65	212.83	0.34
Alignment - (1)	18612.92	50-yr	513.00	122.00	127.53		127.60	0.002329	3.63	376.75	240.48	0.31
Alignment - (1)	18612.92	100-yr	574.00	122.00	127.68		127.75	0.002321	3.70	413.58	251.47	0.31

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	18841.01	2-yr	213.00	124.23	128.26	128.26	128.61	0.010889	5.82	105.15	166.10	0.61
Alignment - (1)	18841.01	10-yr	347.00	124.23	128.57	128.57	128.95	0.012795	6.76	159.86	186.87	0.67
Alignment - (1)	18841.01	25-yr	431.00	124.23	128.69	128.69	129.12	0.015018	7.51	181.58	194.50	0.73
Alignment - (1)	18841.01	50-yr	513.00	124.23	128.83	128.83	129.27	0.015244	7.79	211.41	205.65	0.75
Alignment - (1)	18841.01	100-yr	574.00	124.23	128.89	128.89	129.37	0.016908	8.30	223.16	209.96	0.79
Alignment - (1)	19025	2-yr	213.00	126.51	130.11		130.28	0.007572	4.72	143.35	175.42	0.52
Alignment - (1)	19025	10-yr	347.00	126.51	130.53		130.69	0.007185	5.09	221.19	191.53	0.52
Alignment - (1)	19025	25-yr	431.00	126.51	130.78		130.93	0.006755	5.20	268.93	200.77	0.51
Alignment - (1)	19025	50-yr	513.00	126.51	130.95		131.11	0.006910	5.45	304.97	207.47	0.52
Alignment - (1)	19025	100-yr	574.00	126.51	131.10		131.26	0.006716	5.52	335.93	213.06	0.52
Alignment - (1)	19146.14	2-yr	213.00	126.07	130.74	129.23	131.09	0.004796	4.74	46.76	129.01	0.44
Alignment - (1)	19146.14	10-yr	347.00	126.07	131.20	130.07	131.91	0.008477	6.83	53.20	142.09	0.60
Alignment - (1)	19146.14	25-yr	431.00	126.07	131.39	130.53	132.39	0.011205	8.09	55.86	147.50	0.69
Alignment - (1)	19146.14	50-yr	513.00	126.07	131.53	130.92	132.86	0.014190	9.31	57.87	151.59	0.78
Alignment - (1)	19146.14	100-yr	574.00	126.07	131.60	131.21	133.20	0.016868	10.25	58.82	153.52	0.86
Alignment - (1)	19187		Culvert									
Alignment - (1)	19207	2-yr	213.00	126.60	130.02	130.02	131.55	0.024250	9.93	21.44	122.56	1.00
Alignment - (1)	19207	10-yr	347.00	126.60	131.19	131.19	133.32	0.021775	11.69	29.68	132.30	1.00
Alignment - (1)	19207	25-yr	431.00	126.60	131.86	131.86	134.30	0.020660	12.55	34.34	137.81	1.00
Alignment - (1)	19207	50-yr	513.00	126.60	132.46	132.46	135.21	0.019932	13.31	38.54	142.76	1.00
Alignment - (1)	19207	100-yr	574.00	126.60	132.88	132.88	135.85	0.019480	13.83	41.51	146.28	1.00
Alignment - (1)	19262	2-yr	213.00	128.06	132.08		132.09	0.000478	1.51	452.55	257.92	0.14
Alignment - (1)	19262	10-yr	347.00	128.06	133.97		133.98	0.000133	1.07	975.01	293.37	0.08
Alignment - (1)	19262	25-yr	431.00	128.06	135.05		135.05	0.000088	0.99	1302.50	313.55	0.07
Alignment - (1)	19262	50-yr	513.00	128.06	136.04		136.05	0.000065	0.94	1623.18	332.12	0.06
Alignment - (1)	19262	100-yr	574.00	128.06	136.75		136.75	0.000055	0.91	1862.26	345.32	0.06
Alignment - (1)	19445.34	2-yr	213.00	127.97	132.21		132.23	0.001460	2.35	303.61	212.24	0.21
Alignment - (1)	19445.34	10-yr	347.00	127.97	134.01		134.01	0.000330	1.44	768.68	303.91	0.11
Alignment - (1)	19445.34	25-yr	431.00	127.97	135.07		135.08	0.000171	1.16	1114.55	343.56	0.08
Alignment - (1)	19445.34	50-yr	513.00	127.97	136.06		136.06	0.000110	1.02	1474.73	387.10	0.06
Alignment - (1)	19445.34	100-yr	574.00	127.97	136.76		136.76	0.000083	0.94	1757.13	408.66	0.06

HEC-RAS Plan: *CDS River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	19799.72	2-yr	213.00	129.96	133.08		133.19	0.006136	4.33	114.58	126.48	0.46
Alignment - (1)	19799.72	10-yr	347.00	129.96	134.20		134.24	0.001481	2.68	286.40	183.21	0.24
Alignment - (1)	19799.72	25-yr	431.00	129.96	135.17		135.18	0.000594	1.97	492.38	248.98	0.16
Alignment - (1)	19799.72	50-yr	513.00	129.96	136.11		136.12	0.000277	1.52	771.11	325.80	0.11
Alignment - (1)	19799.72	100-yr	574.00	129.96	136.80		136.81	0.000155	1.22	995.54	329.33	0.08
Alignment - (1)	20189.88	2-yr	213.00	132.20	135.53		135.67	0.006510	4.70	119.24	129.55	0.48
Alignment - (1)	20189.88	10-yr	347.00	132.20	135.48	135.48	135.89	0.019586	8.05	112.85	125.75	0.84
Alignment - (1)	20189.88	25-yr	431.00	132.20	135.63	135.63	136.07	0.021120	8.64	131.92	136.77	0.87
Alignment - (1)	20189.88	50-yr	513.00	132.20	136.31		136.47	0.007138	5.75	243.16	194.87	0.53
Alignment - (1)	20189.88	100-yr	574.00	132.20	136.91		136.99	0.003094	4.19	380.02	259.73	0.36
Alignment - (1)	20618.31	2-yr	213.00	135.89	139.11	138.99	139.38	0.011809	6.17	86.89	97.51	0.65
Alignment - (1)	20618.31	10-yr	347.00	135.89	139.89	139.32	140.02	0.005628	5.00	177.45	134.36	0.47
Alignment - (1)	20618.31	25-yr	431.00	135.89	140.16	139.49	140.29	0.005613	5.25	216.17	154.21	0.47
Alignment - (1)	20618.31	50-yr	513.00	135.89	139.96		140.21	0.010757	7.01	187.00	137.26	0.65
Alignment - (1)	20618.31	100-yr	574.00	135.89	139.72	139.72	140.21	0.021387	9.46	155.94	127.60	0.90
Alignment - (1)	20968.95	2-yr	213.00	137.93	141.31		141.36	0.003207	3.33	222.28	267.72	0.34
Alignment - (1)	20968.95	10-yr	347.00	137.93	141.60	141.05	141.65	0.003871	3.89	306.13	310.09	0.38
Alignment - (1)	20968.95	25-yr	431.00	137.93	141.80	141.15	141.85	0.003585	3.90	371.85	338.16	0.37
Alignment - (1)	20968.95	50-yr	513.00	137.93	142.02		142.07	0.003111	3.79	451.42	383.72	0.35
Alignment - (1)	20968.95	100-yr	574.00	137.93	142.20		142.24	0.002563	3.55	520.68	399.34	0.32

ALTERNATIVE #1

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	10365	2-yr	607.00	96.44	102.02	101.43	102.25	0.005001	5.34	215.01	138.15	0.43
Alignment - (1)	10365	10-yr	1054.00	96.44	102.80	102.06	103.04	0.005005	5.90	330.31	158.70	0.44
Alignment - (1)	10365	25-yr	1330.00	96.44	103.19	102.31	103.45	0.005001	6.17	394.79	169.94	0.44
Alignment - (1)	10365	50-yr	1605.00	96.44	103.54	102.48	103.81	0.005001	6.40	455.36	179.85	0.45
Alignment - (1)	10365	100-yr	1804.00	96.44	103.77	102.65	104.05	0.005001	6.56	498.50	187.51	0.45
Alignment - (1)	10638.24	2-yr	607.00	98.77	103.43		103.59	0.004750	4.79	255.96	155.30	0.42
Alignment - (1)	10638.24	10-yr	1054.00	98.77	104.20		104.38	0.004704	5.36	381.37	170.34	0.43
Alignment - (1)	10638.24	25-yr	1330.00	98.77	104.59		104.78	0.004735	5.66	448.69	177.68	0.44
Alignment - (1)	10638.24	50-yr	1605.00	98.77	104.94		105.15	0.004761	5.92	511.93	184.64	0.44
Alignment - (1)	10638.24	100-yr	1804.00	98.77	105.17		105.39	0.004753	6.08	555.09	188.03	0.45
Alignment - (1)	10849.17	2-yr	607.00	98.54	104.24		104.40	0.003176	4.49	239.34	120.29	0.35
Alignment - (1)	10849.17	10-yr	1054.00	98.54	105.06		105.26	0.003696	5.35	343.62	136.43	0.39
Alignment - (1)	10849.17	25-yr	1330.00	98.54	105.46		105.70	0.003888	5.75	400.85	143.92	0.41
Alignment - (1)	10849.17	50-yr	1605.00	98.54	105.82		106.08	0.004016	6.06	453.96	149.57	0.42
Alignment - (1)	10849.17	100-yr	1804.00	98.54	106.06		106.34	0.004111	6.28	489.94	153.40	0.42
Alignment - (1)	11152.11	2-yr	607.00	98.92	105.01		105.09	0.001678	3.48	334.43	146.69	0.26
Alignment - (1)	11152.11	10-yr	1054.00	98.92	105.95		106.05	0.001892	4.11	481.77	166.33	0.29
Alignment - (1)	11152.11	25-yr	1330.00	98.92	106.41		106.53	0.002012	4.44	561.65	177.94	0.30
Alignment - (1)	11152.11	50-yr	1605.00	98.92	106.82		106.95	0.002113	4.72	636.58	188.85	0.31
Alignment - (1)	11152.11	100-yr	1804.00	98.92	107.09		107.23	0.002169	4.90	688.13	195.40	0.31
Alignment - (1)	11531.01	2-yr	607.00	100.12	105.71		105.89	0.002519	4.22	251.96	127.28	0.35
Alignment - (1)	11531.01	10-yr	1054.00	100.12	106.70		106.92	0.002575	4.89	387.76	145.18	0.37
Alignment - (1)	11531.01	25-yr	1330.00	100.12	107.20		107.43	0.002612	5.22	462.05	154.90	0.38
Alignment - (1)	11531.01	50-yr	1605.00	100.12	107.63		107.88	0.002645	5.51	530.81	162.78	0.39
Alignment - (1)	11531.01	100-yr	1804.00	100.12	107.91		108.18	0.002674	5.70	577.54	167.61	0.39
Alignment - (1)	11640	2-yr	607.00	101.11	105.97	104.85	106.44	0.006146	5.46	111.24	113.04	0.53
Alignment - (1)	11640	10-yr	1054.00	101.11	106.84	105.80	107.71	0.008489	7.50	140.59	129.17	0.65
Alignment - (1)	11640	25-yr	1330.00	101.11	107.23	106.32	108.39	0.010003	8.64	153.88	137.69	0.71
Alignment - (1)	11640	50-yr	1605.00	101.11	107.55	106.81	109.02	0.011663	9.76	164.50	144.65	0.78
Alignment - (1)	11640	100-yr	1804.00	101.11	107.73	107.14	109.46	0.013013	10.57	170.74	148.82	0.83
Alignment - (1)	11700		Culvert									

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	11775	2-yr	607.00	100.19	106.87	104.18	107.13	0.001852	4.08	148.75	59.10	0.32
Alignment - (1)	11775	10-yr	1054.00	100.19	108.99	105.23	109.37	0.001747	5.00	210.81	84.42	0.33
Alignment - (1)	11775	25-yr	1330.00	100.19	110.29	105.81	110.73	0.001594	5.34	249.12	95.76	0.32
Alignment - (1)	11775	50-yr	1605.00	100.19	111.39	106.33	111.58	0.000741	3.87	582.18	129.12	0.22
Alignment - (1)	11775	100-yr	1804.00	100.19	111.70	106.70	111.91	0.000802	4.11	623.15	134.16	0.23
Alignment - (1)	11835	2-yr	469.00	100.00	107.20		107.27	0.000777	2.66	312.33	111.35	0.19
Alignment - (1)	11835	10-yr	815.00	100.00	109.48		109.53	0.000418	2.39	587.57	130.26	0.14
Alignment - (1)	11835	25-yr	1028.00	100.00	110.85		110.89	0.000317	2.30	776.46	147.96	0.13
Alignment - (1)	11835	50-yr	1254.00	100.00	111.60		111.65	0.000392	2.68	903.68	189.26	0.14
Alignment - (1)	11835	100-yr	1405.00	100.00	111.94		111.99	0.000421	2.83	968.64	199.54	0.15
Alignment - (1)	11974.42	2-yr	469.00	100.50	107.32		107.39	0.000962	2.78	322.15	134.81	0.19
Alignment - (1)	11974.42	10-yr	815.00	100.50	109.55		109.59	0.000445	2.31	701.13	204.93	0.14
Alignment - (1)	11974.42	25-yr	1028.00	100.50	110.91		110.94	0.000276	2.01	1007.22	238.51	0.11
Alignment - (1)	11974.42	50-yr	1254.00	100.50	111.67		111.70	0.000249	2.00	1198.94	267.42	0.11
Alignment - (1)	11974.42	100-yr	1405.00	100.50	112.01		112.04	0.000255	2.07	1292.12	282.01	0.11
Alignment - (1)	12143.18	2-yr	469.00	101.50	107.50		107.53	0.000714	2.18	452.00	196.81	0.16
Alignment - (1)	12143.18	10-yr	815.00	101.50	109.63		109.65	0.000293	1.73	924.79	240.13	0.11
Alignment - (1)	12143.18	25-yr	1028.00	101.50	110.96		110.97	0.000182	1.52	1290.03	309.62	0.09
Alignment - (1)	12143.18	50-yr	1254.00	101.50	111.72		111.73	0.000167	1.54	1535.71	338.17	0.09
Alignment - (1)	12143.18	100-yr	1405.00	101.50	112.06		112.07	0.000172	1.59	1653.20	352.19	0.09
Alignment - (1)	12518.55	2-yr	469.00	101.50	107.81		107.88	0.001177	2.91	316.11	143.19	0.21
Alignment - (1)	12518.55	10-yr	815.00	101.50	109.77		109.81	0.000572	2.46	638.70	185.95	0.16
Alignment - (1)	12518.55	25-yr	1028.00	101.50	111.05		111.07	0.000384	2.23	897.74	221.80	0.13
Alignment - (1)	12518.55	50-yr	1254.00	101.50	111.80		111.83	0.000365	2.29	1073.06	244.87	0.13
Alignment - (1)	12518.55	100-yr	1405.00	101.50	112.14		112.17	0.000372	2.37	1158.37	251.68	0.13
Alignment - (1)	12742.17	2-yr	469.00	101.89	108.09		108.15	0.001208	2.91	367.27	185.26	0.21
Alignment - (1)	12742.17	10-yr	815.00	101.89	109.90		109.93	0.000558	2.37	731.10	215.32	0.15
Alignment - (1)	12742.17	25-yr	1028.00	101.89	111.13		111.16	0.000356	2.10	1008.03	233.27	0.12
Alignment - (1)	12742.17	50-yr	1254.00	101.89	111.88		111.90	0.000332	2.14	1186.04	243.73	0.12
Alignment - (1)	12742.17	100-yr	1405.00	101.89	112.22		112.25	0.000343	2.23	1270.94	249.87	0.12
Alignment - (1)	13161.24	2-yr	469.00	103.59	108.84		109.02	0.003935	4.63	220.45	146.14	0.37
Alignment - (1)	13161.24	10-yr	815.00	103.59	110.25		110.35	0.002009	3.93	458.15	189.16	0.28

