Beaver Creek Watershed Storm Water Master Plan

Knox County

DRAFT

August 4, 2000

OGDEN

Beaver Creek Watershed Storm Water Master Plan

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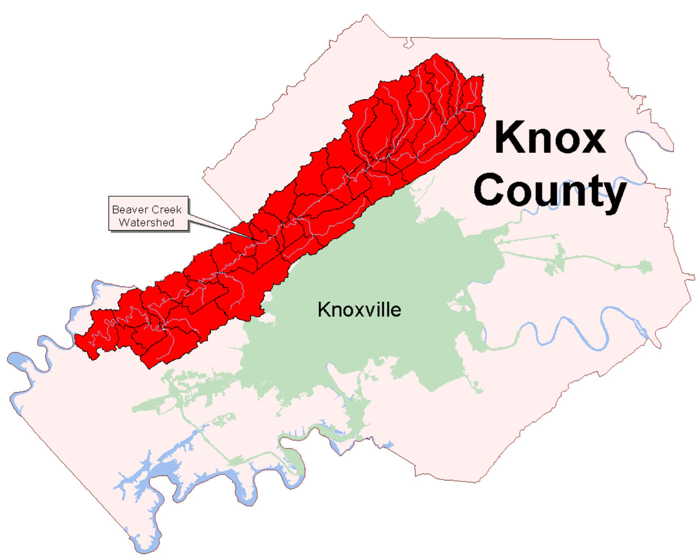

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BEAVER CREEK MASTER PLAN – CURRENT LIST OF FIGURES

1. Figures 2-1a,b – Beaver Creek Watershed and Basins - Same ArcView figures as Flood Study 2-1a, b. No changes.

2. Figures 2-2a,b – Hydrologic Soil Groups - Same ArcView figures as Flood Study 4-1a, b. Legend must be modified to provide description of soil group (e.g., well-drained, moderately well drained, etc.)

3. Figures 2-3a,b – Existing Condition Land Use - Same ArcView figures as Flood Study 4-3a,b. Add roads. Legend will be modified to mesh MPC and hydrologic land use categories.

4. Figures 2-4a,b – Future Condition Land Use – Map is done, figures not yet created. Use same legend as in 2-3a,b.

5. Figure 2-5 - Beaver Creek Channel Elevation vs. River Mile – Not yet created

6. Figure 2-6 – Pre-development Channel Flooding – Not yet created

7. Figure 4-1 - Map of Biological Stream Survey Study Stations - ?

8. Figures 5-1a,b – Drainage Area vs 100-Year Peak Discharge for Beaver Creek(a), for Major Tributaries (b). – Data in Excel – Figure not yet complete.

9. Figures 5-2a,b – Inflow Hydrographs at confluence of Kerns Branch and Beaver Creek (a), at confluence of Grassy Creek and Beaver Creek. – data in Excel,Figure not yet complete

10. Figure 7-1 – 100-year and 500-Year existing condition floodplains in Halls-Crossroads Damage Reach. – modify/expand flood study maps for this figure.

11. Figure 7-2 – Post-project floodplain in Halls-Crossroads Damage Reach – not yet created.

12. Figures 7-3a,b – 100-year and 500-year existing condition floodplains in North Fork – 80% complete.

13. Figures 7-4 – 7-7, photos of North Fork channel – already in document

14. Figure 7-8 – Post-channel improvement floodplain – North Fork – 80% complete

15. Figure 7-9 – Potential locations for regional detention on North Fork – 95% complete

16. Figure 7-10 – 100- and 500-year floodplains at Lovell Road over Plumb Creek – modify/zoom in on flood study maps

17. Figure 7-11 – Large scale map showing Bob Kirby / Chesney Road study area (include 100-yr, 500yr fp from Plumb Creek) – not yet created

18. Figure 7-12 – 100-yr and 500yr fp at Oak Ridge Highway in Karns – not yet created, use flood study maps

19. Figure 7-13 – 100-yr and 500 yr fp on Cox Creek Trib – not yet created, use flood study maps

We will probably be inserting some figures as we get FFEs and finish up the alternatives. There may be some figures associated with the Hydraulics Results as well.

BEAVER CREEK WATERSHED STORM WATER MASTER PLAN
EXECUTIVE SUMMARY

This summary presents that findings and recommendations of the Beaver Creek Watershed Storm Water Master Plan, performed upon the recommendation of Knox County's Storm Water Advisory Committee (SWAC). The SWAC recommended development of a master plan for Beaver Creek because of the development pressures and existing flood problems experienced in the Beaver Creek watershed, and the relative lack of useful data to assist or direct management of the watershed from a storm water perspective.

Background

The Knox County SWAC identified the three principal objectives of this storm water master plan, as shown in Table 1 below.

Table 1. Master Plan Objectives

The **Needs and Issues** objective will: ➢ address major and minor flooding issues, and identify flood solution alternatives to fix existing problems and determine ways to avoid future problems; ➢ provide "what if" analysis capability for planning and storm water management purposes; ➢ inventory the drainage system to the level desired by County staff; ➢ prioritize capital improvement projects (CIPs); ➢ utilize existing GIS data and create new layers of information for use in planning, maintenance, CIPs and complaint handling; ➢ address water quality, both holistically and in response to regulatory permitting pressures; and,
The **Regulatory Instruments** objective will: ➢ extend the regulatory floodplains in Beaver Creek and its tributaries beyond the floodplain boundaries required by FEMA for flood insurance purposes; ➢ be used in the plans approval process to assist with defining requirements for new developments and redevelopments in the Beaver Creek watershed.
The **Storm Water Planning** objective will: ➢ provide an overall land use guide for storm water management; ➢ provide a tool to assist planners with Sector Plan and zoning decisions; and, ➢ be a policy tool to assist policy makers.

The 86-square mile Beaver Creek watershed chosen for Knox County's first storm water master plan because of the development pressures the watershed is currently experiencing, the frequency and extent of existing flood problems, and the high potential for future development and associated flooding. Currently, the majority of land use in the watershed is undeveloped or rural residential, but new development is increasing at a rapid rate, especially along main corridors such as Emory Road, Beaver Creek Drive, Interstate-75, Hardin Valley Road, and Pellissippi Parkway. In recent years, the County has received complaints of house and business flooding along Beaver Creek in the Halls-Crossroads area and near Oak Ridge Highway in Karns, along North Fork near Oaken Drive, along Hines Branch near Maynardville Highway and in the Cox Creek Tributary at Cedar Breeze Lane. Serious roadway flooding occurs frequently at Lovell Road over Plumb Creek, and at various locations in the Plumb Creek basin (Bob Kirby Road, Chesney Road, private driveways). The County has identified all of these areas as Priority Areas for the examination and consideration of flood solution alternatives.

Based on the 15-Year Development Plans for Knox County, the Metropolitan Planning Commission predicts that 85% of the watershed will be developed within 15-years. The most prominent future land use will be medium-density residential areas and commercial development will increase to support the increase in residents. The flood potential and degradation of water quality in the Beaver Creek watershed will increase as the watershed is developed.

Water Quality

Beaver Creek receives major pollutants from urban and suburban runoff, municipal discharges, agricultural runoff and construction activities. According to the Tennessee Department of Environment and Conservation, the creek has pollutant concentrations that exceed the water quality standards for its designated uses, and therefore Beaver Creek is included in TDEC's 303d (i.e., impaired waters) list for nutrients, pathogens, siltation and habitat alteration. A program to collect baseline water quality data in Beaver Creek and its tributaries was performed as part of the master planning effort and concluded that the water quality of streams in the watershed is in poor condition. Sediment and nutrient influx from new development, and the loss of riparian vegetation were determined to be the greatest contributors to the degradation of water quality.

In March 2003, Knox County will be required to obtain a permit to discharge storm water to waters of the State, under the National Pollutant Discharge Elimination System (NPDES) Phase II regulations. The permit requires the county to maintain a storm water program that addresses the following six minimum controls:

- public education and outreach;
- public involvement;
- illicit discharge detection and elimination;
- construction runoff controls;
- post construction runoff controls; and
- best management practices for municipal operations.

Based on the impending Phase II regulations and the results of the water quality surveys performed for the master plan, recommendations were made to address water quality in the Beaver Creek watershed:

- increase public awareness of pollutant sources and encourage the reduction of pollutants through the use of best management practices (BMPs) for business, residents and farms;
- reduce sediment loads by implementing and maintaining a strong erosion control program;
- identify and protect wetland and groundwater recharge areas;
- identify and eliminate non-storm water (i.e., illicit) discharges;
- identify areas of the watershed for priority BMP implementation;
- plan and continue with occasional follow-up monitoring to evaluate trends and the effectiveness of BMPs.

Flooding and Flood Potential

Hydrologic and hydraulic models were developed of the watershed and stream systems to evaluate peak discharges and flood elevations based on the runoff resulting from existing and future land use conditions. The models simulated rainfall/runoff processes and associated changes in flood elevations in the creeks for the 2-, 10-, 25-, 100- and 500-year events. Existing condition models were developed for purposes of the *Beaver Creek Watershed Flood Study* for submittal to the Federal Emergency Management Agency as part of the National Flood Insurance Program. The *Flood Study* was published in February, 2000. The future condition and flood solution alternative analyses were performed as part of this master plan.

Based on the results of the models, the following conclusions can be made about the Beaver Creek watershed and streams:

1. *Upstream of Maynardville Highway*, peak discharges and flood elevations in Beaver Creek are most sensitive to inflows from the surrounding drainage areas. In this area, peak discharges increase an average of 325 cfs per square mile for the 100-year existing condition event. In this area and in the tributaries to Beaver Creek, control of peak discharges and hydrograph timing is key to effective storm water management.

2. *Downstream of Maynardville Highway*, floodplain storage is the controlling factor for peak discharges. The average increase in peak discharges in this area is 10 cfs per square mile. In this area, the preservation of floodplain storage is key to effective storm water management.