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	13161.24	25-yr	1028.00	103.59	111.35		111.41	0.001137	3.30	683.31	220.65	0.22
Alignment - (1)	13161.24	50-yr	1254.00	103.59	112.08		112.13	0.000958	3.23	850.61	242.55	0.20
Alignment - (1)	13161.24	100-yr	1405.00	103.59	112.43		112.48	0.000940	3.29	937.18	254.56	0.20
Alignment - (1)	13456.23	2-yr	469.00	104.41	109.84		109.96	0.002597	3.87	257.01	140.21	0.31
Alignment - (1)	13456.23	10-yr	815.00	104.41	110.88		110.99	0.002298	4.13	411.55	158.23	0.30
Alignment - (1)	13456.23	25-yr	1028.00	104.41	111.73		111.82	0.001655	3.83	554.02	174.72	0.26
Alignment - (1)	13456.23	50-yr	1254.00	104.41	112.40		112.49	0.001443	3.80	674.85	186.82	0.24
Alignment - (1)	13456.23	100-yr	1405.00	104.41	112.74		112.83	0.001414	3.88	739.58	193.09	0.24
Alignment - (1)	13752.12	2-yr	469.00	104.47	110.32		110.36	0.000786	2.24	413.96	200.69	0.17
Alignment - (1)	13752.12	10-yr	815.00	104.47	111.33		111.36	0.000768	2.48	630.94	232.45	0.17
Alignment - (1)	13752.12	25-yr	1028.00	104.47	112.08		112.11	0.000619	2.40	815.85	259.23	0.16
Alignment - (1)	13752.12	50-yr	1254.00	104.47	112.71		112.74	0.000554	2.41	984.84	277.34	0.15
Alignment - (1)	13752.12	100-yr	1405.00	104.47	113.04		113.08	0.000543	2.45	1079.85	287.08	0.15
Alignment - (1)	13993.89	2-yr	469.00	104.65	110.57		110.68	0.002209	3.70	276.47	154.26	0.29
Alignment - (1)	13993.89	10-yr	815.00	104.65	111.56		111.67	0.002065	4.02	443.70	182.09	0.28
Alignment - (1)	13993.89	25-yr	1028.00	104.65	112.27		112.36	0.001656	3.87	578.98	202.63	0.26
Alignment - (1)	13993.89	50-yr	1254.00	104.65	112.88		112.96	0.001453	3.83	707.89	221.34	0.25
Alignment - (1)	13993.89	100-yr	1405.00	104.65	113.21		113.29	0.001398	3.87	783.03	231.55	0.24
Alignment - (1)	14297.17	2-yr	469.00	104.50	111.13		111.24	0.001548	3.45	278.25	130.04	0.25
Alignment - (1)	14297.17	10-yr	815.00	104.50	112.12		112.24	0.001694	3.99	419.91	153.79	0.26
Alignment - (1)	14297.17	25-yr	1028.00	104.50	112.74		112.85	0.001539	4.02	515.70	157.57	0.25
Alignment - (1)	14297.17	50-yr	1254.00	104.50	113.30		113.41	0.001455	4.09	609.00	178.99	0.25
Alignment - (1)	14297.17	100-yr	1405.00	104.50	113.62		113.73	0.001434	4.17	668.65	194.48	0.25
Alignment - (1)	14362.99	2-yr	469.00	105.43	111.21		111.39	0.002787	4.19	209.14	151.24	0.36
Alignment - (1)	14362.99	10-yr	815.00	105.43	112.23		112.37	0.002071	4.16	392.52	206.30	0.32
Alignment - (1)	14362.99	25-yr	1028.00	105.43	112.84		112.95	0.001603	3.94	526.18	231.76	0.29
Alignment - (1)	14362.99	50-yr	1254.00	105.43	113.41		113.50	0.001325	3.81	663.57	255.30	0.26
Alignment - (1)	14362.99	100-yr	1405.00	105.43	113.73		113.82	0.001224	3.78	747.76	268.71	0.26
Alignment - (1)	14499.92	2-yr	469.00	107.01	111.57	109.68	111.78	0.002650	3.60	130.25	39.45	0.35
Alignment - (1)	14499.92	10-yr	815.00	107.01	112.49	110.53	112.86	0.003685	4.88	167.01	60.62	0.42
Alignment - (1)	14499.92	25-yr	1028.00	107.01	112.99	110.98	113.46	0.003983	5.48	187.98	95.88	0.45
Alignment - (1)	14499.92	50-yr	1254.00	107.01	113.50	111.41	113.98	0.003796	5.73	248.27	109.83	0.45

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	14499.92	100-yr	1405.00	107.01	113.79	111.69	114.31	0.003836	5.98	272.04	123.71	0.45
Alignment - (1)	14500		Culvert									
Alignment - (1)	14563.55	2-yr	469.00	107.47	112.19	110.85	112.58	0.005503	5.04	93.09	31.81	0.49
Alignment - (1)	14563.55	10-yr	815.00	107.47	114.11	111.86	114.58	0.003564	5.52	147.74	97.05	0.43
Alignment - (1)	14563.55	25-yr	1028.00	107.47	115.37	112.35	115.60	0.001770	4.13	348.22	149.43	0.30
Alignment - (1)	14563.55	50-yr	1254.00	107.47	115.61	112.84	115.89	0.002195	4.73	385.36	168.54	0.34
Alignment - (1)	14563.55	100-yr	1405.00	107.47	115.83	113.15	116.14	0.002314	4.97	424.48	186.56	0.35
Alignment - (1)	14666.23	2-yr	437.00	108.44	112.80		112.81	0.000448	1.62	488.58	222.58	0.15
Alignment - (1)	14666.23	10-yr	745.00	108.44	114.76		114.77	0.000171	1.32	964.70	251.83	0.10
Alignment - (1)	14666.23	25-yr	933.00	108.44	115.69		115.70	0.000135	1.30	1208.68	280.95	0.09
Alignment - (1)	14666.23	50-yr	1150.00	108.44	116.01		116.02	0.000166	1.49	1300.55	294.27	0.10
Alignment - (1)	14666.23	100-yr	1286.00	108.44	116.26		116.27	0.000178	1.58	1375.23	300.27	0.10
Alignment - (1)	14953.25	2-yr	437.00	108.74	112.88	112.88	113.33	0.013193	7.13	133.39	137.52	0.66
Alignment - (1)	14953.25	10-yr	745.00	108.74	114.84		114.89	0.001417	3.11	483.21	216.18	0.23
Alignment - (1)	14953.25	25-yr	933.00	108.74	115.75		115.78	0.000820	2.62	694.29	245.68	0.18
Alignment - (1)	14953.25	50-yr	1150.00	108.74	116.08		116.12	0.000913	2.86	777.62	256.21	0.19
Alignment - (1)	14953.25	100-yr	1286.00	108.74	116.33		116.38	0.000913	2.93	844.18	265.11	0.19
Alignment - (1)	15162.55	2-yr	437.00	108.90	114.16		114.24	0.002001	3.28	275.59	161.34	0.26
Alignment - (1)	15162.55	10-yr	745.00	108.90	115.14		115.21	0.001552	3.27	438.50	173.00	0.24
Alignment - (1)	15162.55	25-yr	933.00	108.90	115.93		115.99	0.001074	2.96	584.70	195.71	0.20
Alignment - (1)	15162.55	50-yr	1150.00	108.90	116.28		116.35	0.001196	3.24	655.78	209.05	0.22
Alignment - (1)	15162.55	100-yr	1286.00	108.90	116.54		116.61	0.001209	3.34	710.51	219.33	0.22
Alignment - (1)	15355.4	2-yr	437.00	110.34	114.72		115.04	0.009692	6.20	146.71	159.79	0.57
Alignment - (1)	15355.4	10-yr	745.00	110.34	115.56		115.72	0.004716	4.95	286.29	174.15	0.41
Alignment - (1)	15355.4	25-yr	933.00	110.34	116.21		116.32	0.002757	4.14	403.33	188.01	0.32
Alignment - (1)	15355.4	50-yr	1150.00	110.34	116.58		116.69	0.002623	4.23	476.11	205.26	0.32
Alignment - (1)	15355.4	100-yr	1286.00	110.34	116.83		116.94	0.002450	4.21	529.27	216.99	0.31
Alignment - (1)	15557.79	2-yr	437.00	110.42	115.78		116.04	0.002954	4.31	136.52	71.49	0.38
Alignment - (1)	15557.79	10-yr	745.00	110.42	116.31		116.79	0.004952	6.05	183.53	108.35	0.50
Alignment - (1)	15557.79	25-yr	933.00	110.42	116.66		117.21	0.005420	6.65	221.89	112.09	0.53
Alignment - (1)	15557.79	50-yr	1150.00	110.42	116.98		117.61	0.005958	7.27	260.16	128.84	0.56

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	15557.79	100-yr	1286.00	110.42	117.19		117.85	0.006099	7.55	288.54	146.59	0.57
Alignment - (1)	15700	2-yr	437.00	111.23	116.08	114.05	116.26	0.000838	3.42	127.87	37.66	0.33
Alignment - (1)	15700	10-yr	745.00	111.23	116.80	114.85	117.16	0.001321	4.79	155.85	54.84	0.42
Alignment - (1)	15700	25-yr	933.00	111.23	117.15	115.27	117.61	0.001562	5.48	180.84	79.68	0.47
Alignment - (1)	15700	50-yr	1150.00	111.23	117.47	115.72	118.06	0.001842	6.22	214.53	134.32	0.51
Alignment - (1)	15700	100-yr	1286.00	111.23	117.64	115.99	118.31	0.001983	6.62	239.98	153.55	0.54
Alignment - (1)	15735		Culvert									
Alignment - (1)	15770	2-yr	437.00	111.24	116.88	114.23	117.04	0.000650	3.27	133.53	54.16	0.27
Alignment - (1)	15770	10-yr	745.00	111.24	117.89	115.08	118.13	0.000779	4.01	231.49	108.62	0.32
Alignment - (1)	15770	25-yr	933.00	111.24	118.19	115.51	118.50	0.000962	4.63	267.79	133.64	0.36
Alignment - (1)	15770	50-yr	1150.00	111.24	118.42	115.98	118.83	0.001219	5.36	300.74	153.21	0.40
Alignment - (1)	15770	100-yr	1286.00	111.24	118.55	116.26	119.03	0.001375	5.79	321.60	164.48	0.43
Alignment - (1)	15898.43	2-yr	432.00	111.19	116.99		117.21	0.002194	3.94	141.81	99.33	0.36
Alignment - (1)	15898.43	10-yr	735.00	111.19	118.05		118.28	0.001874	4.31	268.73	140.58	0.35
Alignment - (1)	15898.43	25-yr	920.00	111.19	118.44		118.69	0.001965	4.66	326.81	157.54	0.36
Alignment - (1)	15898.43	50-yr	1136.00	111.19	118.79		119.07	0.002123	5.06	384.98	172.95	0.38
Alignment - (1)	15898.43	100-yr	1269.00	111.19	119.00		119.30	0.002173	5.25	422.38	182.17	0.39
Alignment - (1)	16116.29	2-yr	432.00	111.00	117.36		117.42	0.000465	2.21	323.09	193.92	0.18
Alignment - (1)	16116.29	10-yr	735.00	111.00	118.41		118.47	0.000439	2.45	564.35	256.18	0.18
Alignment - (1)	16116.29	25-yr	920.00	111.00	118.83		118.89	0.000458	2.62	674.93	272.81	0.18
Alignment - (1)	16116.29	50-yr	1136.00	111.00	119.22		119.29	0.000489	2.82	784.89	287.51	0.19
Alignment - (1)	16116.29	100-yr	1269.00	111.00	119.45		119.52	0.000502	2.92	850.78	294.85	0.20
Alignment - (1)	16367.71	2-yr	432.00	111.92	117.49		117.60	0.000957	2.87	224.68	138.66	0.25
Alignment - (1)	16367.71	10-yr	735.00	111.92	118.52		118.64	0.000880	3.20	395.12	184.85	0.25
Alignment - (1)	16367.71	25-yr	920.00	111.92	118.95		119.07	0.000907	3.42	475.99	199.38	0.25
Alignment - (1)	16367.71	50-yr	1136.00	111.92	119.34		119.48	0.000971	3.70	558.38	218.06	0.27
Alignment - (1)	16367.71	100-yr	1269.00	111.92	119.57		119.71	0.001004	3.86	609.62	231.44	0.27
Alignment - (1)	16711.97	2-yr	432.00	113.98	117.91		118.43	0.007343	5.79	74.67	28.98	0.64
Alignment - (1)	16711.97	10-yr	735.00	113.98	118.82	118.39	119.43	0.006371	6.55	150.86	97.30	0.62
Alignment - (1)	16711.97	25-yr	920.00	113.98	119.24		119.87	0.006010	6.86	193.09	105.54	0.61
Alignment - (1)	16711.97	50-yr	1136.00	113.98	119.65		120.31	0.005806	7.21	238.11	113.66	0.61

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	16711.97	100-yr	1269.00	113.98	119.88		120.56	0.005687	7.40	265.22	118.29	0.61
Alignment - (1)	16903.85	2-yr	476.00	113.99	118.95		119.23	0.002652	4.31	131.51	79.98	0.40
Alignment - (1)	16903.85	10-yr	785.00	113.99	119.85		120.23	0.002870	5.21	221.78	120.57	0.44
Alignment - (1)	16903.85	25-yr	983.00	113.99	120.25		120.68	0.003070	5.71	272.30	132.88	0.46
Alignment - (1)	16903.85	50-yr	1217.00	113.99	120.65		121.14	0.003253	6.20	327.53	141.94	0.48
Alignment - (1)	16903.85	100-yr	1360.00	113.99	120.87		121.39	0.003343	6.46	360.00	147.22	0.49
Alignment - (1)	17391.26	2-yr	476.00	115.95	120.46		120.79	0.003854	4.75	130.42	115.07	0.48
Alignment - (1)	17391.26	10-yr	785.00	115.95	121.37		121.67	0.002994	4.97	246.87	141.54	0.44
Alignment - (1)	17391.26	25-yr	983.00	115.95	121.81		122.11	0.002758	5.12	313.28	154.69	0.43
Alignment - (1)	17391.26	50-yr	1217.00	115.95	122.27		122.57	0.002593	5.29	386.37	167.38	0.42
Alignment - (1)	17391.26	100-yr	1360.00	115.95	122.52		122.82	0.002517	5.39	429.43	174.34	0.42
Alignment - (1)	17750.27	2-yr	476.00	118.46	122.23	121.60	122.75	0.007797	5.95	102.24	139.72	0.66
Alignment - (1)	17750.27	10-yr	785.00	118.46	122.80	122.70	123.35	0.007444	6.66	187.43	159.01	0.67
Alignment - (1)	17750.27	25-yr	983.00	118.46	123.13		123.66	0.006793	6.80	241.68	170.33	0.65
Alignment - (1)	17750.27	50-yr	1217.00	118.46	123.49		124.00	0.006118	6.90	305.58	183.80	0.62
Alignment - (1)	17750.27	100-yr	1360.00	118.46	123.70		124.19	0.005765	6.94	344.49	191.47	0.61
Alignment - (1)	17947.72	2-yr	476.00	119.60	124.79	124.79	125.18	0.011499	7.17	172.75	195.82	0.67
Alignment - (1)	17947.72	10-yr	785.00	119.60	125.10	125.10	125.57	0.014477	8.51	238.20	218.45	0.76
Alignment - (1)	17947.72	25-yr	983.00	119.60	125.27	125.27	125.77	0.015875	9.15	274.60	229.78	0.80
Alignment - (1)	17947.72	50-yr	1217.00	119.60	125.47	125.47	125.97	0.016044	9.51	322.95	244.42	0.81
Alignment - (1)	17947.72	100-yr	1360.00	119.60	125.53	125.53	126.09	0.017998	10.16	336.51	248.30	0.86
Alignment - (1)	18316.06	2-yr	213.00	120.45	126.14		126.15	0.000529	1.64	358.88	239.50	0.14
Alignment - (1)	18316.06	10-yr	347.00	120.45	126.69		126.71	0.000593	1.88	499.56	269.95	0.15
Alignment - (1)	18316.06	25-yr	431.00	120.45	126.97		126.99	0.000624	2.01	577.17	285.15	0.16
Alignment - (1)	18316.06	50-yr	513.00	120.45	127.23		127.24	0.000635	2.09	651.33	296.00	0.16
Alignment - (1)	18316.06	100-yr	574.00	120.45	127.40		127.41	0.000639	2.14	701.67	298.65	0.16
Alignment - (1)	18612.92	2-yr	213.00	122.00	126.40		126.50	0.003223	3.50	153.05	155.59	0.34
Alignment - (1)	18612.92	10-yr	347.00	122.00	126.98		127.05	0.002707	3.57	255.05	200.00	0.32
Alignment - (1)	18612.92	25-yr	431.00	122.00	127.26		127.34	0.002521	3.62	315.58	220.96	0.31
Alignment - (1)	18612.92	50-yr	513.00	122.00	127.52		127.59	0.002368	3.65	374.15	239.69	0.31
Alignment - (1)	18612.92	100-yr	574.00	122.00	127.69		127.75	0.002294	3.69	415.54	252.04	0.30