3. Flooding in Beaver Creek is a natural condition. Based on an analysis prepared for this master plan that considered undeveloped conditions for the entire watershed, Beaver Creek was out of bank at many locations during the 2-year storm event. Furthermore, the difference between existing flood elevations and flood elevations for undeveloped conditions is approximately 1.5 feet.

4. Once water is out of bank on Beaver Creek, the extent of flooding will quickly reach the edge of the floodplain. For example, while the depth of flooding differs between the 10-year and 100-year event, the floodplains on Beaver Creek are very similar.

5. There are approximately 755 habitable structures located inside the existing condition 100-year and 500-year floodplains. Of these structures, 451 are located along Beaver Creek and 304 are located along tributaries. Thirty-six structures are located in the floodway.

6. Finished flood elevations were surveyed at 375 of the 755 habitable structures located in the existing condition floodplains on Beaver Creek and the tributaries. Table 2 presents the results of a comparison of surveyed FFEs and flood elevations predicted by the hydraulic models.

Table 2. Comparison of Existing and Future Condition FFE Flooding

Stream Name	Number of Flooded Structures (based on surveyed FFEs only)									
	Existing Condition					Future Condition				
	2-Yr	10-Yr	25-Yr	100-Yr	500-Yr	2-Yr	10-Yr	25-Yr	100-Yr	500-Yr
Beaver Creek	0	2	14	48	91	0	10	32	78	117
Tributaries to Beaver Creek	0	33	41	62	80	4	44	52	77	102
TOTALS	**2**	**35**	**55**	**110**	**171**	**4**	**54**	**84**	**155**	**219**

General Storm Water Management Alternatives

The County can choose to implement structural and non-structural management alternatives to mitigate future flooding in the Beaver Creek watershed. Structural alternatives, such as channel improvements, regional detention and various flood proofing options are typically implemented in response to a known flood problem. Based on preliminary analyses, small-scale channel improvements on Beaver Creek would not be effective in eliminating flood potential due to the high peak discharges and large volumes encountered on the main stem. Flood proofing is not attractive for the same reasons. However, large-scale channel improvements are also not a feasible option for Beaver Creek because the cost and permitting issues would outweigh any benefit the improvement could provide. Regional detention is an option for areas upstream of Maynardville Highway, where the watershed is most sensitive to changes in the timing of peak discharges.

While structural controls are more feasible and effective when implemented on the tributaries to Beaver Creek, the most effective and least costly way for the County to mitigate the future flood potential in the watershed is to implement various non-structural alternatives. These include planning and regulatory options, such as requiring more stringent controls on new development, maintaining high percentages of open space and pervious areas, flood fringe encroachment limitations, higher FFE requirements, etc. While least costly to the County when compared to structural alternatives, acceptance of non-structural alternatives by citizens and developers can be difficult. However, some non-structural alternatives should be implemented watershed wide, such as limitations on flood fringe encroachment to preserve the highly valuable floodplain storage. A ½ flood fringe encroachment limitation was analyzed and recommended for implementation.

Other alternatives that may be prove difficult to gain acceptance, such as limitations on types of development or zero increases in post-development runoff, could be implemented in smaller key areas where they can still be highly effective. For example, analyses determined that more stringent requirements for local detention could be effective in reducing potential small-scale flood problems located on tributaries. Several drainage areas in North Fork were identified as a location where increase detention requirements for pre-to-post detention of the runoff from 100-year storm is effective in reducing peak flows and future flooding. In another analysis, management of new development and redevelopment in key areas upstream of Maynardville Highway was considered and found to be very effective in reducing the future condition flood potential in the Halls-Crossroads area and along the entire Beaver Creek.

Flood Solution Alternatives for Priority Areas

Specific flood solution alternatives were evaluated for priority areas identified by Knox County as in need of evaluation. In general, the alternatives analyzed include purchase of flood-prone properties, channel and culvert/bridge improvements (where feasible), and regional detention (where feasible). Cost estimates were developed for each alternative and provided along with the analysis of the effectiveness of the alternatives and a list of pros and cons if the alternatives were implemented. Recommendations were provided based on cost and effectiveness, should the County decide to implement a flood solution alternative for any of the priority areas.

Recommendations

Based on the analyses and findings of the Beaver Creek Watershed Storm Water Master Plan, the following recommendations could be made:

1. Institute regulatory controls on new development and re-development upstream of Maynardville Highway to control future runoff peaks and volumes.

2. Develop regulations to limit flood fringe filling on Beaver Creek and its tributaries.

3. If property purchase is an option the County chooses to mitigate existing flooding, consider a prioritization system for the purchase of flooded properties.

4. Make available the hydrologic and hydraulic models of Beaver Creek and the tributaries developed for this master plan. Require developers to use them to determine the impact of specific developments on flooding downstream.

5. Develop a program to educate Beaver Creek watershed residents and business owners on the general findings of the master plan and the impending NPDES Phase II regulations to gain support for more stringent regulations that the County may choose to implement.

6. Encourage the use of effective water quality BMPs for existing businesses, communities, and farms in the watershed. Work with local developers to implement pilot post-construction water quality BMPs as the opportunity arises.

7. The County should implement and maintain a strong erosion control program for construction activities. For rural and other non-urban areas (e.g., cattle farms), the County should work with the local NRCS office to implement effective BMPs to control agricultural runoff and reduce stream bank degradation and erosion.

8. Wetlands and other sensitive areas should be identified and protected as they provide natural water quality buffers and flood storage. The County should continue to support and participate in the current Beaver Creek conservation easement program to increase the chances of success with water quality initiatives.

9. Commercial storm drains and other potential illicit (non-storm water) discharges should be investigated and eliminated.

10. General land use patterns and water quality should be examined in the watershed to isolate areas for priority water quality BMP implementation.

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1 INTRODUCTION

1.1 Background

Beaver Creek is located in north Knox County. The Beaver Creek watershed has a contributing drainage area of approximately 86 square miles and the creek has a length of approximately 45 miles. For clarity in this report, the complete Beaver Creek drainage area is termed "the watershed". Over the past two decades, the watershed has experienced rapid increase in the development of rural residential areas and pastureland into residential subdivisions and other developed land uses. As the watershed develops, there is more potential for significant changes in land use and consequently runoff peak discharge rates and volumes. One of the consequences of this growth is significant increase in the problems associated with increased storm water runoff and pollution. Recent flood problems, land erosion and stream turbidity have served to highlight the need for the County to re-evaluate its approach to managing storm water in the Beaver Creek watershed.

Prior to this study, the County has had very little data it could use to gain an understanding of the watershed and direct storm water management. There are limited gage records from streams in the watershed and there have been few historical studies performed even though flooding is a well-known problem to watershed and County residents. The need for storm water master planning in the Beaver Creek watershed was identified in the *Storm Water Management Program Assessment and Action Plan for Knox County* (Ogden, 1997) by the Knox County Storm Water Advisory Committee (SWAC). The SWAC consists of a broad cross-section of County residents and staff, political leaders, and technical experts. The SWAC identified the storm water problems and issues in Knox County, assessed the County's storm water program, and provided recommendations on program improvement and priorities. One of the major priorities identified was to implement storm water master planning in key watersheds to assist Knox County with handling the storm water regulatory and planning issues in those areas. The general consensus of the SWAC was that the County should have the authority to manage the watershed based on the findings of the master plans.

The SWAC identified a portion of the Beaver Creek watershed for a pilot master plan because of the development pressures and existing flood problems experienced in the Beaver Creek watershed. The pilot study began in 1998 on the most upstream portion of the watershed, from Maynardville Highway in Halls, to the headwaters of Beaver Creek near the intersection of Fairview Road and Tazwell Pike. The necessary hydrologic and hydraulic models for the pilot study were developed and fine-tuned, but the complete pilot master plan was not completed for two reasons. First, flooding in several areas of Knox County in April 1998 forced the Engineering and Public Works Department to temporarily divert its attention from master planning to the development of flood solution alternatives for the immediately impacted areas.

Second, in late 1998 the Federal Emergency Management Agency (FEMA) initiated a flood insurance restudy of Knox County to update the 1982 Flood Insurance Study (FIS). It was determined that the results of the models that were being developed as part of the master planning effort could be submitted to FEMA for inclusion in the County-wide restudy. This enabled the County to ask FEMA to restudy other County streams, avoiding duplicate studies on Beaver Creek and increasing the number of County streams that are part of the National Flood Insurance Program (NFIP). Because of the timing of the FEMA restudy, the focus changed from master planning the upstream portion of Beaver Creek to performing a "FEMA-style" flood study for the entire length of the creek and its tributaries.

The results of the flood study were presented to Knox County in a report titled *Beaver Creek Watershed Flood Study* (Ogden, 2000). The objective of that report was to provide floodplain and floodway information to update the effective 1982 FIS. Essentially, the flood study provided the 100-year and 500-year floodplain boundaries, the 100-year floodway boundaries, and flood profiles for the 2-, 10-, 25-, 100- and 500-year events for Beaver Creek and selected tributaries for baseline (i.e., existing) land use conditions.

Once the Beaver Creek flood study was finished, the master planning effort could continue. Hydrologic and hydraulic models of the entire watershed and stream systems had already been developed for the flood study effort, therefore a pilot master plan for just the upstream portion of Beaver Creek was deemed unnecessary and the master planning effort was extended to the entire watershed. This report constitutes the Master Plan for the Beaver Creek Watershed. It is a continuation of the flood study and includes a detailed discussion of existing condition results, an analyses hydraulic analyses of full build-out (i.e., future conditions), analyses of general storm water management alternatives, specific flood solution alternatives, and stream water quality information.

1.2 Storm Water Master Planning – Definition and Approach

Knox County is facing rapid development pressures. While improvements to things such as transportation, water supply and wastewater treatment are typically planned and constructed as development increases, drainage concerns are rarely addressed on a level above individual site construction. For areas where new development or re-development is imminent, a storm water master plan for the overall drainage system can be a useful tool because it gives land use planners and storm water managers a better understanding of the dynamics of the watershed and stream systems. Master plans are developed using a "total watershed approach", meaning that solutions to storm water problems are designed to have the local desired effect, but are also analyzed in terms of the overall effect on the watershed or stream system. The hydrologic and hydraulic computer models developed in the master planning process will allow community planners and engineers to assess the impacts of proposed land use changes and to recommend mitigation measures ahead of development. Master plans also assist in the development of cost effective capital improvement plans for existing problems in the watershed, and allow the potential for regional or coordinated solutions to problems, rather than more piecemeal changes and corrections.

The master planning approach involves using mathematical computer models to simulate rainfall on the watershed for different land use conditions, determine the quantity and general timing of runoff hydrographs, and predict flood elevations resulting from the combination of rainfall, land use and storm water conveyance system data. The models are developed and calibrated for existing (i.e., baseline) land use conditions. Existing condition data is developed using extensive field observations, watershed-wide survey data, and any available topographic and planimetric mapping. The watershed and storm water conveyance systems are modeled in sufficient detail for planning and regulatory purposes, and to enable analyses of system improvements to reduce flooding and improve or maintain water quality. Once the models are developed and calibrated, they can be used to predict storm water quantity and flood elevations for future and/or proposed land use conditions, and analyze structural (e.g., detention ponds, channel improvements) and non-structural (e.g., open space and land use management, regulatory management) flood and water quality improvement alternatives.

The key element of a master plan that makes it such a useful tool is this future condition analyses, allowing a prediction of the potential flood and water quality problems due to the planned development in the watershed and the associated encroachments in the floodplain. Because of this predictive capacity, the master plan enables the County to identify and assign priorities for capital improvements, develop meaningful regulatory controls for new development, and protect the safety and welfare of residents and businesses in the watershed.

However, as important as master plans are to any comprehensive storm water program, by themselves they will not solve problems or prevent flooding, drainage or water quality problems. The master plans represent a blue print for action that must be taken if these problems are to be solved or prevented. Too often people see the master plan as the end product and forget that if the plans are not implemented little good will result from the completed work. The real work begins when the master plan is complete.

1.3 Master Plan Objectives

This principal objectives of this storm water master plan, as identified by the Knox County SWAC, can be broken into three main categories: addressing needs and issues, providing a regulatory instrument, and assisting with planning.

In addressing storm water **needs and issues**, the master plan will:

- address major and minor flooding issues, and identify flood solution alternatives to fix existing problems and determine ways to avoid future problems;
- provide "what if" analysis capability for planning and storm water management purposes;
- inventory the drainage system to the level desired by County staff;
- present information to allow prioritization of capital improvement projects (CIPs);
- utilize existing GIS data and create new layers of information for use in planning, maintenance, CIPs and complaint handling; and,
- address water quality, both holistically and in response to regulatory permitting pressures.

For **regulatory instruments**, the master plan will provide the necessary information to:

- extend the regulatory floodplains in Beaver Creek and its tributaries beyond the floodplain boundaries required by FEMA for flood insurance purposes;
- be used in the plans approval process to assist with defining requirements for new developments and redevelopments in the Beaver Creek watershed.

For **planning** purposes, the master plan will:

- provide an overall land use guide for storm water management in the watershed;
- provide a tool to assist planners with Sector Plan and zoning decisions; and,
- be a policy tool to assist policy makers.

1.4 Scope of Study

This study is the second of two planned reports in a comprehensive study of the Beaver Creek watershed. The first report, titled *Beaver Creek Watershed Flood Study* (Ogden, 2000), provided floodplain and floodway information to update the effective FIS performed in 1982. This study provides the following information to the Knox County Department of Engineering and Public

Works for storm water management purposes as defined by the objectives listed previously. Specifically, this master plan provides:

- stream water quality information for Beaver Creek and its tributaries;
- the 100- and 500-year floodplain boundaries for the selected stream reaches for existing (FEMA) conditions (submitted in entirety in the *Beaver Creek Watershed Flood Study*);
- a detailed delineation of the Beaver Creek watershed;
- a detailed delineation of the hydrologic soils types in the Beaver Creek watershed;
- a detailed delineation of the existing and future condition land use in the Beaver Creek watershed;
- existing and future land use condition hydrologic models of the Beaver Creek watershed with frequency discharge information at the sub-basin (approximately 100 acre) level;
- existing and future land use condition hydraulic models of Beaver Creek and selected tributaries;
- an analysis of flood solution alternatives for priority areas identified by Knox County; and,
- an analysis and discussion of structural and non-structural alternatives for storm water management in the watershed.

Because "existing conditions" is a moving condition, the following definition applies to this study: **existing conditions is defined as the state of the watershed as of March 1999**. Future conditions are defined as the planned land use conditions in the watershed according to the 15-Year Growth Plan developed by the Metropolitan Planning Commission (MPC). More information on the future urbanization in the watershed is presented in Chapter 5.

2 STUDY AREA DESCRIPTION

2.1 The Watershed

Figures 2-1a and 2-1b show the Beaver Creek watershed boundary and the location of Beaver Creek and its major tributaries. The Beaver Creek watershed is located entirely in Knox County, as shown in the small locator map in the upper left corner of Figures 2-1a and 2-1b. The watershed has the shape of a long, narrow rectangle, and has a length of approximately 25 miles and an average width of 3.5 miles. The total area of the watershed is approximately 86 square miles, and the majority of that area is located north of the limits of the City of Knoxville. There are some small areas located within the limits of the City along Interstate-75 and along the southern watershed boundary.

The watershed is bounded on the north by Copper Ridge and by Black Oak Ridge to the south. Beaver Ridge is also present, located between the two boundary ridges, along Beaver Creek's south bank. The maximum elevation in the watershed of 1,480 ft is found on Beaver Ridge. All three ridges run in a northeastwardly direction in Knox County. Areas located between Beaver Ridge and Black Oak Ridge drain to Beaver Creek via tributaries that flow through narrow gaps in Beaver Ridge.

To facilitate analysis of the watershed and creeks for the master plan, the Beaver Creek watershed was divided into smaller drainage areas called basins and sub-basins. These areas are referred to throughout this report and therefore are explained here. Basins were delineated where there were major tributaries or logical divides in the watershed. There are 44 basins in the Beaver Creek watershed, 19 of which drain to Beaver Creek via tributaries. Tributary basins were identified according to the stream to which they drain (e.g., the North Fork basin drains to the North Fork tributary) or, for tributaries that did not have a formal name, a major roadway or other feature located in the basin (e.g., Caldwell Lake, Solway Road, Trailer Park). The remaining 25 basins drain directly to Beaver Creek and were given a two-digit numeric identification, from basin 01 at the headwaters of the main stem to basin 25 located at the confluence with the Clinch River. A more detailed explanation of the naming convention used for basins and sub-basins is presented in Appendix A.

The basins were further divided into sub-basins to the level of detail desired by Knox County (approximately 100-acres). Sub-basins were named according the basin in which they are located (e.g., sub-basin NF010 is located in the North Fork basin). There are 660 sub-basins in the Beaver Creek watershed, giving an average sub-basin area of about 87 acres. This level of detail was necessary to provide Knox County with model results that could be used to determine impacts of development at the neighborhood level, and provide frequency discharges outside the area of detailed hydraulic study.

Figure 2-1a

Figure 2-1b

Table 2-1 provides general information about the basins that were delineated for the Beaver Creek master plan. Approximately 53 square miles (59 percent) of the Beaver Creek watershed drain to Beaver Creek via the major tributaries listed in Table 2-1. The remaining 36.6 square miles in Basins 01 through 25 drain directly to the main stem via overland flow or minor conveyance systems. While the majority of the watershed is discharged into Beaver Creek via tributaries, the tributaries have relatively small drainage areas when compared to the watershed as a whole. Grassy Creek is the largest tributary with a drainage area of less than 7 square miles, comprising only 8 percent of the total watershed area. In general, the tributaries located on the south side of Beaver Creek have larger drainage basins and more floodplain storage.

Table 2-1. General Information – Beaver Creek Drainage Basins

Stream Name	Basin Identification	Drainage Area (mi^2)	Number of Sub-basins	Area Draining to Sinkholes (mi^2)
Beaver Creek	01 through 25	36.596[1]	267	1.074
South Fork	SF	1.273	12	0.000
Thompson School	TS	1.310	12	0.000
Kerns Branch	KB	3.070	23	0.140
Cox Creek	CX	3.677	34	0.000
Mill Branch	MB	3.281	22	0.465
Willow Fork	WF	3.937	31	0.930
Trailer Park	TP	0.343	4	0.000
North Fork	NF	3.236	22	0.434
Allen Branch	AB	2.948	24	0.286
Hines Branch	HB	2.270	18	0.000
Caldwell Lake	CL	2.352	18	0.353
Bishop Road	BR	2.695	16	0.320
Haw Branch	HW	1.675	9	0.000
Knob Fork	KF	4.215	32	0.000
Collier Road	CR	2.051	12	0.138
Grassy Creek	GC	6.778	46	0.133
Meadow Creek	MC	3.677	26	0.000
Plumb Creek	PC	3.361	23	0.000
Solway Road	SR	1.203	9	0.046
Watershed Totals	**-**	**89.948**	**660**	**4.319**

1 – Drainage area listed is the sum of the areas of main stem basins 01 through 25.