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	18841.01	2-yr	213.00	124.23	128.26	128.26	128.61	0.010889	5.82	105.15	166.10	0.61
Alignment - (1)	18841.01	10-yr	347.00	124.23	128.57	128.57	128.95	0.012795	6.76	159.86	186.87	0.67
Alignment - (1)	18841.01	25-yr	431.00	124.23	128.69	128.69	129.12	0.015018	7.51	181.58	194.50	0.73
Alignment - (1)	18841.01	50-yr	513.00	124.23	128.83	128.83	129.27	0.015244	7.79	211.41	205.65	0.75
Alignment - (1)	18841.01	100-yr	574.00	124.23	128.89	128.89	129.37	0.016908	8.30	223.16	209.96	0.79
Alignment - (1)	19025	2-yr	213.00	126.51	130.11		130.28	0.007572	4.72	143.35	175.42	0.52
Alignment - (1)	19025	10-yr	347.00	126.51	130.53		130.69	0.007185	5.09	221.19	191.53	0.52
Alignment - (1)	19025	25-yr	431.00	126.51	130.78		130.93	0.006755	5.20	268.93	200.77	0.51
Alignment - (1)	19025	50-yr	513.00	126.51	130.95		131.11	0.006910	5.45	304.97	207.47	0.52
Alignment - (1)	19025	100-yr	574.00	126.51	131.10		131.26	0.006716	5.52	335.93	213.06	0.52
Alignment - (1)	19146.14	2-yr	213.00	126.07	130.74	129.23	131.09	0.004796	4.74	46.76	129.01	0.44
Alignment - (1)	19146.14	10-yr	347.00	126.07	131.20	130.07	131.91	0.008477	6.83	53.20	142.09	0.60
Alignment - (1)	19146.14	25-yr	431.00	126.07	131.39	130.53	132.39	0.011205	8.09	55.86	147.50	0.69
Alignment - (1)	19146.14	50-yr	513.00	126.07	131.53	130.92	132.86	0.014190	9.31	57.87	151.59	0.78
Alignment - (1)	19146.14	100-yr	574.00	126.07	131.60	131.21	133.20	0.016868	10.25	58.82	153.52	0.86
Alignment - (1)	19187		Culvert									
Alignment - (1)	19207	2-yr	213.00	126.60	135.29	130.02	135.29	0.000033	0.68	869.04	166.15	0.04
Alignment - (1)	19207	10-yr	347.00	126.60	135.65	131.19	135.65	0.000072	1.04	929.67	169.14	0.06
Alignment - (1)	19207	25-yr	431.00	126.60	135.81	131.86	135.81	0.000103	1.25	956.58	170.46	0.08
Alignment - (1)	19207	50-yr	513.00	126.60	135.89	132.46	135.90	0.000140	1.47	970.38	171.12	0.09
Alignment - (1)	19207	100-yr	574.00	126.60	135.99	132.88	136.00	0.000166	1.62	988.53	172.00	0.10
Alignment - (1)	19262	2-yr	213.00	128.06	135.29		135.29	0.000018	0.46	1377.79	318.01	0.03
Alignment - (1)	19262	10-yr	347.00	128.06	135.65		135.66	0.000038	0.69	1495.27	324.84	0.05
Alignment - (1)	19262	25-yr	431.00	128.06	135.82		135.82	0.000053	0.83	1547.97	327.86	0.05
Alignment - (1)	19262	50-yr	513.00	128.06	135.90		135.90	0.000071	0.97	1575.72	329.44	0.06
Alignment - (1)	19262	100-yr	574.00	128.06	136.01		136.01	0.000084	1.06	1611.56	331.47	0.07
Alignment - (1)	19445.34	2-yr	213.00	127.97	135.29		135.29	0.000034	0.53	1191.46	351.69	0.04
Alignment - (1)	19445.34	10-yr	347.00	127.97	135.66		135.67	0.000068	0.77	1324.99	370.06	0.05
Alignment - (1)	19445.34	25-yr	431.00	127.97	135.83		135.83	0.000092	0.91	1386.59	377.04	0.06
Alignment - (1)	19445.34	50-yr	513.00	127.97	135.92		135.92	0.000122	1.06	1420.22	380.79	0.07
Alignment - (1)	19445.34	100-yr	574.00	127.97	136.03		136.03	0.000141	1.15	1462.86	385.65	0.07

HEC-RAS Plan: Alt 1 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	19799.72	2-yr	213.00	129.96	135.31		135.32	0.000123	0.91	529.88	263.40	0.07
Alignment - (1)	19799.72	10-yr	347.00	129.96	135.70		135.71	0.000212	1.26	639.39	302.24	0.10
Alignment - (1)	19799.72	25-yr	431.00	129.96	135.88		135.88	0.000266	1.45	694.25	317.91	0.11
Alignment - (1)	19799.72	50-yr	513.00	129.96	135.98		135.99	0.000332	1.63	727.39	324.55	0.12
Alignment - (1)	19799.72	100-yr	574.00	129.96	136.10		136.11	0.000354	1.71	766.07	325.72	0.13
Alignment - (1)	20189.88	2-yr	213.00	132.20	135.29		135.56	0.012860	6.22	89.23	114.76	0.67
Alignment - (1)	20189.88	10-yr	347.00	132.20	135.82		136.01	0.008729	5.79	159.60	150.83	0.57
Alignment - (1)	20189.88	25-yr	431.00	132.20	136.06		136.23	0.008139	5.86	197.09	168.32	0.56
Alignment - (1)	20189.88	50-yr	513.00	132.20	136.22		136.40	0.008493	6.17	225.44	184.75	0.57
Alignment - (1)	20189.88	100-yr	574.00	132.20	136.36		136.54	0.008202	6.22	252.33	199.91	0.57
Alignment - (1)	20618.31	2-yr	213.00	135.89	139.34	138.98	139.50	0.006835	4.94	110.55	110.25	0.50
Alignment - (1)	20618.31	10-yr	347.00	135.89	139.64		139.86	0.009208	6.11	146.13	124.36	0.59
Alignment - (1)	20618.31	25-yr	431.00	135.89	139.83		140.05	0.009715	6.51	169.80	132.00	0.61
Alignment - (1)	20618.31	50-yr	513.00	135.89	140.04		140.27	0.009503	6.69	199.20	145.30	0.61
Alignment - (1)	20618.31	100-yr	574.00	135.89	140.16		140.40	0.009874	6.96	216.91	154.49	0.62
Alignment - (1)	20968.95	2-yr	213.00	137.93	141.23	140.83	141.29	0.003950	3.64	203.36	255.43	0.38
Alignment - (1)	20968.95	10-yr	347.00	137.93	141.66		141.70	0.003344	3.66	324.43	318.31	0.35
Alignment - (1)	20968.95	25-yr	431.00	137.93	141.85		141.89	0.003201	3.72	387.48	344.36	0.35
Alignment - (1)	20968.95	50-yr	513.00	137.93	142.02		142.07	0.003136	3.80	450.20	383.44	0.35
Alignment - (1)	20968.95	100-yr	574.00	137.93	142.13		142.17	0.003012	3.80	492.77	393.12	0.34

ALTERNATIVE #1A

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	10365	2-yr	600.00	96.44	102.00	101.42	102.23	0.005001	5.33	213.02	137.78	0.43
Alignment - (1)	10365	10-yr	1015.00	96.44	102.74	102.02	102.98	0.005005	5.86	320.83	156.99	0.44
Alignment - (1)	10365	25-yr	1259.00	96.44	103.09	102.22	103.35	0.005002	6.10	378.60	167.19	0.44
Alignment - (1)	10365	50-yr	1473.00	96.44	103.37	102.38	103.64	0.005009	6.30	426.42	175.18	0.45
Alignment - (1)	10365	100-yr	1664.00	96.44	103.61	102.53	103.88	0.004999	6.45	468.05	181.86	0.45
Alignment - (1)	10638.24	2-yr	600.00	98.77	103.42		103.57	0.004751	4.78	253.79	155.03	0.42
Alignment - (1)	10638.24	10-yr	1015.00	98.77	104.14		104.32	0.004705	5.31	371.50	169.46	0.43
Alignment - (1)	10638.24	25-yr	1259.00	98.77	104.49		104.68	0.004724	5.58	431.82	175.78	0.43
Alignment - (1)	10638.24	50-yr	1473.00	98.77	104.77		104.98	0.004751	5.80	481.96	181.38	0.44
Alignment - (1)	10638.24	100-yr	1664.00	98.77	105.00		105.22	0.004782	5.98	524.42	185.96	0.44
Alignment - (1)	10849.17	2-yr	600.00	98.54	104.23		104.38	0.003166	4.47	237.54	120.04	0.35
Alignment - (1)	10849.17	10-yr	1015.00	98.54	104.99		105.20	0.003655	5.29	335.23	134.98	0.39
Alignment - (1)	10849.17	25-yr	1259.00	98.54	105.36		105.59	0.003849	5.66	386.57	142.36	0.40
Alignment - (1)	10849.17	50-yr	1473.00	98.54	105.66		105.90	0.003958	5.92	428.87	146.94	0.41
Alignment - (1)	10849.17	100-yr	1664.00	98.54	105.90		106.16	0.004044	6.13	464.76	150.69	0.42
Alignment - (1)	11152.11	2-yr	600.00	98.92	104.99		105.07	0.001673	3.47	331.86	146.30	0.26
Alignment - (1)	11152.11	10-yr	1015.00	98.92	105.87		105.98	0.001878	4.06	469.94	164.91	0.28
Alignment - (1)	11152.11	25-yr	1259.00	98.92	106.30		106.42	0.001982	4.35	541.73	175.04	0.29
Alignment - (1)	11152.11	50-yr	1473.00	98.92	106.63		106.76	0.002071	4.60	601.23	184.20	0.30
Alignment - (1)	11152.11	100-yr	1664.00	98.92	106.90		107.04	0.002131	4.78	652.02	190.85	0.31
Alignment - (1)	11531.01	2-yr	600.00	100.12	105.69		105.87	0.002519	4.21	249.58	126.93	0.35
Alignment - (1)	11531.01	10-yr	1015.00	100.12	106.63		106.84	0.002569	4.84	376.91	143.86	0.37
Alignment - (1)	11531.01	25-yr	1259.00	100.12	107.08		107.31	0.002604	5.14	443.53	152.70	0.38
Alignment - (1)	11531.01	50-yr	1473.00	100.12	107.43		107.67	0.002626	5.37	498.60	159.14	0.38
Alignment - (1)	11531.01	100-yr	1664.00	100.12	107.72		107.97	0.002655	5.57	544.87	164.39	0.39
Alignment - (1)	11640	2-yr	600.00	101.11	105.96	104.83	106.41	0.006110	5.42	110.66	112.73	0.53
Alignment - (1)	11640	10-yr	1015.00	101.11	106.78	105.72	107.61	0.008279	7.33	138.49	127.85	0.64
Alignment - (1)	11640	25-yr	1259.00	101.11	107.14	106.20	108.22	0.009598	8.35	150.76	135.64	0.70
Alignment - (1)	11640	50-yr	1473.00	101.11	107.40	106.57	108.73	0.010837	9.22	159.72	141.52	0.75
Alignment - (1)	11640	100-yr	1664.00	101.11	107.60	106.91	109.16	0.012048	10.00	166.47	145.95	0.79
Alignment - (1)	11700		Culvert									

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	11775	2-yr	600.00	100.19	106.84	104.16	107.10	0.001850	4.06	147.77	58.71	0.32
Alignment - (1)	11775	10-yr	1015.00	100.19	108.80	105.15	109.18	0.001765	4.94	205.46	82.42	0.33
Alignment - (1)	11775	25-yr	1259.00	100.19	109.94	105.66	110.37	0.001642	5.27	238.91	92.74	0.33
Alignment - (1)	11775	50-yr	1473.00	100.19	111.14	106.09	111.31	0.000710	3.72	550.20	121.44	0.22
Alignment - (1)	11775	100-yr	1664.00	100.19	111.49	106.45	111.68	0.000759	3.94	594.51	131.19	0.23
Alignment - (1)	11835	2-yr	487.00	100.00	107.16		107.23	0.000872	2.80	307.66	111.00	0.20
Alignment - (1)	11835	10-yr	817.00	100.00	109.29		109.33	0.000475	2.51	562.11	128.63	0.15
Alignment - (1)	11835	25-yr	1043.00	100.00	110.49		110.53	0.000392	2.49	723.36	142.12	0.14
Alignment - (1)	11835	50-yr	1222.00	100.00	111.33		111.38	0.000424	2.74	852.99	180.83	0.15
Alignment - (1)	11835	100-yr	1362.00	100.00	111.70		111.75	0.000442	2.86	922.13	192.24	0.15
Alignment - (1)	11974.42	2-yr	487.00	100.50	107.30		107.36	0.001065	2.92	318.42	133.93	0.20
Alignment - (1)	11974.42	10-yr	817.00	100.50	109.37		109.40	0.000514	2.45	663.17	199.15	0.15
Alignment - (1)	11974.42	25-yr	1043.00	100.50	110.56		110.59	0.000366	2.26	923.38	235.65	0.13
Alignment - (1)	11974.42	50-yr	1222.00	100.50	111.40		111.43	0.000280	2.09	1128.61	256.25	0.11
Alignment - (1)	11974.42	100-yr	1362.00	100.50	111.78		111.81	0.000276	2.12	1227.41	271.81	0.11
Alignment - (1)	12143.18	2-yr	487.00	101.50	107.49		107.52	0.000779	2.27	450.09	196.58	0.17
Alignment - (1)	12143.18	10-yr	817.00	101.50	109.46		109.48	0.000336	1.83	882.83	237.23	0.12
Alignment - (1)	12143.18	25-yr	1043.00	101.50	110.62		110.64	0.000236	1.69	1187.62	295.93	0.10
Alignment - (1)	12143.18	50-yr	1222.00	101.50	111.46		111.47	0.000187	1.60	1447.94	328.48	0.09
Alignment - (1)	12143.18	100-yr	1362.00	101.50	111.83		111.84	0.000185	1.63	1573.33	342.24	0.09
Alignment - (1)	12518.55	2-yr	487.00	101.50	107.83		107.90	0.001248	3.00	318.23	143.56	0.22
Alignment - (1)	12518.55	10-yr	817.00	101.50	109.61		109.65	0.000650	2.59	609.90	182.68	0.16
Alignment - (1)	12518.55	25-yr	1043.00	101.50	110.73		110.77	0.000481	2.44	829.64	212.05	0.15
Alignment - (1)	12518.55	50-yr	1222.00	101.50	111.54		111.57	0.000402	2.36	1011.76	237.10	0.13
Alignment - (1)	12518.55	100-yr	1362.00	101.50	111.92		111.95	0.000403	2.43	1102.28	248.39	0.14
Alignment - (1)	12742.17	2-yr	487.00	101.89	108.12		108.18	0.001253	2.97	372.78	185.76	0.22
Alignment - (1)	12742.17	10-yr	817.00	101.89	109.76		109.80	0.000630	2.49	701.42	213.09	0.16
Alignment - (1)	12742.17	25-yr	1043.00	101.89	110.84		110.87	0.000446	2.30	940.63	229.20	0.14
Alignment - (1)	12742.17	50-yr	1222.00	101.89	111.63		111.66	0.000365	2.20	1126.55	240.28	0.13
Alignment - (1)	12742.17	100-yr	1362.00	101.89	112.01		112.03	0.000364	2.26	1217.06	245.50	0.13
Alignment - (1)	13161.24	2-yr	487.00	103.59	108.89		109.07	0.003929	4.66	227.95	147.62	0.37
Alignment - (1)	13161.24	10-yr	817.00	103.59	110.16		110.27	0.002231	4.10	440.46	186.42	0.29