The Beaver Creek watershed has a fair amount of karst topography, located predominantly north of the creek. A combined area of 4.319 square miles in the Beaver Creek watershed drain to sinkholes of significant size, such that they will not fill and overtop during the 100-year rainfall events. Approximately 75% of that area are located in tributary basins on the north side of Beaver Creek. Interviews with residents and observations taken during field investigations indicate that the runoff captured by the sinkholes remains in the watershed and eventually discharges to Beaver Creek or a tributary. While there is no inventory or historical study of significant recharge areas located within the Beaver Creek watershed, it is believed that that the timing of the recharge from these sinkholes is so delayed that they do not influence peak discharges and flood levels during a flood event.

2.2 Soils Coverage

Because most urban and suburban areas are only partially covered by impervious surfaces, the soils and surface cover types will continue to have a significant influence on runoff generated from the Beaver Creek watershed. Figures 2-2a and 2-2b present a map of the hydrologic soils groups present in the watershed. The hydrologic soil group is an indication amount of infiltration the soil will allow. Sandy soils will allow significant infiltration while rock formations tend to allow no infiltration. The definition of each hydrologic soil group is given in Table 2-2.

Table 2-2. Definition of Hydrologic Soil Groups

Hydrologic Soil Group	Soil Group Characteristics
A	Soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
B	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
C	Soils having slow infiltration rates when thoroughly wetted and consisting 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.
D	Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan 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.

Figure2-2a

Figure2-2b

Like the rest of Knox County, the predominant soil group in the Beaver Creek watershed is the type B soil. These moderately well drained soils cover approximately 52% of the watershed, the vast majority of which are located on the north side of Beaver Creek. The remainder of the watershed, more specifically along the south floodplain of Beaver Creek and throughout Beaver Ridge and Black Oak Ridge, is covered with the poorly drained soils of groups C and D. From the standpoint of runoff volume, this implies that urbanization on the north side of Beaver Creek will have a much greater effect on increasing runoff volume than development on the south side of the creek because impervious areas associated with development on the north side will cover soils that have a relatively higher infiltration capacity. A summary of the soil group distribution for the watershed is provided in Table 2-3. More detailed soil group information at the basin level is provided in the *Beaver Creek Watershed Flood Study* (Ogden, 2000).

Table 2-3. Hydrologic Soil Group Distribution – Beaver Creek Watershed

	DISTRIBUTION OF HYDROLOGIC SOIL GROUPS (%)			
	A	**B**	**C**	**D**
Watershed Totals	0	52	33	15

2.3 Land Use and Urbanization

The affect of urbanization and associated impervious cover on storm water processes and flood frequency has been well-documented (Debo, 1997; USGS, 1984). As urbanization within a watershed increases, the changes in land use from undeveloped conditions to developed conditions can cause significant changes in the hydrologic, hydraulic and water quality characteristics of the watershed. From a flooding standpoint, increases in impervious area coverage will cause subsequent rises in the volume of runoff and flood elevations. And man-made storm water control devices such as curb and gutter systems, underground drainage systems (e.g., storm sewers) can drastically change the natural timing of a watershed changing peak discharge rates, usually increasing flood frequencies and velocities within the streams. From a water quality standpoint, development in a watershed increases the number of pollutant sources while decreasing some of the natural features (open spaces, riparian zones, vegetated areas) that can serve to reduce pollutant loading to water bodies.

The Beaver Creek watershed is now experiencing these changes. Historically, land use in the watershed was predominantly rural, with any residential and limited commercial development largely confined to the communities of Halls-Crossroads, Powell and Karns. Today, rural and rural residential are still the predominant land uses in the watershed, but development has begun to spread beyond the three main communities. Figures 2-3a and 2-3b show the existing land use conditions in the Beaver Creek watershed, as of March 1999. Table 2-4 provides a summary, in percent by land use category, of the existing condition land use in the Beaver Creek watershed. More detailed existing land use information at the basin level is provided in the *Beaver Creek Watershed Flood Study* (Ogden, 2000).

Approximately 62% of the watershed is covered by undeveloped, low impervious area, land uses (open space, agricultural, meadow, and woods). Of the developed land uses, residential areas with >1-acre lots covers the largest percentage of the watershed at 19%. More densely populated residential areas (e.g., 1 acre lots) cover 15% of the watershed. Residential development is the most rapidly growing land use in the watershed, located mainly along the major roadways (Oak Ridge Highway, Emory Road, Beaver Creek Drive, Pellissippi Parkway, etc.). As expected, commercial development is also increasing as residents move into the watershed. Recent commercial developments at the intersection of I-75 and Emory Road and along Clinton Highway are examples of this growth. In addition, a large light industrial/technical office park is being constructed at the corner of Pellissippi Parkway and Hardin Valley Road.

Table 2-4. Existing Condition Land Use Distribution in the Beaver Creek Watershed

	DISTRIBUTION OF LAND USES BY LAND USE CODE (%)												
	Res HI	Res MD	Res LO	Com	Ind	Dst	Ag	Open good	Mead	Thk wds	Thn wds	Imp	water
Watershed	1	14	19	2	1	1	0	10	21	19	12	0	0

Figure 2-3a

Figure 2-3b

2.4 Channels and Floodplains

Table 2-5 provides general information about Beaver Creek and the major tributaries analyzed for the master plan. Beaver Creek, also referred to as "the main stem" in this report, is a long, winding creek that is approximately 45 miles in length. The headwaters of Beaver Creek are located in north Knox County and the creek flows southwest to its confluence with the Clinch River at Clinch River Mile 39.6.

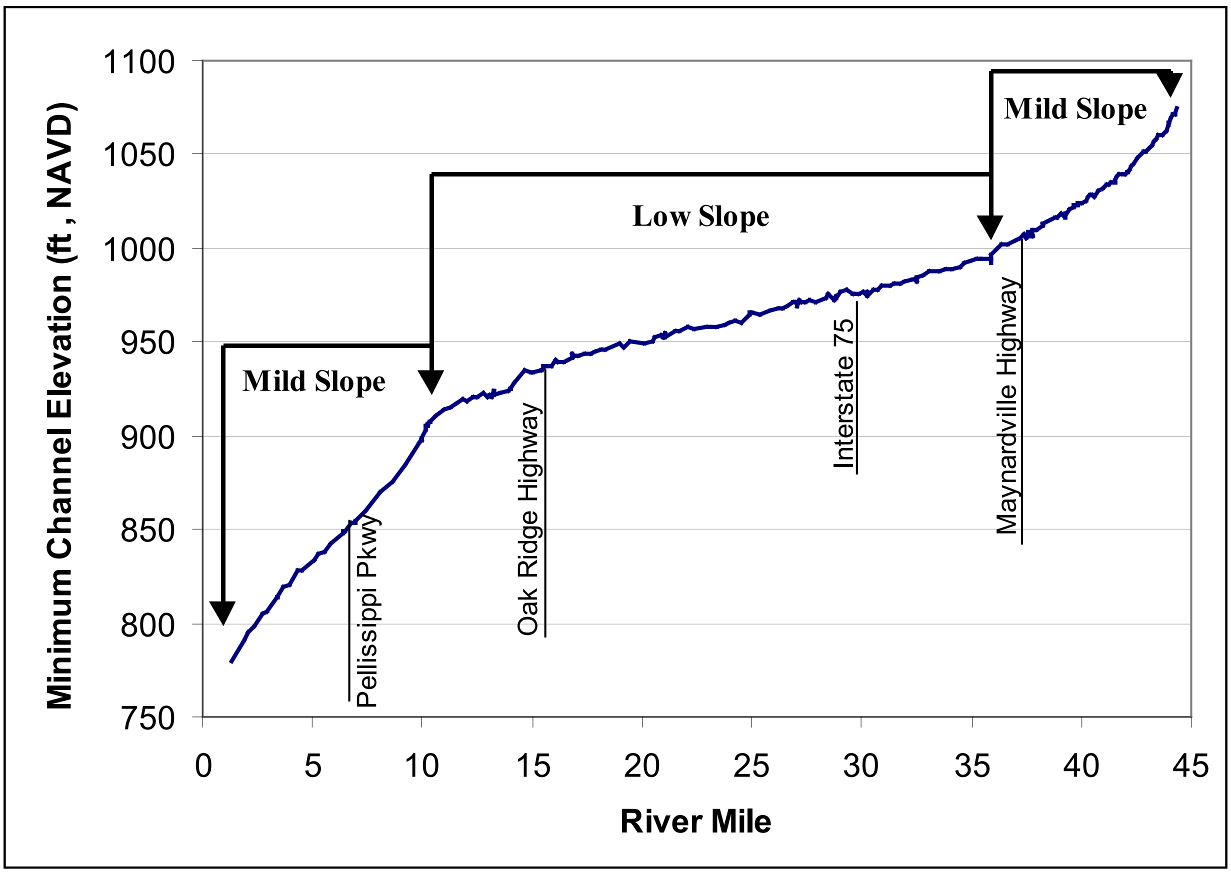
Table 2-5. General Information – Beaver Creek and Tributaries (starting upstream)

Tributary Name	Location of Confluence (River Mile)	Stream Length (miles)	Average Slope (ft/mile)	Recorded Flood Complaints?
Beaver Creek (upper portion)	Beaver Creek 35.930[1]	9.1	0.002	Yes
Beaver Creek (middle portion)	Beaver Creek 10.870[1]	25.1	0.0006	Yes
Beaver Creek (lower portion)	Clinch River RM 39.6	10.1	0.003	No
South Fork	Beaver Creek RM 43.935	1.630	0.009	Yes
Thompson School Tributary	Beaver Creek RM 43.563	2.827	0.014	No
Kerns Branch	Beaver Creek RM 42.700	2.576	0.015	No
Cox Creek	Beaver Creek RM 39.809	3.172	0.008	No
Cox Creek Tributary	Cox Creek RM 0.347	1.070	0.012	Yes
Mill Branch	Willow Fork RM 0.593	3.759	0.013	No
Willow Fork	Beaver Creek RM 37.804	5.739	0.012	Yes
Trailer Park Tributary	Beaver Creek RM 37.604	0.773	0.010	No
North Fork	Beaver Creek RM 36.992	3.110	0.013	Yes
Allen Branch	Beaver Creek RM 36.114	3.303	0.015	No
Hines Branch	Beaver Creek RM 35.756	3.097	0.010	Yes
Caldwell Lake Tributary	Beaver Creek RM 34.027	2.638	0.015	No
Bishop Road Tributary	Beaver Creek RM 31.596	2.328	0.014	No
Haw Branch	Knob Fork RM 1.515	2.063	0.011	No
Knob Fork	Beaver Creek RM 29.367	4.924	0.006	No
Collier Road Tributary	Beaver Creek RM 27.838	1.395	0.019	No
Grassy Creek	Beaver Creek RM 21.818	3.636	0.004	No
Meadow Creek	Beaver Creek RM 12.692	3.976	0.008	No
Plumb Creek	Beaver Creek RM 12.678	3.125	0.008	Yes
Solway Road Tributary	Beaver Creek RM 6.800	2.026	0.021	No

1 – River mile listed is a point along the stream, and is not located at a confluence of streams.