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	13161.24	25-yr	1043.00	103.59	111.12		111.19	0.001435	3.63	632.20	214.26	0.24
Alignment - (1)	13161.24	50-yr	1222.00	103.59	111.85		111.91	0.001067	3.34	797.18	233.74	0.21
Alignment - (1)	13161.24	100-yr	1362.00	103.59	112.22		112.28	0.001020	3.37	885.94	247.55	0.21
Alignment - (1)	13456.23	2-yr	487.00	104.41	109.89		110.01	0.002613	3.90	264.30	141.33	0.31
Alignment - (1)	13456.23	10-yr	817.00	104.41	110.84		110.96	0.002406	4.20	405.21	157.45	0.30
Alignment - (1)	13456.23	25-yr	1043.00	104.41	111.59		111.69	0.001932	4.08	528.61	171.90	0.28
Alignment - (1)	13456.23	50-yr	1222.00	104.41	112.21		112.30	0.001585	3.92	639.83	183.58	0.26
Alignment - (1)	13456.23	100-yr	1362.00	104.41	112.56		112.66	0.001510	3.95	705.44	189.81	0.25
Alignment - (1)	13752.12	2-yr	487.00	104.47	110.38		110.41	0.000790	2.26	424.97	202.42	0.17
Alignment - (1)	13752.12	10-yr	817.00	104.47	111.30		111.34	0.000789	2.51	625.59	231.72	0.18
Alignment - (1)	13752.12	25-yr	1043.00	104.47	111.98		112.02	0.000693	2.52	790.82	256.33	0.17
Alignment - (1)	13752.12	50-yr	1222.00	104.47	112.55		112.58	0.000597	2.46	940.29	272.66	0.16
Alignment - (1)	13752.12	100-yr	1362.00	104.47	112.88		112.92	0.000573	2.48	1034.38	282.46	0.16
Alignment - (1)	13993.89	2-yr	487.00	104.65	110.63		110.73	0.002211	3.73	285.14	155.75	0.29
Alignment - (1)	13993.89	10-yr	817.00	104.65	111.55		111.66	0.002112	4.06	440.69	181.63	0.29
Alignment - (1)	13993.89	25-yr	1043.00	104.65	112.19		112.29	0.001826	4.03	563.94	200.33	0.27
Alignment - (1)	13993.89	50-yr	1222.00	104.65	112.73		112.82	0.001562	3.92	675.29	216.76	0.25
Alignment - (1)	13993.89	100-yr	1362.00	104.65	113.06		113.15	0.001479	3.93	748.62	226.93	0.25
Alignment - (1)	14297.17	2-yr	487.00	104.50	111.19		111.30	0.001569	3.50	285.92	131.60	0.25
Alignment - (1)	14297.17	10-yr	817.00	104.50	112.12		112.23	0.001713	4.01	418.91	153.75	0.26
Alignment - (1)	14297.17	25-yr	1043.00	104.50	112.70		112.82	0.001631	4.13	510.35	157.36	0.26
Alignment - (1)	14297.17	50-yr	1222.00	104.50	113.18		113.29	0.001519	4.14	587.56	173.13	0.25
Alignment - (1)	14297.17	100-yr	1362.00	104.50	113.49		113.60	0.001485	4.20	643.84	188.12	0.25
Alignment - (1)	14362.99	2-yr	487.00	105.43	111.28		111.45	0.002741	4.19	218.57	154.80	0.36
Alignment - (1)	14362.99	10-yr	817.00	105.43	112.23		112.37	0.002095	4.19	391.44	206.08	0.32
Alignment - (1)	14362.99	25-yr	1043.00	105.43	112.81		112.93	0.001702	4.05	519.70	230.59	0.30
Alignment - (1)	14362.99	50-yr	1222.00	105.43	113.29		113.39	0.001416	3.89	633.61	250.36	0.27
Alignment - (1)	14362.99	100-yr	1362.00	105.43	113.60		113.70	0.001295	3.84	713.96	263.41	0.26
Alignment - (1)	14499.92	2-yr	487.00	107.01	111.63	109.73	111.84	0.002716	3.67	132.53	39.63	0.35
Alignment - (1)	14499.92	10-yr	817.00	107.01	112.48	110.54	112.86	0.003709	4.90	166.93	60.56	0.43
Alignment - (1)	14499.92	25-yr	1043.00	107.01	112.98	111.01	113.46	0.004146	5.58	187.34	95.26	0.46
Alignment - (1)	14499.92	50-yr	1222.00	107.01	113.37	111.35	113.93	0.004321	6.01	203.67	105.50	0.47

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	14499.92	100-yr	1362.00	107.01	113.67	111.61	114.20	0.003918	5.96	262.69	118.31	0.46
Alignment - (1)	14500		Culvert									
Alignment - (1)	14563.55	2-yr	487.00	107.47	112.28	110.91	112.68	0.005403	5.09	95.74	32.17	0.49
Alignment - (1)	14563.55	10-yr	817.00	107.47	114.12	111.87	114.60	0.003546	5.51	148.18	97.67	0.43
Alignment - (1)	14563.55	25-yr	1043.00	107.47	115.39	112.38	115.62	0.001792	4.17	351.35	151.14	0.31
Alignment - (1)	14563.55	50-yr	1222.00	107.47	115.52	112.77	115.81	0.002229	4.72	371.28	161.56	0.34
Alignment - (1)	14563.55	100-yr	1362.00	107.47	115.74	113.06	116.05	0.002324	4.94	409.24	179.76	0.35
Alignment - (1)	14666.23	2-yr	435.00	108.44	112.89		112.91	0.000392	1.54	510.09	225.10	0.14
Alignment - (1)	14666.23	10-yr	724.00	108.44	114.77		114.78	0.000159	1.28	968.22	251.90	0.09
Alignment - (1)	14666.23	25-yr	927.00	108.44	115.71		115.72	0.000131	1.29	1215.90	282.03	0.09
Alignment - (1)	14666.23	50-yr	1092.00	108.44	115.92		115.94	0.000158	1.44	1276.16	290.88	0.10
Alignment - (1)	14666.23	100-yr	1215.00	108.44	116.17		116.19	0.000167	1.52	1349.78	298.24	0.10
Alignment - (1)	14953.25	2-yr	435.00	108.74	112.96		113.33	0.010845	6.56	145.38	142.44	0.60
Alignment - (1)	14953.25	10-yr	724.00	108.74	114.84		114.90	0.001324	3.01	485.13	216.57	0.22
Alignment - (1)	14953.25	25-yr	927.00	108.74	115.77		115.81	0.000791	2.58	700.15	246.41	0.18
Alignment - (1)	14953.25	50-yr	1092.00	108.74	115.99		116.04	0.000890	2.80	755.56	253.23	0.19
Alignment - (1)	14953.25	100-yr	1215.00	108.74	116.24		116.29	0.000880	2.85	820.64	262.00	0.19
Alignment - (1)	15162.55	2-yr	435.00	108.90	114.13		114.21	0.002082	3.33	270.73	160.98	0.27
Alignment - (1)	15162.55	10-yr	724.00	108.90	115.13		115.19	0.001480	3.19	436.97	172.75	0.23
Alignment - (1)	15162.55	25-yr	927.00	108.90	115.95		116.00	0.001043	2.93	588.13	196.21	0.20
Alignment - (1)	15162.55	50-yr	1092.00	108.90	116.19		116.25	0.001166	3.17	636.84	205.37	0.21
Alignment - (1)	15162.55	100-yr	1215.00	108.90	116.44		116.51	0.001168	3.25	689.56	215.45	0.22
Alignment - (1)	15355.4	2-yr	435.00	110.34	114.71		115.03	0.009805	6.23	145.41	159.45	0.57
Alignment - (1)	15355.4	10-yr	724.00	110.34	115.53		115.69	0.004657	4.90	281.83	173.69	0.41
Alignment - (1)	15355.4	25-yr	927.00	110.34	116.22		116.32	0.002687	4.09	405.15	188.46	0.32
Alignment - (1)	15355.4	50-yr	1092.00	110.34	116.48		116.59	0.002657	4.20	456.69	200.80	0.32
Alignment - (1)	15355.4	100-yr	1215.00	110.34	116.73		116.84	0.002459	4.16	507.13	212.19	0.31
Alignment - (1)	15557.79	2-yr	435.00	110.42	115.77		116.03	0.002933	4.29	136.39	71.46	0.38
Alignment - (1)	15557.79	10-yr	724.00	110.42	116.27		116.74	0.004851	5.96	179.74	107.79	0.49
Alignment - (1)	15557.79	25-yr	927.00	110.42	116.65		117.20	0.005365	6.61	221.60	112.06	0.52
Alignment - (1)	15557.79	50-yr	1092.00	110.42	116.90		117.51	0.005833	7.12	249.63	121.61	0.55

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	15557.79	100-yr	1215.00	110.42	117.09		117.73	0.005965	7.38	275.09	138.46	0.56
Alignment - (1)	15700	2-yr	435.00	111.23	116.08	114.04	116.26	0.000833	3.41	127.71	37.65	0.33
Alignment - (1)	15700	10-yr	724.00	111.23	116.76	114.80	117.10	0.001291	4.70	154.16	51.86	0.42
Alignment - (1)	15700	25-yr	927.00	111.23	117.14	115.26	117.60	0.001552	5.45	180.21	79.11	0.47
Alignment - (1)	15700	50-yr	1092.00	111.23	117.39	115.61	117.95	0.001774	6.03	204.37	120.63	0.50
Alignment - (1)	15700	100-yr	1215.00	111.23	117.56	115.85	118.18	0.001907	6.41	226.90	143.99	0.53
Alignment - (1)	15735		Culvert									
Alignment - (1)	15770	2-yr	435.00	111.24	116.87	114.23	117.03	0.000650	3.27	133.17	53.24	0.27
Alignment - (1)	15770	10-yr	724.00	111.24	117.85	115.02	118.08	0.000762	3.94	226.81	106.20	0.31
Alignment - (1)	15770	25-yr	927.00	111.24	118.18	115.50	118.49	0.000957	4.61	266.61	132.89	0.36
Alignment - (1)	15770	50-yr	1092.00	111.24	118.36	115.86	118.74	0.001153	5.18	291.55	148.01	0.39
Alignment - (1)	15770	100-yr	1215.00	111.24	118.51	116.11	118.94	0.001271	5.53	314.36	160.60	0.41
Alignment - (1)	15898.43	2-yr	414.00	111.19	116.98		117.19	0.002038	3.79	140.88	99.01	0.35
Alignment - (1)	15898.43	10-yr	692.00	111.19	118.02		118.22	0.001727	4.12	263.67	139.13	0.34
Alignment - (1)	15898.43	25-yr	867.00	111.19	118.46		118.68	0.001715	4.36	329.62	158.32	0.34
Alignment - (1)	15898.43	50-yr	1017.00	111.19	118.73		118.97	0.001802	4.63	374.76	170.34	0.35
Alignment - (1)	15898.43	100-yr	1129.00	111.19	118.95		119.19	0.001813	4.76	412.14	179.70	0.35
Alignment - (1)	16116.29	2-yr	414.00	111.00	117.32		117.38	0.000443	2.15	316.49	191.35	0.17
Alignment - (1)	16116.29	10-yr	692.00	111.00	118.34		118.40	0.000415	2.36	548.04	253.63	0.17
Alignment - (1)	16116.29	25-yr	867.00	111.00	118.80		118.86	0.000418	2.49	667.09	271.66	0.18
Alignment - (1)	16116.29	50-yr	1017.00	111.00	119.10		119.16	0.000437	2.63	749.87	283.32	0.18
Alignment - (1)	16116.29	100-yr	1129.00	111.00	119.32		119.38	0.000443	2.71	813.30	290.72	0.18
Alignment - (1)	16367.71	2-yr	414.00	111.92	117.45		117.55	0.000921	2.80	219.19	136.42	0.24
Alignment - (1)	16367.71	10-yr	692.00	111.92	118.45		118.56	0.000839	3.09	382.28	182.44	0.24
Alignment - (1)	16367.71	25-yr	867.00	111.92	118.91		119.02	0.000836	3.27	468.22	198.03	0.24
Alignment - (1)	16367.71	50-yr	1017.00	111.92	119.21		119.33	0.000870	3.45	529.55	209.53	0.25
Alignment - (1)	16367.71	100-yr	1129.00	111.92	119.43		119.55	0.000894	3.59	577.32	223.49	0.26
Alignment - (1)	16711.97	2-yr	414.00	113.98	117.86		118.36	0.007134	5.66	73.14	28.71	0.62
Alignment - (1)	16711.97	10-yr	692.00	113.98	118.74	118.27	119.32	0.006295	6.40	142.71	95.63	0.61
Alignment - (1)	16711.97	25-yr	867.00	113.98	119.17		119.77	0.005767	6.65	186.16	104.23	0.60
Alignment - (1)	16711.97	50-yr	1017.00	113.98	119.48		120.09	0.005607	6.90	218.80	110.25	0.60