The general characteristics of Beaver Creek vary along its length. Figure 2-4 shows the elevation of the channel bed along the length of Beaver Creek. As shown in the figure and in Table 2-5, the channel gradient is mild (approximately 9 ft/mile) for the upstream-most 9 miles of stream, and low (approximately 3 ft/mile) in the middle 25 miles, and mild again (about 14 ft/mile) for the remainder of the stream to its confluence with the Clinch River. The low-flow channel is fairly small considering the size of the watershed, and the bed can be described as fairly clean and winding, without large boulders and cobbles, or shallow, weedy reaches. There are occasional deeper pools located in the middle portion of the creek that, when combined with low slopes, can make the stream flow somewhat sluggish. Much of the floodplain is used for livestock pasture, therefore cattle fences that cross the creek are not uncommon. Typically, these fences are composed of barbed wire and tend to become clogged with large amounts of debris if not properly maintained.

Figure 2-4. Profile of Beaver Creek Channel Bed



The natural floodplain for the creek tends to be wider and fairly well defined by the surrounding topography along the length of the main stem, except in the most downstream 10 miles where the topography provides for only a narrow floodplain. Vegetation in the floodplain and along the stream bank varies in amount and condition, and is largely dependent upon the land use in the floodplain. The banks are more likely to be denuded of vegetation where pastures are, or have been, located in the floodplain. In general, dense development has remained out of the floodplain, with some exceptions in the Halls-Crossroads and Powell communities. Pasture, open land, woods and low-density residential areas are the predominant land uses along the stream banks. Erosion along the stream banks is not uncommon, but no critical areas for erosion, from a property damage standpoint, have been identified or observed.

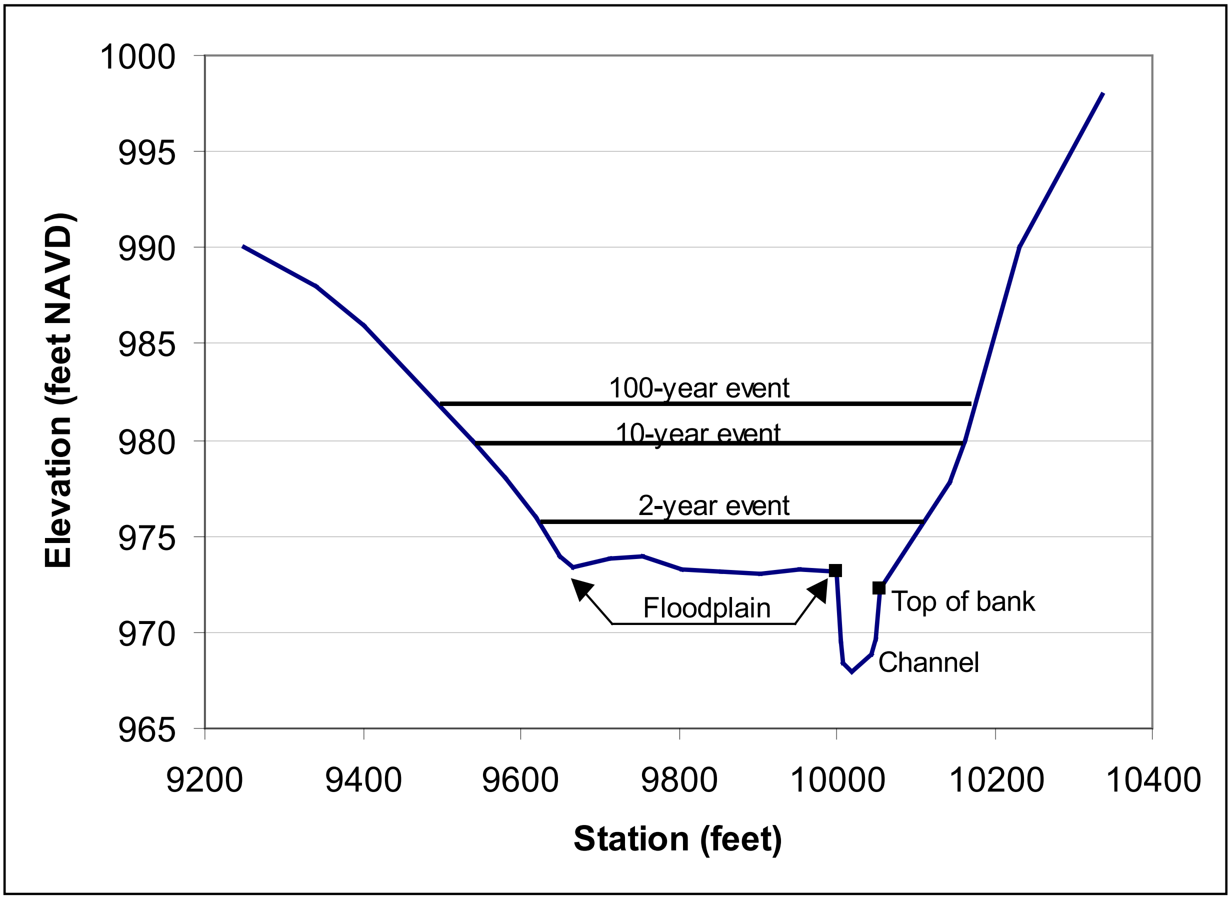
The general characteristics of the tributaries differ from the main stem. On average, the tributaries are steeper. The upstream reaches of the tributaries drain the slopes of the predominant ridges that define the watershed and therefore have fairly narrow, steep channels that transition to more mild channel gradients closer to the confluence with the main stem. The tributaries that drain large areas between Beaver Ridge and Black Oak Ridge and run parallel to the ridgelines (i.e., Cox Creek, Knob Fork, and Grassy Creek) tend to have lower slopes and wider floodplains than those located on the north side of Beaver Creek. Compared to the main stem, tributary stream channels are generally are straighter and steeper than the main stem, resulting in higher channel velocities. The channel bottoms vary in constitution, but tend to have more rocks and small cobbles than the main stem. The stream bank and floodplain vegetation varies with the land use, with more developed land uses, and therefore more flood potential located in the downstream portion of the tributaries where the floodplains are naturally wider. The most notable exception to this is on Hines Branch, where a large and densely populated trailer park is located adjacent to upstream reach of the creek. No significant erosion areas have been identified on the tributaries.

2.5 Flood History

Nuisance flooding of yards, pastures and other undeveloped property along Beaver Creek and in some of its tributaries is not uncommon and occurs on a fairly frequent basis. This type of flooding is typically short-lived, limited to lower areas that are located very close to the low-flow channel and does not impact habitable structures. While this out-of-bank flow occurs along the majority of the length of the stream, there are several areas well known to local residents where nuisance flooding can easily be seen from roadways, including the Powell Airport, upstream of Maynardville Highway and near Emory Road in Powell.

A "pre-development" analysis of the watershed, prior to any agricultural or residential development, indicates that it is the natural condition for Beaver Creek to overtop its banks and spill into the floodplain after relatively high frequency, low volume storm events. This analysis was performed assuming the entire watershed was wooded, and that no developed land uses existed. (Peak discharges and flood elevations were determined using the models and methods discussed in more detail in later sections of this report, and therefore will not be addressed here.) Figure 2-5 presents the results of this analysis for a typical channel cross-section in Beaver Creek for the 2-, 10- and 100-year storm events. The figure shows that in the main stem, the creek is out of bank for the most frequent 2-year, 24-hour storm event (3.3 inches of rain in 24 hours).

Figure 2-5. Typical Beaver Creek Cross-Section with Pre-Development Flood Elevations



While nuisance flooding is a common and probably natural occurrence, storm events that have occurred in the past five years indicate that the flood potential in the watershed has increased as a result of development. The County has received complaints of flooded homes and/or streets in the locations listed below, prompting the County to identify these locations as *priority areas* for which specific flood solution alternatives should be evaluated. The existing flooding problems and priority areas in the Beaver Creek watershed are:

1. Flooding at a number of homes and businesses located along Beaver Creek in the Halls-Crossroads area. These include homes in the Hallbrook subdivision, and businesses in the Halls Center Shopping area on Maynardville Highway.

2. House, basement and crawlspace flooding at several homes on Oaken Drive, located along the north bank of North Fork.

3. Roadway flooding along Lovell Road and Bob Kirby Road near Plumb Creek.

4. Crawlspace flooding at residences located along Oak Ridge Highway in Karns.

5. Mobile home and roadway flooding along Hines Branch.

6. Flooding at a home on Cedar Breeze Drive, on the Cox Creek Tributary.

3 WATER QUALITY

3.1 Background

The gradual development of the Beaver Creek watershed has affected the water quality of the creek. The creek does not fully support its designated uses and habitat alterations have impacted the general health of the creek (Jones, 2000). In their 305b report published in 1996, the Tennessee Department of Environment and Conservation (TDEC) designated uses for Beaver Creek using a standard stream use classification system (TDEC, 1996). Table 3-1 lists the stream use classifications that TDEC determined for various reaches of Beaver Creek.