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	16711.97	100-yr	1129.00	113.98	119.71		120.33	0.005414	7.03	244.33	114.74	0.59
Alignment - (1)	16903.85	2-yr	377.00	113.99	118.84		119.04	0.001871	3.55	123.13	75.12	0.34
Alignment - (1)	16903.85	10-yr	622.00	113.99	119.75		120.00	0.001998	4.28	209.27	115.79	0.36
Alignment - (1)	16903.85	25-yr	770.00	113.99	120.15		120.44	0.002067	4.62	259.55	130.67	0.37
Alignment - (1)	16903.85	50-yr	904.00	113.99	120.46		120.77	0.002135	4.90	300.69	137.61	0.38
Alignment - (1)	16903.85	100-yr	1000.00	113.99	120.67		121.00	0.002154	5.06	330.66	142.43	0.39
Alignment - (1)	17391.26	2-yr	377.00	115.95	120.07		120.40	0.004286	4.59	88.34	103.86	0.49
Alignment - (1)	17391.26	10-yr	622.00	115.95	120.94		121.25	0.003278	4.82	189.47	129.17	0.45
Alignment - (1)	17391.26	25-yr	770.00	115.95	121.34		121.64	0.002965	4.92	243.62	140.86	0.43
Alignment - (1)	17391.26	50-yr	904.00	115.95	121.66		121.95	0.002783	5.02	289.77	150.12	0.43
Alignment - (1)	17391.26	100-yr	1000.00	115.95	121.87		122.16	0.002671	5.08	322.52	156.46	0.42
Alignment - (1)	17750.27	2-yr	377.00	118.46	121.98	121.24	122.45	0.007565	5.48	69.21	73.43	0.64
Alignment - (1)	17750.27	10-yr	622.00	118.46	122.50	122.47	123.07	0.007912	6.43	142.21	149.06	0.67
Alignment - (1)	17750.27	25-yr	770.00	118.46	122.77	122.70	123.33	0.007550	6.66	182.61	157.98	0.67
Alignment - (1)	17750.27	50-yr	904.00	118.46	123.00	122.87	123.54	0.007090	6.77	219.43	165.46	0.66
Alignment - (1)	17750.27	100-yr	1000.00	118.46	123.15		123.68	0.006774	6.83	245.78	171.23	0.65
Alignment - (1)	17947.72	2-yr	377.00	119.60	124.68	124.68	125.02	0.009609	6.42	152.09	187.79	0.61
Alignment - (1)	17947.72	10-yr	622.00	119.60	124.95	124.95	125.38	0.013002	7.85	205.82	208.02	0.71
Alignment - (1)	17947.72	25-yr	770.00	119.60	125.09	125.09	125.55	0.014350	8.45	235.37	217.59	0.76
Alignment - (1)	17947.72	50-yr	904.00	119.60	125.20	125.20	125.69	0.015435	8.93	259.81	224.88	0.79
Alignment - (1)	17947.72	100-yr	1000.00	119.60	125.28	125.28	125.78	0.015971	9.20	277.69	230.84	0.80
Alignment - (1)	18316.06	2-yr	213.00	120.45	125.96		125.98	0.000724	1.87	316.92	228.43	0.16
Alignment - (1)	18316.06	10-yr	347.00	120.45	126.50		126.52	0.000792	2.12	447.61	259.28	0.17
Alignment - (1)	18316.06	25-yr	431.00	120.45	126.75		126.77	0.000844	2.26	515.09	273.06	0.18
Alignment - (1)	18316.06	50-yr	513.00	120.45	126.96		126.98	0.000901	2.40	573.22	284.39	0.19
Alignment - (1)	18316.06	100-yr	574.00	120.45	127.09		127.12	0.000945	2.51	612.65	291.83	0.19
Alignment - (1)	18612.92	2-yr	213.00	122.00	126.31		126.43	0.003920	3.79	139.72	148.80	0.38
Alignment - (1)	18612.92	10-yr	347.00	122.00	126.87		126.96	0.003306	3.88	234.01	191.88	0.35
Alignment - (1)	18612.92	25-yr	431.00	122.00	127.14		127.23	0.003129	3.95	288.19	211.63	0.35
Alignment - (1)	18612.92	50-yr	513.00	122.00	127.36		127.45	0.003033	4.03	337.76	228.23	0.35
Alignment - (1)	18612.92	100-yr	574.00	122.00	127.51		127.60	0.002990	4.10	372.85	239.29	0.35

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	18841.01	2-yr	213.00	124.23	128.26	128.26	128.61	0.010889	5.82	105.15	166.10	0.61
Alignment - (1)	18841.01	10-yr	347.00	124.23	128.57	128.57	128.95	0.012795	6.76	159.86	186.87	0.67
Alignment - (1)	18841.01	25-yr	431.00	124.23	128.69	128.69	129.12	0.015018	7.51	181.58	194.50	0.73
Alignment - (1)	18841.01	50-yr	513.00	124.23	128.83	128.83	129.27	0.015244	7.79	211.41	205.65	0.75
Alignment - (1)	18841.01	100-yr	574.00	124.23	128.89	128.89	129.37	0.016908	8.30	223.16	209.96	0.79
Alignment - (1)	19025	2-yr	213.00	126.51	130.11		130.28	0.007572	4.72	143.35	175.42	0.52
Alignment - (1)	19025	10-yr	347.00	126.51	130.53		130.69	0.007185	5.09	221.19	191.53	0.52
Alignment - (1)	19025	25-yr	431.00	126.51	130.78		130.93	0.006755	5.20	268.93	200.77	0.51
Alignment - (1)	19025	50-yr	513.00	126.51	130.95		131.11	0.006910	5.45	304.97	207.47	0.52
Alignment - (1)	19025	100-yr	574.00	126.51	131.10		131.26	0.006716	5.52	335.93	213.06	0.52
Alignment - (1)	19146.14	2-yr	213.00	126.07	130.74	129.23	131.09	0.004796	4.74	46.76	129.01	0.44
Alignment - (1)	19146.14	10-yr	347.00	126.07	131.20	130.07	131.91	0.008477	6.83	53.20	142.09	0.60
Alignment - (1)	19146.14	25-yr	431.00	126.07	131.39	130.53	132.39	0.011205	8.09	55.86	147.50	0.69
Alignment - (1)	19146.14	50-yr	513.00	126.07	131.53	130.92	132.86	0.014190	9.31	57.87	151.59	0.78
Alignment - (1)	19146.14	100-yr	574.00	126.07	131.60	131.21	133.20	0.016868	10.25	58.82	153.52	0.86
Alignment - (1)	19187		Culvert									
Alignment - (1)	19207	2-yr	213.00	126.60	135.29	130.02	135.29	0.000033	0.68	869.04	166.15	0.04
Alignment - (1)	19207	10-yr	347.00	126.60	135.65	131.19	135.65	0.000072	1.04	929.67	169.14	0.06
Alignment - (1)	19207	25-yr	431.00	126.60	135.81	131.86	135.81	0.000103	1.25	956.58	170.46	0.08
Alignment - (1)	19207	50-yr	513.00	126.60	135.89	132.46	135.90	0.000140	1.47	970.38	171.12	0.09
Alignment - (1)	19207	100-yr	574.00	126.60	135.99	132.88	136.00	0.000166	1.62	988.53	172.00	0.10
Alignment - (1)	19262	2-yr	213.00	128.06	135.29		135.29	0.000018	0.46	1377.79	318.01	0.03
Alignment - (1)	19262	10-yr	347.00	128.06	135.65		135.66	0.000038	0.69	1495.27	324.84	0.05
Alignment - (1)	19262	25-yr	431.00	128.06	135.82		135.82	0.000053	0.83	1547.97	327.86	0.05
Alignment - (1)	19262	50-yr	513.00	128.06	135.90		135.90	0.000071	0.97	1575.72	329.44	0.06
Alignment - (1)	19262	100-yr	574.00	128.06	136.01		136.01	0.000084	1.06	1611.56	331.47	0.07
Alignment - (1)	19445.34	2-yr	213.00	127.97	135.29		135.29	0.000034	0.53	1191.46	351.69	0.04
Alignment - (1)	19445.34	10-yr	347.00	127.97	135.66		135.67	0.000068	0.77	1324.99	370.06	0.05
Alignment - (1)	19445.34	25-yr	431.00	127.97	135.83		135.83	0.000092	0.91	1386.59	377.04	0.06
Alignment - (1)	19445.34	50-yr	513.00	127.97	135.92		135.92	0.000122	1.06	1420.22	380.79	0.07
Alignment - (1)	19445.34	100-yr	574.00	127.97	136.03		136.03	0.000141	1.15	1462.86	385.65	0.07

HEC-RAS Plan: Alt #1A River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	19799.72	2-yr	213.00	129.96	135.31		135.32	0.000123	0.91	529.88	263.40	0.07
Alignment - (1)	19799.72	10-yr	347.00	129.96	135.70		135.71	0.000212	1.26	639.39	302.24	0.10
Alignment - (1)	19799.72	25-yr	431.00	129.96	135.88		135.88	0.000266	1.45	694.25	317.91	0.11
Alignment - (1)	19799.72	50-yr	513.00	129.96	135.98		135.99	0.000332	1.63	727.39	324.55	0.12
Alignment - (1)	19799.72	100-yr	574.00	129.96	136.10		136.11	0.000354	1.71	766.07	325.72	0.13
Alignment - (1)	20189.88	2-yr	213.00	132.20	135.29		135.56	0.012860	6.22	89.23	114.76	0.67
Alignment - (1)	20189.88	10-yr	347.00	132.20	135.82		136.01	0.008729	5.79	159.60	150.83	0.57
Alignment - (1)	20189.88	25-yr	431.00	132.20	136.06		136.23	0.008139	5.86	197.09	168.32	0.56
Alignment - (1)	20189.88	50-yr	513.00	132.20	136.22		136.40	0.008493	6.17	225.44	184.75	0.57
Alignment - (1)	20189.88	100-yr	574.00	132.20	136.36		136.54	0.008202	6.22	252.33	199.91	0.57
Alignment - (1)	20618.31	2-yr	213.00	135.89	139.34	138.98	139.50	0.006835	4.94	110.55	110.25	0.50
Alignment - (1)	20618.31	10-yr	347.00	135.89	139.64		139.86	0.009208	6.11	146.13	124.36	0.59
Alignment - (1)	20618.31	25-yr	431.00	135.89	139.83		140.05	0.009715	6.51	169.80	132.00	0.61
Alignment - (1)	20618.31	50-yr	513.00	135.89	140.04		140.27	0.009503	6.69	199.20	145.30	0.61
Alignment - (1)	20618.31	100-yr	574.00	135.89	140.16		140.40	0.009874	6.96	216.91	154.49	0.62
Alignment - (1)	20968.95	2-yr	213.00	137.93	141.23	140.83	141.29	0.003950	3.64	203.36	255.43	0.38
Alignment - (1)	20968.95	10-yr	347.00	137.93	141.66		141.70	0.003344	3.66	324.43	318.31	0.35
Alignment - (1)	20968.95	25-yr	431.00	137.93	141.85		141.89	0.003201	3.72	387.48	344.36	0.35
Alignment - (1)	20968.95	50-yr	513.00	137.93	142.02		142.07	0.003136	3.80	450.20	383.44	0.35
Alignment - (1)	20968.95	100-yr	574.00	137.93	142.13		142.17	0.003012	3.80	492.77	393.12	0.34

ALTERNATIVE #2

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	10365	2-yr	601.00	96.44	102.01	101.42	102.23	0.005001	5.33	213.31	137.84	0.43
Alignment - (1)	10365	10-yr	1028.00	96.44	102.76	102.03	103.00	0.005005	5.87	324.00	157.56	0.44
Alignment - (1)	10365	25-yr	1304.00	96.44	103.15	102.25	103.41	0.005001	6.14	388.89	168.94	0.44
Alignment - (1)	10365	50-yr	1801.00	96.44	103.77	102.65	104.05	0.005001	6.55	497.85	187.39	0.45
Alignment - (1)	10365	100-yr	2026.00	96.44	104.02	102.79	104.30	0.005004	6.72	545.49	195.88	0.45
Alignment - (1)	10638.24	2-yr	601.00	98.77	103.42		103.57	0.004751	4.79	254.10	155.07	0.42
Alignment - (1)	10638.24	10-yr	1028.00	98.77	104.16		104.34	0.004704	5.33	374.81	169.76	0.43
Alignment - (1)	10638.24	25-yr	1304.00	98.77	104.55		104.75	0.004731	5.63	442.53	176.99	0.44
Alignment - (1)	10638.24	50-yr	1801.00	98.77	105.16		105.38	0.004754	6.08	554.45	187.98	0.45
Alignment - (1)	10638.24	100-yr	2026.00	98.77	105.41		105.64	0.004742	6.24	601.01	191.08	0.45
Alignment - (1)	10849.17	2-yr	601.00	98.54	104.23		104.38	0.003168	4.47	237.79	120.08	0.35
Alignment - (1)	10849.17	10-yr	1028.00	98.54	105.01		105.22	0.003669	5.31	338.04	135.47	0.39
Alignment - (1)	10849.17	25-yr	1304.00	98.54	105.43		105.66	0.003874	5.71	395.65	143.36	0.40
Alignment - (1)	10849.17	50-yr	1801.00	98.54	106.06		106.33	0.004109	6.28	489.40	153.34	0.42
Alignment - (1)	10849.17	100-yr	2026.00	98.54	106.31		106.60	0.004215	6.51	528.61	157.82	0.43
Alignment - (1)	11152.11	2-yr	601.00	98.92	104.99		105.07	0.001673	3.47	332.23	146.36	0.26
Alignment - (1)	11152.11	10-yr	1028.00	98.92	105.90		106.00	0.001883	4.08	473.90	165.39	0.28
Alignment - (1)	11152.11	25-yr	1304.00	98.92	106.37		106.49	0.002001	4.41	554.40	176.89	0.30
Alignment - (1)	11152.11	50-yr	1801.00	98.92	107.08		107.23	0.002168	4.90	687.36	195.30	0.31
Alignment - (1)	11152.11	100-yr	2026.00	98.92	107.37		107.52	0.002222	5.08	743.92	202.22	0.32
Alignment - (1)	11531.01	2-yr	601.00	100.12	105.69		105.87	0.002519	4.21	249.92	126.98	0.35
Alignment - (1)	11531.01	10-yr	1028.00	100.12	106.65		106.87	0.002571	4.85	380.54	144.30	0.37
Alignment - (1)	11531.01	25-yr	1304.00	100.12	107.15		107.39	0.002609	5.19	455.31	154.10	0.38
Alignment - (1)	11531.01	50-yr	1801.00	100.12	107.91		108.17	0.002673	5.70	576.85	167.55	0.39
Alignment - (1)	11531.01	100-yr	2026.00	100.12	108.21		108.48	0.002697	5.89	627.32	171.67	0.40
Alignment - (1)	11640	2-yr	601.00	101.11	105.96	104.83	106.42	0.006116	5.43	110.74	112.78	0.53
Alignment - (1)	11640	10-yr	1028.00	101.11	106.80	105.75	107.65	0.008348	7.39	139.20	128.30	0.64
Alignment - (1)	11640	25-yr	1304.00	101.11	107.20	106.28	108.33	0.009854	8.54	152.76	136.95	0.71
Alignment - (1)	11640	50-yr	1801.00	101.11	107.73	107.14	109.46	0.012991	10.55	170.66	148.76	0.83
Alignment - (1)	11640	100-yr	2026.00	101.11	107.90	107.50	109.95	0.014714	11.48	176.43	152.21	0.89
Alignment - (1)	11700		Culvert									

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	11775	2-yr	601.00	100.19	106.85	104.16	107.10	0.001850	4.06	147.91	58.77	0.32
Alignment - (1)	11775	10-yr	1028.00	100.19	108.86	105.18	109.25	0.001759	4.96	207.24	83.18	0.33
Alignment - (1)	11775	25-yr	1304.00	100.19	110.15	105.75	110.59	0.001617	5.32	245.13	94.58	0.32
Alignment - (1)	11775	50-yr	1801.00	100.19	111.70	106.70	111.91	0.000800	4.11	623.07	134.15	0.23
Alignment - (1)	11775	100-yr	2026.00	100.19	112.11	107.10	112.33	0.000831	4.30	679.12	139.78	0.24
Alignment - (1)	11835	2-yr	488.00	100.00	107.17		107.24	0.000871	2.81	308.24	111.04	0.20
Alignment - (1)	11835	10-yr	830.00	100.00	109.35		109.40	0.000470	2.51	570.41	129.16	0.15
Alignment - (1)	11835	25-yr	1051.00	100.00	110.71		110.75	0.000356	2.41	755.55	145.69	0.14
Alignment - (1)	11835	50-yr	1507.00	100.00	111.93		111.99	0.000486	3.04	966.72	199.25	0.16
Alignment - (1)	11835	100-yr	1692.00	100.00	112.35		112.42	0.000502	3.17	1054.35	212.35	0.16
Alignment - (1)	11974.42	2-yr	488.00	100.50	107.30		107.37	0.001064	2.92	319.11	134.09	0.20
Alignment - (1)	11974.42	10-yr	830.00	100.50	109.43		109.47	0.000505	2.44	675.96	201.12	0.15
Alignment - (1)	11974.42	25-yr	1051.00	100.50	110.78		110.80	0.000317	2.13	974.90	237.38	0.12
Alignment - (1)	11974.42	50-yr	1507.00	100.50	112.01		112.04	0.000293	2.22	1292.68	282.17	0.12
Alignment - (1)	11974.42	100-yr	1692.00	100.50	112.44		112.47	0.000293	2.28	1421.25	316.69	0.12
Alignment - (1)	12143.18	2-yr	488.00	101.50	107.49		107.53	0.000777	2.27	451.05	196.70	0.17
Alignment - (1)	12143.18	10-yr	830.00	101.50	109.52		109.54	0.000331	1.82	897.69	238.26	0.12
Alignment - (1)	12143.18	25-yr	1051.00	101.50	110.83		110.85	0.000207	1.61	1250.53	304.41	0.10
Alignment - (1)	12143.18	50-yr	1507.00	101.50	112.07		112.08	0.000197	1.71	1656.38	352.74	0.09
Alignment - (1)	12143.18	100-yr	1692.00	101.50	112.50		112.52	0.000195	1.75	1813.46	377.87	0.09
Alignment - (1)	12518.55	2-yr	488.00	101.50	107.83		107.90	0.001247	3.00	318.86	143.67	0.22
Alignment - (1)	12518.55	10-yr	830.00	101.50	109.67		109.71	0.000640	2.58	620.89	183.94	0.16
Alignment - (1)	12518.55	25-yr	1051.00	101.50	110.93		110.96	0.000432	2.34	871.98	218.17	0.14
Alignment - (1)	12518.55	50-yr	1507.00	101.50	112.16		112.20	0.000423	2.53	1163.48	251.91	0.14
Alignment - (1)	12518.55	100-yr	1692.00	101.50	112.59		112.62	0.000412	2.56	1272.27	256.88	0.14
Alignment - (1)	12742.17	2-yr	488.00	101.89	108.12		108.18	0.001252	2.97	373.55	185.83	0.22
Alignment - (1)	12742.17	10-yr	830.00	101.89	109.82		109.85	0.000619	2.48	713.72	214.02	0.16
Alignment - (1)	12742.17	25-yr	1051.00	101.89	111.03		111.05	0.000399	2.20	983.34	231.79	0.13
Alignment - (1)	12742.17	50-yr	1507.00	101.89	112.26		112.29	0.000388	2.37	1278.89	250.51	0.13
Alignment - (1)	12742.17	100-yr	1692.00	101.89	112.68		112.71	0.000391	2.45	1387.40	259.06	0.13
Alignment - (1)	13161.24	2-yr	488.00	103.59	108.89		109.08	0.003926	4.66	228.43	147.72	0.37
Alignment - (1)	13161.24	10-yr	830.00	103.59	110.21		110.32	0.002182	4.08	449.88	187.88	0.29