Table 3-1. Beaver Creek Designated Stream Uses

Stream Reach (Mile)	Domestic Water Supply	Industrial Water Supply	Fish & Aquatic Life	Recreation	Irrigation	Livestock Watering & Wildlife
0.0 - 8.4	X	X	X	X	X	X
8.4 - 10.4		X	X	X	X	X
10.4 - 17.5	X	X	X	X	X	X
17.5 - 17.9		X	X	X	X	X
17.9 - 21.6	X	X	X	X	X	X
21.6 - 23.6			X	X	X	X
23.6 - 29.4	X	X	X	X	X	X
29.4 - 31.4			X	X	X	X
31.4 to origin	X	X	X	X	X	X

Water quality in Beaver Creek is generally viewed by the public as poor to fair. The results of a study on public views on the watershed, performed by the University of Tennessee, indicated that the public is concerned about the quality of Beaver Creek and understands the potential impacts of urban and agricultural runoff, poor land and stream bank practices, and sedimentation. However, the study also showed that the public is not well-informed about the fact that these problems are currently the primary causes of the degradation of water quality in Beaver Creek and its tributaries. Instead, residents ranked industrial runoff and bacterial contamination as the two most serious threats to water quality in Beaver Creek (Jones, 2000).

In fact, the stream receives its major pollutants from urban/suburban runoff, municipal discharges, agricultural runoff and construction activities. Industrial discharges do exist, but most are permitted under the National Pollutant Discharge Elimination System (NPDES) and should not contribute greatly to the pollutant loads in the creek. TDEC lists five industrial NPDES permittees in the watershed, consisting of three sewage treatment plants (STP) and two commercial oil operations. One of the 3 STPs is no longer in operation, therefore only two municipal STPs discharge treated effluent into Beaver Creek. The Hallsdale-Powell Utility District (UD) STP discharges into Beaver Creek near Beaver Creek Drive on the lower half of the creek. The West Knox UD operates a STP that discharges its effluent at the mouth of Beaver Creek. Hallsdale-Powell UD also uses Beaver Creek as a source of drinking water, withdrawing water at its Dry Gap Water Plant near Brickey School on Dry Gap Road.

Pollutant discharges to the creek through illicit connections (i.e., non-permitted, non-storm water discharges) probably exist and contribute to the degradation of water quality. The extent of any illicit discharge problem is not known at this time. However, Knox County will be required to implement a legally enforceable illicit discharge detection and elimination program in the coming years, as part of their compliance with the NPDES Phase II regulations published in late 1999. This program will require the County to find and eliminate existing illicit discharges, and to perform occasional screening activities to detect or prevent new discharges.

The residents are correct in their perception that bacterial contamination exists in Beaver Creek, however it is not a major problem. In the 1998 303d list for the State of Tennessee, TDEC recognized pathogens as a pollutant in Beaver Creek, but with the lowest magnitude (slight) on TDEC's scale.

Table 3-2 presents the current 303d listing for Beaver Creek. Currently, the entire stream is listed as partially supporting its designated uses, because of the impacts of habitat alterations and siltation, and pollutants such as nutrients and pathogens. Municipal point discharges (i.e., the West Knox and Hallsdale-Powell Uds) are listed as the cause of high nutrient levels. Agricultural areas account for the pathogens, in the form of fecal coliform. And poor land development practices, such as filling in wetlands, are listed as the cause of siltation and habitat alteration problems.

In the Spring of 1995, the Tennessee Valley Authority (TVA), Water Management Group River Action Teams (RAT) conducted biological assessments in the upper, middle and lower reaches of Beaver Creek. The biological assessments included cursory surveys of both fish and benthic macro-invertebrate (aquatic insects) at each location. The data collected from the surveys were then analyzed and used to assess the creeks' water quality. The results of the RAT study, summarized in Table 3-3, show that Beaver Creek is a "Fair" to "Poor" quality stream.

Table 3-2. Beaver Creek 303d Listing

					CAUSE		Pollutant Source		
Waterbody ID	**Impacted Waterbody**	**County**	**Partial**	**Not**	**(Pollutant)**	**Mag**	**Source**	**Mag**	**TMDL**
TN06010207011	BEAVER CREEK From mouth on Clinch River to headwaters.	Knox	137.4		Nutrients	M	Municipal Point Source	M	H
					Pathogens	S	Agriculture	M	
					Siltation	M	filling wetlands	M	
					Habitat Alteration	M	Land development	M	

COMMENTS: Depressed biological communities and excessive algal growth indicate nutrient problems. Sources for nutrients include agricultural runoff, land development, and municipal point sources.

WATERBODY ID -In 1988, the Division divided the state's waters into "waterbodies" and created a database of information about each. Each waterbody has an ID based on EPA's River Reach System. The first eight digits of the ID after TN are the USGS HUC Code numbers. We are making substantial progress toward converting this system into a GIS-based system. **The 303(d) List is sorted in hydrologic order within each major watershed basin.**

WATERBODY NAME - The name of the main body of water within the waterbody is provided as well as a short description of the impacted segments.

COUNTY - The county the waterbody is in. Where waterbodies stretch across multiple counties, the more downstream county is usually listed.

PARTIAL- If the stream is considered partially supporting designated uses, the number of impacted miles (according to Reachfile 3) are shown in this column. Lake acres are listed as "ac".

NOT If the stream is considered not supporting designated uses, the number of impacted miles (according to Reachfile 3) are shown in this column. Lake acres are listed as "ac".

CAUSE The pollutant or pollutants exceeding water quality standards is identified.

SOURCE -The general source of each pollutant exceeding water quality standards within the waterbody is identified. (For both causes and sources, the Division uses categories provided by EPA so that we might be consistent with language used by other states.)

MAG -The magnitude of the cause or source is given as **H**igh, **M**edium, or **S**light.

TMDL -TMDL Priority is either **H**igh, **L**ow, or **N**ot Applicable. High Priority-the body of water is in a watershed identified to begin its five-year cycle in 1996, 1997, or 1998 and the pollutant causing the impact is one for which EPA has provided tools for TMDL generation, such as low dissolved oxygen, metals or fecal coliforms. Our assessment of priority considers the severity of pollution in the waterbody and the uses to be made of the waters.

Source: TDEC

Table 3-3. RAT Team Water Quality Assessment for Beaver Creek

Location	**Beaver Creek Stream Reach**	**Drainage Area (Sq mi)**	**Water Quality Assessment Based On:**		
			Fish	**Benthics**	**Overall**
No. Pt. Subdivision	Upper	14	Fair/Good	Poor	Fair
25W Bridge	Middle	56	Poor	Poor	Poor
Solway Rd	Lower	86.8	Very Poor/Poor	Poor	Poor

3.2 Water Quality Stream Surveys - Assessments and Results

As part of the master planning process, Knox County initiated a survey program to collect baseline water quality data in Beaver Creek. A summary of the survey results is presented in this report. A detailed discussion of the survey methods used and the data collected are presented in two reports*: Water Quality Survey, Upper Beaver Creek, Knox County* (Ogden, July 27, 1998) and *Water Quality Survey, Beaver Creek Phase II, Knox County* (Ogden, June 21, 1999).

Twelve study stations on Beaver Creek and selected tributaries were included in a biological stream survey. The location of each station is shown in Figure 3-1. The surveys included the systematic collection and identification of biological organisms, typically benthic macro-invertebrate organisms (i.e., bugs) and fish. The number, type and condition of the benthic macro-invertebrates and fish were recorded, along with habitat and basic water chemistry data. Together, this data was used to assess overall water quality for the streams. The results of the stream surveys are summarized in Table 3-4. The “overall assessment” column shown in Table 3-4 is a combination of the various assessment methods applied to the data, tempered with professional judgment based on observations collected during the field survey.

The physical characteristics of the watershed vary from high-gradient, habitat rich conditions of Lammie Branch (Station 1) to the more typical conditions in Beaver Creek exemplified by low-gradient, turbid, habitat-limited stations. The physical characteristics of Beaver Creek directly affect the biological component of the system as well as the water quality. In general, it would be unreasonable to expect “excellent” water quality in Beaver Creek proper, however, there are conditions that have caused a reduction in water quality and therefore, an impairment to biological integrity that are not attributable to habitat or flow regime.

In general, water quality in the upper third of the Beaver Creek watershed appears to be in fair condition (Stations 2, 3, and 4. Station 3 being the one exception), whereas water quality in the middle third (Stations 6 and 9) is in poor condition. Station 12 in Solway indicates a recovery in the lower third of Beaver Creek. The tributaries in the upper third (represented by Stations 1 and 5 on Willow Fork) appear to be in fair condition. Downstream of Maynardville Highway all of the tributaries were rated as poor.