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	13161.24	25-yr	1051.00	103.59	111.27		111.34	0.001273	3.47	665.86	218.59	0.23
Alignment - (1)	13161.24	50-yr	1507.00	103.59	112.48		112.55	0.001039	3.47	951.72	256.34	0.21
Alignment - (1)	13161.24	100-yr	1692.00	103.59	112.91		112.97	0.000982	3.49	1063.04	269.55	0.21
Alignment - (1)	13456.23	2-yr	488.00	104.41	109.90		110.02	0.002613	3.91	264.70	141.39	0.31
Alignment - (1)	13456.23	10-yr	830.00	104.41	110.88		110.99	0.002386	4.20	411.34	158.20	0.30
Alignment - (1)	13456.23	25-yr	1051.00	104.41	111.69		111.79	0.001788	3.96	547.25	173.98	0.27
Alignment - (1)	13456.23	50-yr	1507.00	104.41	112.83		112.93	0.001530	4.06	756.55	194.70	0.25
Alignment - (1)	13456.23	100-yr	1692.00	104.41	113.23		113.33	0.001467	4.12	836.78	202.15	0.25
Alignment - (1)	13752.12	2-yr	488.00	104.47	110.38		110.42	0.000790	2.27	425.58	202.52	0.17
Alignment - (1)	13752.12	10-yr	830.00	104.47	111.34		111.38	0.000786	2.52	633.98	232.87	0.18
Alignment - (1)	13752.12	25-yr	1051.00	104.47	112.06		112.10	0.000655	2.47	812.08	258.82	0.16
Alignment - (1)	13752.12	50-yr	1507.00	104.47	113.16		113.19	0.000576	2.55	1111.94	289.85	0.16
Alignment - (1)	13752.12	100-yr	1692.00	104.47	113.55		113.59	0.000552	2.57	1227.54	298.89	0.15
Alignment - (1)	13993.89	2-yr	488.00	104.65	110.63		110.74	0.002211	3.73	285.62	155.84	0.29
Alignment - (1)	13993.89	10-yr	830.00	104.65	111.58		111.69	0.002101	4.06	447.06	182.61	0.29
Alignment - (1)	13993.89	25-yr	1051.00	104.65	112.26		112.36	0.001737	3.96	578.22	202.51	0.26
Alignment - (1)	13993.89	50-yr	1507.00	104.65	113.33		113.42	0.001466	4.00	811.19	235.26	0.25
Alignment - (1)	13993.89	100-yr	1692.00	104.65	113.71		113.80	0.001393	4.02	903.86	247.47	0.24
Alignment - (1)	14297.17	2-yr	488.00	104.50	111.19		111.30	0.001570	3.50	286.35	131.69	0.25
Alignment - (1)	14297.17	10-yr	830.00	104.50	112.15		112.27	0.001712	4.02	424.02	153.95	0.26
Alignment - (1)	14297.17	25-yr	1051.00	104.50	112.75		112.87	0.001587	4.09	518.24	157.67	0.26
Alignment - (1)	14297.17	50-yr	1507.00	104.50	113.76		113.88	0.001491	4.30	696.23	201.74	0.26
Alignment - (1)	14297.17	100-yr	1692.00	104.50	114.12		114.24	0.001445	4.35	773.30	217.21	0.25
Alignment - (1)	14362.99	2-yr	488.00	105.43	111.28		111.45	0.002738	4.19	219.10	155.00	0.36
Alignment - (1)	14362.99	10-yr	830.00	105.43	112.26		112.40	0.002073	4.18	398.36	207.48	0.32
Alignment - (1)	14362.99	25-yr	1051.00	105.43	112.86		112.98	0.001639	3.99	530.78	232.59	0.29
Alignment - (1)	14362.99	50-yr	1507.00	105.43	113.87		113.97	0.001233	3.85	787.15	274.76	0.26
Alignment - (1)	14362.99	100-yr	1692.00	105.43	114.24		114.33	0.001129	3.81	890.15	289.60	0.25
Alignment - (1)	14499.92	2-yr	488.00	107.01	111.64	109.73	111.85	0.002719	3.68	132.65	39.64	0.35
Alignment - (1)	14499.92	10-yr	830.00	107.01	112.51	110.56	112.89	0.003744	4.94	168.11	61.36	0.43
Alignment - (1)	14499.92	25-yr	1051.00	107.01	113.01	111.03	113.50	0.004099	5.57	188.86	96.73	0.46
Alignment - (1)	14499.92	50-yr	1507.00	107.01	113.94	111.85	114.44	0.003715	5.99	320.59	131.04	0.45

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	14499.92	100-yr	1692.00	107.01	114.28	112.15	114.79	0.003583	6.12	368.09	147.44	0.44
Alignment - (1)	14500		Culvert									
Alignment - (1)	14563.55	2-yr	488.00	107.47	112.29	110.91	112.69	0.005398	5.09	95.89	32.19	0.49
Alignment - (1)	14563.55	10-yr	830.00	107.47	114.22	111.90	114.69	0.003444	5.50	150.91	101.51	0.42
Alignment - (1)	14563.55	25-yr	1051.00	107.47	115.21	112.40	115.48	0.002112	4.43	325.07	141.60	0.33
Alignment - (1)	14563.55	50-yr	1507.00	107.47	115.95	113.35	116.28	0.002408	5.14	448.70	196.90	0.36
Alignment - (1)	14563.55	100-yr	1692.00	107.47	116.19	113.71	116.54	0.002516	5.38	497.01	216.04	0.37
Alignment - (1)	14666.23	2-yr	436.00	108.44	112.90		112.91	0.000391	1.54	511.33	225.25	0.14
Alignment - (1)	14666.23	10-yr	737.00	108.44	114.86		114.87	0.000154	1.27	991.29	252.37	0.09
Alignment - (1)	14666.23	25-yr	932.00	108.44	115.58		115.59	0.000145	1.34	1179.07	276.48	0.09
Alignment - (1)	14666.23	50-yr	1368.00	108.44	116.41		116.42	0.000183	1.63	1420.07	303.81	0.11
Alignment - (1)	14666.23	100-yr	1533.00	108.44	116.67		116.69	0.000197	1.73	1500.76	310.09	0.11
Alignment - (1)	14953.25	2-yr	436.00	108.74	112.97		113.33	0.010727	6.54	146.41	142.85	0.60
Alignment - (1)	14953.25	10-yr	737.00	108.74	114.93		114.98	0.001232	2.94	504.53	220.44	0.22
Alignment - (1)	14953.25	25-yr	932.00	108.74	115.64		115.69	0.000904	2.72	669.47	242.55	0.19
Alignment - (1)	14953.25	50-yr	1368.00	108.74	116.48		116.53	0.000910	2.96	884.49	270.36	0.19
Alignment - (1)	14953.25	100-yr	1533.00	108.74	116.75		116.80	0.000920	3.05	958.15	279.70	0.20
Alignment - (1)	15162.55	2-yr	436.00	108.90	114.13		114.21	0.002089	3.33	270.88	160.99	0.27
Alignment - (1)	15162.55	10-yr	737.00	108.90	115.20		115.26	0.001414	3.14	449.37	174.79	0.23
Alignment - (1)	15162.55	25-yr	932.00	108.90	115.85		115.90	0.001160	3.05	568.31	193.30	0.21
Alignment - (1)	15162.55	50-yr	1368.00	108.90	116.69		116.76	0.001213	3.39	743.86	225.36	0.22
Alignment - (1)	15162.55	100-yr	1533.00	108.90	116.96		117.03	0.001235	3.50	806.18	236.18	0.22
Alignment - (1)	15355.4	2-yr	436.00	110.34	114.71		115.04	0.009782	6.23	145.85	159.58	0.57
Alignment - (1)	15355.4	10-yr	737.00	110.34	115.58		115.73	0.004407	4.81	290.97	174.62	0.40
Alignment - (1)	15355.4	25-yr	932.00	110.34	116.15		116.26	0.002988	4.28	391.91	185.16	0.33
Alignment - (1)	15355.4	50-yr	1368.00	110.34	116.98		117.09	0.002347	4.19	561.59	222.55	0.30
Alignment - (1)	15355.4	100-yr	1533.00	110.34	117.24		117.35	0.002190	4.16	621.99	229.71	0.29
Alignment - (1)	15557.79	2-yr	436.00	110.42	115.78		116.04	0.002941	4.30	136.52	71.49	0.38
Alignment - (1)	15557.79	10-yr	737.00	110.42	116.29		116.77	0.004915	6.02	182.08	108.21	0.50
Alignment - (1)	15557.79	25-yr	932.00	110.42	116.64		117.20	0.005519	6.69	219.67	111.88	0.53
Alignment - (1)	15557.79	50-yr	1368.00	110.42	117.31		117.98	0.006138	7.69	306.98	157.06	0.57

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	15557.79	100-yr	1533.00	110.42	117.54		118.22	0.006201	7.93	344.77	176.56	0.58
Alignment - (1)	15700	2-yr	436.00	111.23	116.08	114.04	116.26	0.000835	3.41	127.81	37.66	0.33
Alignment - (1)	15700	10-yr	737.00	111.23	116.78	114.83	117.14	0.001310	4.75	155.21	53.71	0.42
Alignment - (1)	15700	25-yr	932.00	111.23	117.14	115.27	117.61	0.001567	5.48	180.35	79.24	0.47
Alignment - (1)	15700	50-yr	1368.00	111.23	117.76	116.14	118.45	0.002021	6.79	258.58	157.10	0.54
Alignment - (1)	15700	100-yr	1533.00	111.23	117.99	116.44	118.73	0.002091	7.12	297.37	201.85	0.56
Alignment - (1)	15735		Culvert									
Alignment - (1)	15770	2-yr	436.00	111.24	116.87	114.24	117.04	0.000649	3.27	133.37	53.75	0.27
Alignment - (1)	15770	10-yr	737.00	111.24	117.88	115.06	118.11	0.000770	3.98	230.21	107.96	0.32
Alignment - (1)	15770	25-yr	932.00	111.24	118.19	115.51	118.50	0.000960	4.63	267.78	133.63	0.36
Alignment - (1)	15770	50-yr	1368.00	111.24	118.61	116.42	119.13	0.001488	6.06	331.02	169.44	0.45
Alignment - (1)	15770	100-yr	1533.00	111.24	118.68	116.74	119.30	0.001761	6.65	344.17	176.14	0.49
Alignment - (1)	15898.43	2-yr	416.00	111.19	116.99		117.19	0.002041	3.80	141.55	99.24	0.35
Alignment - (1)	15898.43	10-yr	701.00	111.19	118.06		118.26	0.001698	4.11	269.23	140.72	0.33
Alignment - (1)	15898.43	25-yr	885.00	111.19	118.46		118.69	0.001781	4.44	330.11	158.45	0.35
Alignment - (1)	15898.43	50-yr	1317.00	111.19	119.13		119.42	0.002088	5.22	446.28	190.54	0.38
Alignment - (1)	15898.43	100-yr	1475.00	111.19	119.34		119.65	0.002173	5.46	488.03	204.54	0.39
Alignment - (1)	16116.29	2-yr	416.00	111.00	117.33		117.39	0.000444	2.15	317.92	191.91	0.17
Alignment - (1)	16116.29	10-yr	701.00	111.00	118.38		118.44	0.000411	2.36	557.12	255.05	0.17
Alignment - (1)	16116.29	25-yr	885.00	111.00	118.81		118.87	0.000429	2.53	671.36	272.29	0.18
Alignment - (1)	16116.29	50-yr	1317.00	111.00	119.56		119.63	0.000490	2.92	885.05	298.58	0.19
Alignment - (1)	16116.29	100-yr	1475.00	111.00	119.80		119.87	0.000508	3.03	955.94	306.14	0.20
Alignment - (1)	16367.71	2-yr	416.00	111.92	117.46		117.56	0.000922	2.80	220.23	136.85	0.24
Alignment - (1)	16367.71	10-yr	701.00	111.92	118.49		118.59	0.000831	3.09	388.56	183.62	0.24
Alignment - (1)	16367.71	25-yr	885.00	111.92	118.92		119.04	0.000856	3.31	471.89	198.67	0.25
Alignment - (1)	16367.71	50-yr	1317.00	111.92	119.68		119.82	0.000985	3.87	635.85	237.08	0.27
Alignment - (1)	16367.71	100-yr	1475.00	111.92	119.92		120.07	0.001016	4.02	693.62	248.97	0.28
Alignment - (1)	16711.97	2-yr	416.00	113.98	117.87		118.37	0.007149	5.67	73.35	28.75	0.63
Alignment - (1)	16711.97	10-yr	701.00	113.98	118.77	118.30	119.35	0.006220	6.40	145.52	96.21	0.61
Alignment - (1)	16711.97	25-yr	885.00	113.98	119.20		119.80	0.005830	6.71	188.85	104.74	0.60
Alignment - (1)	16711.97	50-yr	1317.00	113.98	119.98		120.65	0.005544	7.41	277.14	120.26	0.61