Figure 3-1

Table 3-4. Water Quality Assessment Summary, Beaver Creek and Selected Tributaries

		Benthic Macro-Invertebrates			Fish	Habitat	
Survey Location	**Survey Date**	**NBC/NCBI**	**Percent Contribution of EPT Taxa**	**TN RBP III Biological Score**	**Total IBI Score**	**Assessment Score (200 possible)**	**Overall Assessment**
STATION 1 Lammie Branch (trib to Willow Fork)	Oct. 1,1997	3.27 Excellent - No Pollution	52 % Very Good	N/A	N/A	172	Very Good-Excellent
STATION 2 Beaver Creek at E. Beeler Rd.	Oct. 1,1997	4.94 Good - Some Pollution	25 % Fair	33 % Moderately Impaired	40 Fair	84	Fair
STATION 3 Beaver Creek at Brown Gap Rd.	Oct. 1,1997	6.66 Fairly Poor - Significant Pollution	1.7 % Very Poor	24 % Moderately Impaired	30 Poor	119	Poor
STATION 4 Beaver Creek at Halls Comm. Park.	Oct. 1,1997	4.42 Very Good - Slight Pollution	23 % Fair	24 % Moderately Impaired	28 Poor	120	Fair
STATION 5 Willow Fork at Willow Fork Dr.	Oct. 1,1997	4.68 Good - Some Pollution	35 % Fair	38 % Moderately Impaired	38 Poor-Fair	118	Fair
STATION 6 Beaver Creek at Maynardville Pike	Oct. 1,1997	6.00 Fairly Poor - Significant Pollution	9 % Poor	24 % Moderately Impaired	40 Fair	114	Poor - Fair
STATION 7 Hines Branch at Cunningham Dr.	May 14, 1998	5.16 Good - Some Pollution	9 % Poor	23% Severely-Moderately Impaired	28 Poor	136	Poor
STATION 8 Knob Fork at Beaver Creek Dr.	May 14, 1998	7.42 Fairly Poor - Significant Pollution	0 % Very Poor	9.5% Severely Impaired	30 Poor	112	Poor
STATION 9 Beaver Creek at Clinton Highway	May 14, 1998	6.39 Fair -Fairly Significant Pollution	6 % Poor	29% Moderately Impaired	28 Poor	138	Poor
STATION 10 Grassy Creek at Beaver Creek Dr.	May 14, 1998	7.06 Fairly Poor – Significant Pollution	2 % Very Poor	19% Severely Impaired	38 Poor-Fair	123	Poor
STATION 11 Meadow Creek near mouth	May 14, 1998	7.82 Poor – Very Significant Pollution	7 % Poor	23% Severely-Moderately Impaired	40 Fair	113	Poor
STATION 12 Beaver Creek at Clinton Hwy	May 14, 1998	5.81 Fair - Fairly Significant Pollution	14 % Poor	33% Moderately Impaired	32 Poor	158	Poor - Fair

The results from this survey show that the combination of pollution inputs to the Beaver Creek watershed have impacted water quality along Beaver Creek. Although the stations sampled for this survey were generally located in residential or light-commercial areas, the streams receive runoff from a number of different land uses that contribute pollutants to the streams. Examples of pollutant sources that could contribute to the degradation of water quality at one or more of the survey stations include: residential applications of lawn and garden chemicals; roads and highways (oils, gas, antifreeze, heavy metals, asbestos, acids etc.,); gas stations; agricultural pesticides and herbicides; construction runoff (primarily sediment); and sewage treatment plant effluent. The reduction in, and/or absence of, intolerant fish and benthic macro-invertebrate species at the survey stations, as indicated by the percent EPT, suggests that water quality conditions in the creeks are compromised due to significant pollution contributions from the surrounding watershed.

Sediment influx appears to be one of the greatest contributors to water quality degradation in Beaver Creek. Sediments not only physically impair aquatic organisms and their habitat, but also transport chemicals (toxicants), nutrients, oils and greases and organic salts into the creek. It is the natural condition of a creek to pick-up sediment during high and fast flood flows, and the flat stream gradient of the creek between the Halls-Crossroads and Karns communities slows the flow and allows some of the suspended sediment to deposit back to the channel bed. However, excess sediment beyond the creek's natural sediment carrying capacity will cause additional sediment depositions and degrade water quality and habitat, as evidenced by the stream survey results. Field observations at the survey sites showed that the substrate was laden with thick sediment deposits. At some stations the deposited sediment was measured at 8 to 10 inches deep. Suspended sediments were also prevalent at each of the Beaver Creek stations.

There is some indication that toxicants may also be present in the system, carried in on vegetative material sprayed with herbicides or pesticides. Oils and greases were also observed in the sediments of Station 6, located below the most commercialized segment of the survey. This is evidence of illicit, non-stormwater discharges entering Beaver Creek.

3.3 Water Quality Stream Survey Conclusions

Portions of Beaver Creek are suffering from poor habitat quality, which in turn creates harsh living conditions for aquatic organisms. In general, the creek has fair water quality in the upper reaches, poor water quality in the middle, and poor water quality in the bottom third, although water quality does appear to improve from the middle to the lower third. Water quality in the lower reaches appears to be influenced by stream conditions (i.e., better habitat and higher stream gradient), as well as less residential and agricultural development per stream mile.

Stations 3, 6, 9 and 12, located in the middle to upper portion reaches, show signs of significant pollution.

The water quality on the tributaries of Beaver Creek appears to be poor downstream of Maynardville Pike. The tributaries sampled (Hines Branch, Knob Creek, Grassy Creek, and Meadow Creek) showed very poor or poor water quality. All of these tributaries drain from the southern side of Beaver Creek and have potential industrial and commercial pollutant sources. These sources should be investigated for illicit discharges and targeted for BMPs as outlined in Section 3.4. Lammie Branch (a tributary to Willow Fork), a first order stream feeding into Beaver Creek from the northwest ridge, is in good biological condition, indicating that high quality water is sustained in the headwaters of the watershed along this ridgeline.

Increased sediment loads have created water quality problems in Beaver Creek. Sediment influx into the system is reducing available habitat and breeding grounds for fish and benthic macro-invertebrates, choking-out filter feeding organisms, and potentially transporting toxicants, oils and greases, and inorganic salts into the system. The reduction in benthic macro-invertebrate shredders and filter feeders suggest the presence of toxicants in the system.

3.4 NPDES Phase II Regulation Implications

In December of 1999 EPA promulgated the National Pollutant Discharge Elimination System (NPDES) regulations known as Phase II. Under these regulations the County will be required to obtain a permit to discharge storm water from urbanized areas to waters of the State. This permit will require the County develop and maintain a storm water program that addresses the following six minimum controls for water quality:

1. Public Education and Outreach
2. Public Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Runoff Controls
5. Post Construction Runoff Controls
6. Best Management Practices for Municipal Operations

As outlined previously, Beaver Creek is listed as partially supporting for the entire creek on the state 303d list for impaired streams. The State listing also includes urban runoff as a contributing pollutant source for the impairment. Because of this designation, TDEC, who is the

NPDES permitting authority for the State of Tennessee, will be very interested in the water quality and the proposed best management practices (BMPs) that Knox County implements to comply with the six minimum controls.

Methods useful for improving water quality in Beaver Creek and its tributaries can also be used for compliance with the six minimum controls of the Phase II regulation. First and foremost, the County must develop various strategies for public education and outreach in order educate the general public about the primary sources of pollution in the watershed, and ways they can help to improve water quality. Because of the large size of the watershed and the nature of non-point pollution, the citizens of Knox County (not the County Storm Water staff) are the most effective means to control further degradation of water quality through education and pollution prevention. The strategies should focus separately on the diverse groups located in the watershed (e.g., homeowners, farming operations, commercial businesses, various industries), their particular contributions to pollution in the creeks, and ways to prevent pollution from entering the system.

Next, the stream surveys indicated that illicit discharges are present in the Beaver Creek watershed. The land use maps and watershed/sub-basin delineations developed in the County GIS system can be used to pinpoint specific hotspots and maximize the effort for illicit discharge detection and elimination. Illicit discharge detection efforts can start with dry-weather screenings (i.e., visual observations) at the outlet points of the sub-basins that have significant areas of commercial and industrial development. If discharges are noted during the dry weather, the field crew can gradually work upstream to locate the source of discharges.

The third minimum control measure addresses runoff from construction sites, particularly sedimentation and erosion. Both the State's 303d listing and the Master Plan stream surveys reveal that siltation and sediment is a major contributor to poor water quality on Beaver Creek. One can be sure that TDEC will be focusing on strong BMPs to control pollution from land development practices. Knox County will be required to comply with the BMP through enforcement of an ordinance prohibiting discharges of pollutants from construction sites, and through a regular site inspection and plans review process.

However, urban and construction runoff are not the only sources of sediment. Sediment from agricultural practices is also a significant source of sediment. Beaver Creek is used as a main water source for several cattle farms located along the creek, and cattle are allowed full access the creek. Erosion and sediment loss in these areas is high due to the loss of significant vegetation to anchor soils in the floodplain and along the stream and the degradation of the stream bank from cattle accessing the creek.

As commercial development continues to grow in Beaver Creek, the County must develop strategies to control non-point source pollutant sources after construction has been completed. Control of pollutants and runoff after construction has been completed is the fifth minimum control measure of the Phase II regulations. Areas with high impervious cover have been shown to discharge the highest pollutant loads, therefore commercial, industrial and high-density residential areas have the greatest impact on receiving water quality after construction. Knox County should target these types for developments for post-construction BMP efforts.

Finally, any municipal operations performed by the County must include to minimize pollutant discharges. EPA's intention for this control measure is that the County "practice what it preaches" in regards to pollution prevention and water quality improvement. Therefore, the County will need to review its own operations to determine what modifications should be made in work practices, County-owned storm water systems, County maintenance and operations facilities, and County construction practices in order to comply with Phase II.

3.5 Water Quality Management Recommendations

Based on the results of the water quality surveys in the Beaver Creek watershed and the impending Phase II regulations, the following recommendations are made to improve or maintain water quality in Beaver Creek and its tributaries.

1. Public awareness and education information should be distributed to encourage reduction of source pollutants.

2. The County should encourage the use of effective BMPs for businesses, communities, and farms in the watershed. Examples of methods used to encourage such practices are "environmental friend" awards or similar public acknowledgements and "fast-track" permitting processes or fee reductions for new construction or re-developments.