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	16711.97	100-yr	1475.00	113.98	120.22		120.92	0.005562	7.68	306.32	126.71	0.61
Alignment - (1)	16903.85	2-yr	258.00	113.99	118.80		118.89	0.000922	2.47	119.71	73.03	0.24
Alignment - (1)	16903.85	10-yr	418.00	113.99	119.74		119.86	0.000904	2.88	209.02	115.70	0.24
Alignment - (1)	16903.85	25-yr	519.00	113.99	120.18		120.31	0.000912	3.08	263.45	131.35	0.25
Alignment - (1)	16903.85	50-yr	613.00	113.99	121.01		121.11	0.000606	2.80	380.34	151.17	0.21
Alignment - (1)	16903.85	100-yr	686.00	113.99	121.28		121.38	0.000612	2.90	422.11	159.29	0.21
Alignment - (1)	17391.26	2-yr	258.00	115.95	119.50		119.75	0.003860	3.96	65.13	27.66	0.45
Alignment - (1)	17391.26	10-yr	418.00	115.95	120.39		120.67	0.003277	4.32	122.99	113.17	0.44
Alignment - (1)	17391.26	25-yr	519.00	115.95	120.81		121.06	0.002742	4.30	172.73	125.33	0.41
Alignment - (1)	17391.26	50-yr	613.00	115.95	121.42		121.59	0.001706	3.78	254.65	143.13	0.33
Alignment - (1)	17391.26	100-yr	686.00	115.95	121.69		121.85	0.001556	3.77	293.58	150.85	0.32
Alignment - (1)	17750.27	2-yr	258.00	118.46	121.34	120.73	121.74	0.008151	5.08	50.76	26.27	0.64
Alignment - (1)	17750.27	10-yr	418.00	118.46	122.01	121.39	122.57	0.008810	5.97	73.22	132.55	0.69
Alignment - (1)	17750.27	25-yr	519.00	118.46	122.21	121.75	122.85	0.009581	6.57	99.79	139.12	0.73
Alignment - (1)	17750.27	50-yr	613.00	118.46	122.46	122.46	123.05	0.008413	6.55	135.00	147.41	0.69
Alignment - (1)	17750.27	100-yr	686.00	118.46	122.58	122.58	123.18	0.008381	6.73	153.51	151.60	0.70
Alignment - (1)	17947.72	2-yr	258.00	119.60	124.45	124.45	124.79	0.008662	5.82	110.82	172.15	0.57
Alignment - (1)	17947.72	10-yr	418.00	119.60	124.71	124.71	125.09	0.010830	6.86	158.16	190.18	0.65
Alignment - (1)	17947.72	25-yr	519.00	119.60	124.84	124.84	125.24	0.011934	7.37	183.18	199.75	0.68
Alignment - (1)	17947.72	50-yr	613.00	119.60	124.94	124.94	125.37	0.012914	7.81	203.92	207.34	0.71
Alignment - (1)	17947.72	100-yr	686.00	119.60	125.02	125.02	125.46	0.013611	8.12	218.98	212.56	0.73
Alignment - (1)	18316.06	2-yr	213.00	120.45	125.74		125.77	0.001072	2.19	268.69	210.40	0.19
Alignment - (1)	18316.06	10-yr	347.00	120.45	126.22		126.25	0.001233	2.54	377.54	243.86	0.21
Alignment - (1)	18316.06	25-yr	431.00	120.45	126.45		126.48	0.001317	2.71	434.97	256.62	0.22
Alignment - (1)	18316.06	50-yr	513.00	120.45	126.65		126.68	0.001385	2.86	487.11	267.43	0.23
Alignment - (1)	18316.06	100-yr	574.00	120.45	126.78		126.82	0.001430	2.96	524.03	274.83	0.23
Alignment - (1)	18612.92	2-yr	213.00	122.00	126.25		126.38	0.004587	4.04	129.71	143.49	0.40
Alignment - (1)	18612.92	10-yr	347.00	122.00	126.77		126.88	0.004016	4.19	214.98	183.99	0.39
Alignment - (1)	18612.92	25-yr	431.00	122.00	127.02		127.13	0.003862	4.30	263.64	203.04	0.39
Alignment - (1)	18612.92	50-yr	513.00	122.00	127.23		127.34	0.003753	4.40	309.07	218.78	0.38
Alignment - (1)	18612.92	100-yr	574.00	122.00	127.38		127.49	0.003688	4.46	341.91	229.57	0.38

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	18841.01	2-yr	213.00	124.23	128.26	128.26	128.61	0.010889	5.82	105.15	166.10	0.61
Alignment - (1)	18841.01	10-yr	347.00	124.23	128.57	128.57	128.95	0.012795	6.76	159.86	186.87	0.67
Alignment - (1)	18841.01	25-yr	431.00	124.23	128.69	128.69	129.12	0.015018	7.51	181.58	194.50	0.73
Alignment - (1)	18841.01	50-yr	513.00	124.23	128.83	128.83	129.27	0.015244	7.79	211.41	205.65	0.75
Alignment - (1)	18841.01	100-yr	574.00	124.23	128.89	128.89	129.37	0.016908	8.30	223.16	209.96	0.79
Alignment - (1)	19025	2-yr	213.00	126.51	130.11		130.28	0.007572	4.72	143.35	175.42	0.52
Alignment - (1)	19025	10-yr	347.00	126.51	130.53		130.69	0.007185	5.09	221.19	191.53	0.52
Alignment - (1)	19025	25-yr	431.00	126.51	130.78		130.93	0.006755	5.20	268.93	200.77	0.51
Alignment - (1)	19025	50-yr	513.00	126.51	130.95		131.11	0.006910	5.45	304.97	207.47	0.52
Alignment - (1)	19025	100-yr	574.00	126.51	131.10		131.26	0.006716	5.52	335.93	213.06	0.52
Alignment - (1)	19146.14	2-yr	213.00	126.07	130.74	129.23	131.09	0.004796	4.74	46.76	129.01	0.44
Alignment - (1)	19146.14	10-yr	347.00	126.07	131.20	130.07	131.91	0.008477	6.83	53.20	142.09	0.60
Alignment - (1)	19146.14	25-yr	431.00	126.07	131.39	130.53	132.39	0.011205	8.09	55.86	147.50	0.69
Alignment - (1)	19146.14	50-yr	513.00	126.07	131.53	130.92	132.86	0.014190	9.31	57.87	151.59	0.78
Alignment - (1)	19146.14	100-yr	574.00	126.07	131.60	131.21	133.20	0.016868	10.25	58.82	153.52	0.86
Alignment - (1)	19187		Culvert									
Alignment - (1)	19207	2-yr	213.00	126.60	135.29	130.02	135.29	0.000033	0.68	869.04	166.15	0.04
Alignment - (1)	19207	10-yr	347.00	126.60	135.65	131.19	135.65	0.000072	1.04	929.67	169.14	0.06
Alignment - (1)	19207	25-yr	431.00	126.60	135.81	131.86	135.81	0.000103	1.25	956.58	170.46	0.08
Alignment - (1)	19207	50-yr	513.00	126.60	135.89	132.46	135.90	0.000140	1.47	970.38	171.12	0.09
Alignment - (1)	19207	100-yr	574.00	126.60	135.99	132.88	136.00	0.000166	1.62	988.53	172.00	0.10
Alignment - (1)	19262	2-yr	213.00	128.06	135.29		135.29	0.000018	0.46	1377.79	318.01	0.03
Alignment - (1)	19262	10-yr	347.00	128.06	135.65		135.66	0.000038	0.69	1495.27	324.84	0.05
Alignment - (1)	19262	25-yr	431.00	128.06	135.82		135.82	0.000053	0.83	1547.97	327.86	0.05
Alignment - (1)	19262	50-yr	513.00	128.06	135.90		135.90	0.000071	0.97	1575.72	329.44	0.06
Alignment - (1)	19262	100-yr	574.00	128.06	136.01		136.01	0.000084	1.06	1611.56	331.47	0.07
Alignment - (1)	19445.34	2-yr	213.00	127.97	135.29		135.29	0.000034	0.53	1191.46	351.69	0.04
Alignment - (1)	19445.34	10-yr	347.00	127.97	135.66		135.67	0.000068	0.77	1324.99	370.06	0.05
Alignment - (1)	19445.34	25-yr	431.00	127.97	135.83		135.83	0.000092	0.91	1386.59	377.04	0.06
Alignment - (1)	19445.34	50-yr	513.00	127.97	135.92		135.92	0.000122	1.06	1420.22	380.79	0.07
Alignment - (1)	19445.34	100-yr	574.00	127.97	136.03		136.03	0.000141	1.15	1462.86	385.65	0.07

HEC-RAS Plan: Alt #2 River: MC2 Reach: Alignment - (1) (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - (1)	19799.72	2-yr	213.00	129.96	135.31		135.32	0.000123	0.91	529.88	263.40	0.07
Alignment - (1)	19799.72	10-yr	347.00	129.96	135.70		135.71	0.000212	1.26	639.39	302.24	0.10
Alignment - (1)	19799.72	25-yr	431.00	129.96	135.88		135.88	0.000266	1.45	694.25	317.91	0.11
Alignment - (1)	19799.72	50-yr	513.00	129.96	135.98		135.99	0.000332	1.63	727.39	324.55	0.12
Alignment - (1)	19799.72	100-yr	574.00	129.96	136.10		136.11	0.000354	1.71	766.07	325.72	0.13
Alignment - (1)	20189.88	2-yr	213.00	132.20	135.29		135.56	0.012860	6.22	89.23	114.76	0.67
Alignment - (1)	20189.88	10-yr	347.00	132.20	135.82		136.01	0.008729	5.79	159.60	150.83	0.57
Alignment - (1)	20189.88	25-yr	431.00	132.20	136.06		136.23	0.008139	5.86	197.09	168.32	0.56
Alignment - (1)	20189.88	50-yr	513.00	132.20	136.22		136.40	0.008493	6.17	225.44	184.75	0.57
Alignment - (1)	20189.88	100-yr	574.00	132.20	136.36		136.54	0.008202	6.22	252.33	199.91	0.57
Alignment - (1)	20618.31	2-yr	213.00	135.89	139.34	138.98	139.50	0.006835	4.94	110.55	110.25	0.50
Alignment - (1)	20618.31	10-yr	347.00	135.89	139.64		139.86	0.009208	6.11	146.13	124.36	0.59
Alignment - (1)	20618.31	25-yr	431.00	135.89	139.83		140.05	0.009715	6.51	169.80	132.00	0.61
Alignment - (1)	20618.31	50-yr	513.00	135.89	140.04		140.27	0.009503	6.69	199.20	145.30	0.61
Alignment - (1)	20618.31	100-yr	574.00	135.89	140.16		140.40	0.009874	6.96	216.91	154.49	0.62
Alignment - (1)	20968.95	2-yr	213.00	137.93	141.23	140.83	141.29	0.003950	3.64	203.36	255.43	0.38
Alignment - (1)	20968.95	10-yr	347.00	137.93	141.66		141.70	0.003344	3.66	324.43	318.31	0.35
Alignment - (1)	20968.95	25-yr	431.00	137.93	141.85		141.89	0.003201	3.72	387.48	344.36	0.35
Alignment - (1)	20968.95	50-yr	513.00	137.93	142.02		142.07	0.003136	3.80	450.20	383.44	0.35
Alignment - (1)	20968.95	100-yr	574.00	137.93	142.13		142.17	0.003012	3.80	492.77	393.12	0.34

Appendix K:
Preliminary Opinion of Probable Construction Cost

List of Contents:

Project: Maple Creek Tributary #2, Rocky Mount, NC
Preliminary Opinion of Probable Construction Cost
Project # : 20120202.00.RA
Date: 05/30/2012

City Design			
Location	**Construction Cost**	**Additional Cost**	**Total Cost**
Location: Michael Scott Drive, City Design Standard	$84,980	$17,000	$101,980
Location: Woodstock Road, City Design Standard	$505,990	$101,200	$607,190
Location: Ketch Point Drive, City Design Standard	$1,145,470	$343,640	$1,489,110
Location: East Railroad Crossing, City Design Standard	$119,590	$23,920	$143,510
Location: Kingswood Drive Secondary System, City Design Standard	$6,749,980	$1,350,000	$8,099,980
Location: South Halifax, City Design Standard	$432,780	$86,560	$519,340
Location: Stream Grading and Floodplain Benching, City Design Standard	$1,835,880	$2,150,760	$3,986,640
Total	$10,874,670	$4,073,080	**$14,947,750**

Alternative #1			
Location	**Construction Cost**	**Additional Cost**	**Total Cost**
Location: Woodstock Road, Alternative #1	$340,660	$68,130	$408,790
Location: Hampton Road Detention Pond, Alternative #1	$259,510	$64,880	$324,390
Total	$600,170	$133,010	**$733,180**

Alternative #1A			
Location	**Construction Cost**	**Additional Cost**	**Total Cost**
Location: Woodstock Road and U/S Detention Areas, Alternative #1A	$916,440	$183,290	$1,099,730
Total	$916,440	$183,290	**$1,099,730**

Alternative #2			
Location	**Construction Cost**	**Additional Cost**	**Total Cost**
Location: Woodstock Road, Alternative #2	$340,660	$68,130	$408,790
Total	$340,660	$68,130	**$408,790**

Alternative #3			
Location	**Construction Cost**	**Additional Cost**	**Total Cost**
Location: South Halifax Road - Kingswood Drive, Alternative #3	$3,093,820	$618,760	$3,712,580
Total	$3,093,820	$618,760	**$3,712,580**

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Michael Scott Drive, City Design Standard
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 3,400.00	$ 3,400.00
2	Comprehensive Grading[1]	1	LS	$ 13,500.00	$ 13,500.00
3	Clearing and Grubbing	1	LS	$ 3,000.00	$ 3,000.00
4	Bedding Material, Pipe Culverts	50	TN	$ 30.00	$ 1,500.00
5	Aggregate Base Course	24	TN	$ 40.00	$ 960.00
6	Bituminous Surface Course	10	TN	$ 75.00	$ 750.00
7	Reinforced Concrete Headwall	2	EA	$ 8,000.00	$ 16,000.00
8	72" Reinforced Concrete Floodplain Culvert	95	LF	$ 200.00	$ 19,000.00
9	Remove/Dispose Excess Excavation	50	CY	$ 25.00	$ 1,250.00
10	Select Backfill/Unclassified Excavation	32	TN	$ 30.00	$ 957.60
11	Construction Staking	1	LS	$ 2,500.00	$ 2,500.00
12	Traffic Control	1	LS	$ 6,000.00	$ 6,000.00
13	Erosion Control	1	LS	$ 2,000.00	$ 2,000.00
				Subtotal	$ 70,820.00
	20% Contingency				$ 14,160.00
	Total Opinion of Probable Construction Cost[2]				$84,980.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$17,000.00
	Total Opinion of Probable Project Cost				**$101,980.00**

[1] Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.

[2] The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

[3] Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Woodstock Road, City Design Standard
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 20,100.00	$ 20,100.00
2	Comprehensive Grading[1]	1	LS	$ 80,250.00	$ 80,250.00
3	Clearing and Grubbing	1	LS	$ 4,000.00	$ 4,000.00
4	Bedding Material, Pipe Culverts	94	TN	$ 30.00	$ 2,820.00
5	Aggregate Base Course	55	TN	$ 40.00	$ 2,200.00
6	Bituminous Surface Course	11	TN	$ 75.00	$ 825.00
7	Reinforced Concrete Headwall	2	EA	$ 15,000.00	$ 30,000.00
8	10' x 7' Reinforced Concrete Box Culvert	150	LF	$ 1,600.00	$ 240,000.00
9	Remove/Dispose Excess Excavation	220	CY	$ 25.00	$ 5,500.00
10	Select Backfill/Unclassified Excavation	76	TN	$ 30.00	$ 2,268.00
11	Remove Existing Corrugated Metal Pipe	100	LF	$ 40.00	$ 4,000.00
12	Remove Existing Headwall	2	EA	$ 850.00	$ 1,700.00
13	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
14	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
15	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	$ 421,660.00
	20% Contingency				$ 84,330.00
	Total Opinion of Probable Construction Cost[2]				$ 505,990.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$101,200.00
	Total Opinion of Probable Project Cost				**$607,190.00**

[1] *Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.*

[2] *The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.*

[3] *Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)*

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Ketch Point Drive, City Design Standard
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 45,500.00	$ 45,500.00
2	Comprehensive Grading[1]	1	LS	$ 181,750.00	$ 181,750.00
3	Clearing and Grubbing	1	LS	$ 3,000.00	$ 3,000.00
4	Bedding Material, Pipe Culverts	171	TN	$ 30.00	$ 5,130.00
5	Aggregate Base Course	77	TN	$ 40.00	$ 3,080.00
6	Bituminous Surface Course	20	TN	$ 75.00	$ 1,500.00
7	Raise Road Surface For Minimum Cover	1	LS	$ 200,000.00	$ 200,000.00
8	Reinforced Concrete Headwall	2	EA	$ 15,000.00	$ 30,000.00
9	10' x 7' Reinforced Concrete Box Culvert	240	LF	$ 1,600.00	$ 384,000.00
10	Remove/Dispose Excess Excavation	560	CY	$ 25.00	$ 14,000.00
11	Select Backfill/Unclassified Excavation	2000	TN	$ 30.00	$ 60,000.00
12	Remove Existing Reinforced Concrete Box Culvert	120	LF	$ 40.00	$ 4,800.00
13	Remove Existing Headwall	2	EA	$ 850.00	$ 1,700.00
14	Construction Staking	1	LS	$ 2,500.00	$ 2,500.00
15	Traffic Control	1	LS	$ 6,000.00	$ 6,000.00
16	Erosion Control	1	LS	$ 11,600.00	$ 11,600.00
				Subtotal	$954,560.00
	20% Contingency				$ 190,910.00
	Total Opinion of Probable Construction Cost[2]				$ 1,145,470.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$343,640.00
	Total Opinion of Probable Project Cost				**$1,489,110.00**

[1] Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.

[2] The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

[3] Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (30% of total opinion of probable construction cost)

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: East Railroad Crossing, City Design Standard
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 4,700.00	$ 4,700.00
2	Comprehensive Grading[1]	1	LS	$ 19,000.00	$ 19,000.00
3	Clearing and Grubbing	1	LS	$ 3,000.00	$ 3,000.00
4	Reinforced Concrete Headwall	4	EA	$ 4,000.00	$ 16,000.00
5	72" Reinforced Concrete Floodplain Culvert	70	LF	$ 200.00	$ 14,000.00
6	Tunnel Installation	70	LF	$ 500.00	$ 35,000.00
7	Remove/Dispose Excess Excavation	50	CY	$ 25.00	$ 1,250.00
8	Select Backfill/Unclassified Excavation	24	TN	$ 30.00	$ 705.60
9	Construction Staking	1	LS	$ 2,500.00	$ 2,500.00
10	Traffic Control	1	LS	$ 1,000.00	$ 1,000.00
11	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
				Subtotal	$99,660.00
	20% Contingency				$ 19,930.00
	Total Opinion of Probable Construction Cost[2]				$119,590.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$23,920.00
	Total Opinion of Probable Project Cost				**$143,510.00**

[1] *Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.*

[2] *The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.*

[3] *Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)*

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Kingswood Drive Secondary System, City Design Standard
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 267,900.00	$ 267,900.00
2	Comprehensive Grading[1]	1	LS	$ 1,071,500.00	$ 1,071,500.00
3	Clearing and Grubbing	1	LS	$ 3,000.00	$ 3,000.00
4	Bedding Material, Pipe Culverts	1789	TN	$ 30.00	$ 53,670.00
5	Aggregate Base Course	380	TN	$ 40.00	$ 15,200.00
6	Bituminous Surface Course	48	TN	$ 75.00	$ 3,600.00
7	Raise Road Surface For Minimum Cover	1	LS	$ 100,000.00	$ 100,000.00
8	Reinforced Concrete Headwall	2	EA	$ 15,000.00	$ 30,000.00
9	10' x 6' Reinforced Concrete Box Culvert	2752	LF	$ 1,400.00	$ 3,852,800.00
10	Remove/Dispose Excess Excavation	3060	CY	$ 25.00	$ 76,500.00
11	Select Backfill/Unclassified Excavation	1387	TN	$ 30.00	$ 41,610.24
12	Remove Existing Corrugated Metal Pipe	850	LF	$ 40.00	$ 34,000.00
13	Remove Existing Headwall	2	EA	$ 850.00	$ 1,700.00
14	Construction Staking	1	LS	$ 2,500.00	$ 2,500.00
15	Traffic Control	1	LS	$ 25,000.00	$ 25,000.00
16	Erosion Control	1	LS	$ 25,000.00	$ 25,000.00
17	Utility Conflicts	7	EA	$ 3,000.00	$ 21,000.00
				Subtotal	$5,624,980.00
	20% Contingency				$ 1,125,000.00
	Total Opinion of Probable Construction Cost[2]				$ 6,749,980.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$1,350,000.00
	Total Opinion of Probable Project Cost				**$8,099,980.00**

[1] *Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.*

[2] *The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.*

[3] *Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)*

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: South Halifax, City Design Standard
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 17,200.00	$ 17,200.00
2	Comprehensive Grading[1]	1	LS	$ 44,850.00	$ 44,850.00
3	Clearing and Grubbing	1	LS	$ 3,000.00	$ 3,000.00
4	Bedding Material, Pipe Culverts	117	TN	$ 30.00	$ 3,510.00
5	Aggregate Base Course	380	TN	$ 40.00	$ 15,200.00
6	Bituminous Surface Course	11	TN	$ 75.00	$ 825.00
7	Raise Road Surface For Minimum Cover	1	LS	$ 100,000.00	$ 100,000.00
8	Reinforced Concrete Headwall	2	EA	$ 15,000.00	$ 30,000.00
9	10' x 6' Reinforced Concrete Box Culvert	90	LF	$ 1,400.00	$ 126,000.00
10	Remove/Dispose Excess Excavation	20	CY	$ 25.00	$ 500.00
11	Select Backfill/Unclassified Excavation	45	TN	$ 30.00	$ 1,360.80
12	Remove Existing Headwall	2	EA	$ 850.00	$ 1,700.00
13	Construction Staking	1	LS	$ 1,000.00	$ 1,000.00
14	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
15	Erosion Control	1	LS	$ 2,500.00	$ 2,500.00
16	Utility Conflicts	1	EA	$ 3,000.00	$ 3,000.00
				Subtotal	$360,650.00
	20% Contingency				$ 72,130.00
	Total Opinion of Probable Construction Cost[2]				$ 432,780.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$86,560.00
	Total Opinion of Probable Project Cost				**$519,340.00**

[1] *Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.*

[2] *The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.*

[3] *Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)*

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Stream Grading and Floodplain Benching, City Design Standard
Project # : 20110202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 72,900.00	$ 72,900.00
2	Comprehensive Grading[1]	1	LS	$ 291,500.00	$ 291,500.00
3	Clearing and Grubbing	1	LS	$ 20,000.00	$ 20,000.00
4	Stream Grading	4000	LF	$ 280.00	$ 1,120,000.00
5	Remove/Dispose Excess Excavation	500	CY	$ 13.00	$ 6,500.00
6	Construction Staking	1	LS	$ 4,000.00	$ 4,000.00
7	10' x 7' Reinforced Concrete Box Culvert	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	$ 1,529,900.00
	20% Contingency				$ 305,980.00
	Total Opinion of Probable Construction Cost[2]				$ 1,835,880.00
	Additional Items				
	Design and Administrative Costs[3]				$550,760.00
	Permitting Cost				$1,600,000.00
	Total Opinion of Probable Project Cost				**$3,986,640.00**

[1] *Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.*

[2] *The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.*

[3] *Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (30% of total opinion of probable construction cost)*

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Woodstock Road, Alternative #1
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 13,500.00	$ 13,500.00
2	Comprehensive Grading[1]	1	LS	$ 54,000.00	$ 54,000.00
3	Clearing and Grubbing	1	LS	$ 4,000.00	$ 4,000.00
4	Bedding Material, Pipe Culverts	65	TN	$ 30.00	$ 1,950.00
5	Aggregate Base Course	41	TN	$ 40.00	$ 1,640.00
6	Bituminous Surface Course	11	TN	$ 75.00	$ 825.00
7	Reinforced Concrete Headwall	2	EA	$ 15,000.00	$ 30,000.00
8	10' x 6' Reinforced Concrete Box Culvert	100	LF	$ 1,400.00	$ 140,000.00
9	Remove/Dispose Excess Excavation	110	CY	$ 25.00	$ 2,750.00
10	Select Backfill/Unclassified Excavation	50	TN	$ 30.00	$ 1,512.00
11	Remove Existing Corrugated Metal Pipe	100	LF	$ 40.00	$ 4,000.00
12	Remove Existing Headwall	2	EA	$ 850.00	$ 1,700.00
13	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
14	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
15	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	$ 283,880.00
20% Contingency					$ 56,780.00
Total Opinion of Probable Construction Cost[2]					$ 340,660.00
Additional Items					
Design, Permitting, and Administrative Costs[3]					$68,130.00
Total Opinion of Probable Project Cost					**$408,790.00**

[1] *Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.*

[2] *The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.*

[3] *Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)*

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Hampton Road Detention Pond, Alternative #1
Project # : 20120202.00.RA
Date: 4/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 9,300.00	$ 9,300.00
2	Comprehensive Grading[1]	1	LS	$ 20,000.00	$ 20,000.00
3	Plantings	87120	SF	$ 0.50	$ 43,560.00
4	Erosion Control	1	EA	$ 10,000.00	$ 10,000.00
5	Remove/Dispose Excess Excavation at Hampton Road Pond	7700	CY	$ 13.00	$ 100,100.00
6	Property value for Parcel 383015631173	1	EA	$ 3,300.00	$ 3,300.00
7	Property value for Parcel 383014420922	1	EA	$ 15,500.00	$ 15,500.00
8	Embankment Culvert	1	EA	$ 12,000.00	$ 12,000.00
9	Construction Staking	1	LS	$ 2,500.00	$ 2,500.00
				Subtotal	$ 216,260.00
	20% Contingency				$ 43,250.00
	Total Opinion of Probable Construction Cost[2]				$ 259,510.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$64,880.00
	Total Opinion of Probable Project Cost				**$324,390.00**

[1] Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary measures needed for the project not included in any other unit costs, and geotechnical recommendations.

[2] The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

[3] Design, Permitting, and Administrative Costs includes, survey, consultant planning & design costs, permitting, administrative costs, and easement acquisition (25% of total opinion of probable construction cost)

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Woodstock Road and Detention Areas - Alternative #1A
Project # : 20120202.00.RA
Date: 05/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 13,500.00	$ 13,500.00
2	Comprehensive Grading[1]	1	LS	$ 54,000.00	$ 54,000.00
3	Clearing and Grubbing	1	LS	$ 4,000.00	$ 4,000.00
4	Bedding Material, Pipe Culverts	65	TN	$ 30.00	$ 1,950.00
5	Aggregate Base Course	41	TN	$ 40.00	$ 1,640.00
6	Bituminous Surface Course	11	TN	$ 75.00	$ 825.00
7	Reinforced Concrete Headwall	2	EA	$ 15,000.00	$ 30,000.00
8	10' x 6' Reinforced Concrete Box Culvert	100	LF	$ 1,400.00	$ 140,000.00
9	Remove/Dispose Excess Excavation	110	CY	$ 25.00	$ 2,750.00
10	Select Backfill/Unclassified Excavation	50	TN	$ 30.00	$ 1,512.00
11	Remove Existing Corrugated Metal Pipe	100	LF	$ 40.00	$ 4,000.00
12	Remove Existing Headwall	2	EA	$ 850.00	$ 1,700.00
13	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
14	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
15	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
				Woostock Labor & Materials	$ 283,880.00
	Land For Community Drive and Railroad West Detention Areas				
16	Tax Property Value for Parcel 383009172227	1	EA	$ 58,650.00	$ 58,650.00
17	Tax Property Value for Parcel 383009272050	1	EA	$ 2,440.00	$ 2,440.00
18	Tax Property Value for Parcel 383009170090	1	EA	$ 194,820.00	$ 194,820.00
19	Tax Property Value for Parcel 383009161712	1	EA	$ 55,000.00	$ 55,000.00
20	Tax Property Value for Parcel 383009169300	1	EA	$ 136,520.00	$ 136,520.00
21	Tax Property Value for Parcel 383010361647	1	EA	$ 30,860.00	$ 30,860.00
22	Tax Property Value for Parcel 383010353764	1	EA	$ 1,530.00	$ 1,530.00
				Land Subtotal	$ 479,820.00
	Total Land and Woodstock Road Culvert				$ 763,700.00
	20% Contingency				$ 152,740.00
	Total Opinion of Probable Construction Cost[2]				$ 916,440.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$183,290.00
	Total Opinion of Probable Project Cost				**$1,099,730.00**

[1] Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.

[2] The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

[3] Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: Woodstock Road, Alternative #2
Project # : 20120202.00.RA
Date: 04/30/2012

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 13,500.00	$ 13,500.00
2	Comprehensive Grading[1]	1	LS	$ 54,000.00	$ 54,000.00
3	Clearing and Grubbing	1	LS	$ 4,000.00	$ 4,000.00
4	Bedding Material, Pipe Culverts	65	TN	$ 30.00	$ 1,950.00
5	Aggregate Base Course	41	TN	$ 40.00	$ 1,640.00
6	Bituminous Surface Course	11	TN	$ 75.00	$ 825.00
7	Reinforced Concrete Headwall	2	EA	$ 15,000.00	$ 30,000.00
8	10' x 6' Reinforced Concrete Box Culvert	100	LF	$ 1,400.00	$ 140,000.00
9	Remove/Dispose Excess Excavation	110	CY	$ 25.00	$ 2,750.00
10	Select Backfill/Unclassified Excavation	50	TN	$ 30.00	$ 1,512.00
11	Remove Existing Corrugated Metal Pipe	100	LF	$ 40.00	$ 4,000.00
12	Remove Existing Headwall	2	EA	$ 850.00	$ 1,700.00
13	Construction Staking	1	LS	$ 3,000.00	$ 3,000.00
14	Traffic Control	1	LS	$ 10,000.00	$ 10,000.00
15	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	$ 283,880.00
20% Contingency					$ 56,780.00
Total Opinion of Probable Construction Cost[2]					$ 340,660.00
Additional Items					
Design, Permitting, and Administrative Costs[3]					$68,130.00
Total Opinion of Probable Project Cost					**$408,790.00**

[1] *Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.*

[2] *The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.*

[3] *Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)*

Project: Maple Creek Tributary #2, Rocky Mount, NC
Location: South Halifax Road – Kingswood Drive Secondary Flow Bypass - Alternative #3
Project # : 20120202.00.RA
Date: 05/6/2012

Conceptual Opinion of Cost

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization (5% of total cost)	1	LS	$ 122,800.00	$ 122,800.00
2	Comprehensive Grading[1]	1	LS	$ 223,200.00	$ 223,200.00
3	Clearing and Grubbing	1	LS	$ 3,000.00	$ 3,000.00
4	Aggregate Base Course	165	TN	$ 40.00	$ 6,600.00
5	Bituminous Surface Course	21	TN	$ 75.00	$ 1,575.00
6	8' x 6' Reinforced Concrete Box Culvert	1800	LF	$ 1,200.00	$ 2,160,000.00
7	Construction Staking	1	LS	$ 1,000.00	$ 1,000.00
8	Traffic Control	1	LS	$ 25,000.00	$ 25,000.00
9	Erosion Control	1	LS	$ 15,000.00	$ 15,000.00
10	Utility Conflicts	1	EA	$ 20,000.00	$ 20,000.00
				Subtotal	$ 2,578,180.00
	20% Contingency				$ 515,640.00
	Total Opinion of Probable Construction Cost[2]				$ 3,093,820.00
	Additional Items				
	Design, Permitting, and Administrative Costs[3]				$618,760.00
	Total Opinion of Probable Project Cost				**$3,712,580.00**

[1] Cost for comprehensive grading includes, but is not limited to, roadway excavation, saw cutting, compaction of select material, sheeting, shoring, dewatering, permanent and temporary seeding and mulching, and geotechnical recommendations.

[2] The Engineer's opinions of probable construction costs are made on the basis of the Engineer's experience and qualifications and represent the Engineer's best judgment as a professional generally familiar with the construction industry. Since the Engineer has no control over the cost of labor, materials, equipment, or services furnished by others; over the contractors methods of determining prices; or over competitive bidding or marketing conditions, the Engineer's cannot and does not guarantee that proposal, bids or actual construction costs will not vary from opinions of probable construction costs prepared by the Engineer.

[3] Design, Permitting, and Administrative Costs includes, consultant planning & design costs, permitting, administrative costs, and easement acquisition (20% of total opinion of probable construction cost)

Appendix L:
Digital Copy of Modeling

List of Contents:

1. HEC-HMS

2. HEC-RAS

Digital Copy of HEC-HMS & HEC-RAS included on Separate CD