3. Reduce sediment loads to Beaver Creek by implementing and maintaining a strong erosion control program. For construction activities, sediment controls need to be established and maintained prior to, and throughout the duration of, all construction activities, including those located away from the creek. For rural and other non-urban areas (e.g., cattle farms), the County should work with the local NRCS office to implement effective BMPs to control stream bank degradation and erosion.

4. Wetlands and other sensitive areas should be identified and protected as they provide natural water quality buffers and flood storage. The County has already initiated a study to identify and map sensitive areas of the watershed as part of a program originally funded by the Knox Land and Water Conservancy to develop a conservation easement acquisition plan for the

watershed. Collection and further analysis of the water quality data collected for this master plan, and in 1999 by TDEC will be included in this effort. The County should continue to support and participate in this program to increase the chances of success, because the benefit of a successful conservation easement program can positively impact both water quality and flooding.

5. Commercial storm drains and other potential illicit (non-storm water) discharges should be investigated and eliminated.

6. General land use patterns and water quality should be examined in the watershed to isolate areas for priority BMP implementation.

7. Follow-up monitoring should be conducted in the future to develop long term trend monitoring.

4 EXISTING CONDITION ANALYSIS

This section presents a brief summary of the methodology used to analyze the Beaver Creek watershed and creeks for existing conditions, and a detailed discussion of the results of the existing condition analysis. The scientific and engineering methods utilized to study Beaver Creek are well-documented in previous reports presented to Knox County, and for brevity will not be discussed extensively in this report. The reader is referred to the *Beaver Creek Watershed Flood Study* for a detailed discussion of the modeling approach, the data used, and the methods employed to calibrate and verify the hydrologic and hydraulic models of the Beaver Creek watershed (Ogden, 2000).

4.1 Methodology

4.1.1 Hydrology

Hydrologic modeling is necessary to predict the response of a watershed to specific rainfall events and changing watershed conditions. Different conditions include theoretical rainstorms, urban development, channel improvements, and detention ponds. The HEC-1 Flood Hydrograph Package (USACE, 1998) computer model was used to facilitate the hydrologic calculations for the Beaver Creek watershed. Design rainfall events were used along with SCS curve number and Clark unit hydrograph methods, to predict watershed response and generate design storm hydrographs at each calculation point in the watershed. Peak discharge rates from the design storm hydrographs generated by the HEC-1 model were used as input for the hydraulic models. The existing condition HEC-1 model is based on the land use conditions in the watershed as of March 1999, when the model was developed for the FEMA flood study. It is the intent that the existing condition HEC-1 model will be periodically updated to reflect changes in land use or floodplain storage that would impact frequency discharges.

Input for the hydrologic model includes precipitation data, sub-basin data (area, standard SCS runoff curve number, time of concentration, and the Clark storage coefficient), stream data (channel length, slope, roughness value, and geometry or storage-elevation relationship), and storage node data (storage-elevation-discharge relationships). A 24-hour balanced storm approach was used to simulate the design rainfall in the Beaver Creek HEC-1 model. Because the Beaver Creek watershed is approximately 86 square miles in area, areal reduction of point rainfall was performed in the manner recommended by the Corps of Engineers for large watersheds (USACE, 1998). The rainfall events used for hydrologic simulation frequencies of 2-, 10-, 25-, 100- and 500-years. Consideration of base flow was not included in the Beaver Creek HEC-1 model. A computation interval of 3-minutes (0.05 hrs) was chosen for the HEC-1 model of the Beaver Creek watershed.

Existing Condition Curve Numbers

The land use categories used for curve number estimation are shown in Table 4-1. All curve numbers used for hydrologic modeling in the Beaver Creek watershed represent AMC II soil moisture conditions. No adjustment was made for other soil moisture conditions.

Table 4-1. SCS Land Use Categories and Associated Curve Numbers

Land Use Code	Description	Average % Impervious	Curve Number by Hydrologic Soil Group				Typical Land Uses
			A	B	C	D	
1	Residential (High Density)	65	77	85	90	92	Multi-family, Apartments, Condos, Trailer Parks
2	Residential (Med. Density)	30	57	72	81	86	Single-Family, Lot Size ¼ to 1 acre
3	Residential (Low Density)	15	48	66	78	83	Single-Family, Lot Size 1 acre and Greater
4	Commercial	85	89	92	94	95	Strip Commercial, Shopping Ctrs, Convenience Stores
5	Industrial	72	81	88	91	93	Light Industrial, Schools, Prisons, Treatment Plants
6	Disturbed/Transitional		76	85	89	91	Gravel Parking, Quarries, Land Under Development
7	Agricultural		67	77	83	87	Cultivated Land, Row crops, Broadcast Legumes
9	Open Land – Good		39	61	74	80	Parks, Golf Courses, Greenways, Grazed Pasture
10	Meadow		30	58	71	78	Hay Fields, Tall Grass, Ungrazed Pasture
11	Woods (Thick Cover)		30	55	70	77	Forest Litter and Brush adequately cover soil
12	Woods (Thin Cover)		43	65	76	82	Light Woods, Woods-Grass combination, Tree Farms
13	Impervious	95	98	98	98	98	Paved Parking, Shopping Malls, Major Roadways
14	Water	100	100	100	100	100	Water Bodies, Lakes, Ponds, Wetlands

4.1.2 Hydraulics

The HEC-RAS computer program version 2.2 (USACE, 1998) was used to perform the hydraulic modeling and develop water surface profiles (i.e., flood elevations) for Beaver Creek and its tributaries. The streams studied in hydraulic detail are Beaver Creek, South Fork, Thompson School Tributary, Kerns Branch, Cox Creek, Cox Creek Tributary, Mill Branch, Willow Fork, North Fork, Hines Branch, Knob Fork, Grassy Creek, and Plumb Creek. The scope of detailed hydraulic analysis on each stream, shown in Table 4-2, was determined through discussions with County staff and review of previous studies.

Table 4-2. Limits of the HEC-RAS Models for Beaver Creek and Tributaries

Stream	Downstream Limit		Upstream Limit	
	Landmark	River Mile	Landmark	River Mile
Beaver Creek	Clinch River (RM 39.6)	0.0	1000 ft. upstream of Tazewell Pike	44.333
South Fork	Beaver Creek (RM 43.935)	0.0	400 ft. upstream of Maloneyville Rd.	1.000
Thompson School Tributary	Beaver Creek (RM 43.563)	0.0	500 ft. upstream of Emory Rd.	0.789
Kerns Branch	Beaver Creek (RM 42.700)	0.0	800 ft. upstream of Coppock Rd.	2.318
Cox Creek	Beaver Creek (RM 39.809)	0.0	700 ft. upstream of Tazewell Pike	2.190
Cox Creek Tributary	Cox Creek (RM 0.347)	0.0	150 ft. upstream of Cedar Breeze Lane	0.676
Mill Branch	Willow Fork (RM 0.593)	0.0	250 ft. upstream of Maynardville Hwy.	2.850
Willow Fork	Beaver Creek (RM 37.804)	0.0	600 ft. upstream of Brackett Rd.	3.851
North Fork	Beaver Creek (RM 36.992)	0.0	100 ft. upstream of McCloud Rd.	2.020
Hines Branch	Beaver Creek (RM 35.756)	0.0	1700 ft. upstream of Mynatt Dr.	2.225
Knob Fork	Beaver Creek (RM 29.367)	0.0	200 ft upstream of Fountain City Rd	4.205
Grassy Creek	Beaver Creek (RM 21.818)	0.0	450 ft upstream of Ball Road	2.222
Plumb Creek	Beaver Creek (RM 12.678)	0.0	300 ft. upstream of Hickey Rd.	1.501

Separate HEC-RAS models were developed for each stream utilizing stream channel and hydraulic structure surveys, topographic mapping of the watershed provided by KGIS, and field investigation of the streams. Stream cross-sections on Beaver Creek and the tributaries were numbered by river mile (RM). On Beaver Creek, RM 0.0 was defined at the confluence of Beaver Creek and the Clinch River. Similar procedures were followed for each tributary. Cross-section data includes geometry, reach length, Manning's n values, expansion and contraction coefficients and ineffective flow areas.

Peak discharges were obtained from the existing and future condition HEC-1 models. Flow change points were determined based on the relative locations of HEC-1 operations and HEC-RAS cross-section locations. Cross-section river miles in HEC-RAS were associated with appropriate HEC-1 operations. Starting water surface elevations for all streams were obtained using the slope-area method. Encroachment analyses were performed using HEC-RAS models using Encroachment Method 1 to define the left and right encroachment stations.

4.2 Analysis and Results

4.2.1 Land Use and Curve Numbers

Table 4-3 presents a breakdown of the existing land uses in the Beaver Creek watershed. Today, the majority of the watershed (52%) remains undeveloped (e.g., woods, meadows). Open land uses that have a relatively low amount of impervious surfaces (e.g., cemeteries, golf courses and parks) account for 10% of the total area, and developed land uses that have a greater contribution to runoff quantity cover 38% of the watershed.

Table 4-3. Land Use Distribution in the Beaver Creek Watershed

	DISTRIBUTION OF LAND USES BY LAND USE CATEGORY (%)												
	Res HI	Res MD	Res LO	Com	Ind	Imp	Dst	Ag	Openf air	Open good	Mead	Thk wds	Thn wds
Watershed	1	14	19	2	1	0	1	0	0	10	21	19	12
	38% developed land uses							62% undeveloped and open land uses					

Figures 4-1a and 4-1b present a map of the existing condition curve numbers for each sub-basin. As shown the figures, existing condition curve numbers ranged from a basin average high of 86 in Basin 07 in Halls to a 63 in Willow Fork. The average curve number for the watershed is 72. The highest curve numbers can be found in sub-basins located near the Halls-Crossroads area, and in main stem basins along Emory Road in the Halls and Powell areas. The lowest curve numbers can be found in sub-basins located along ridges, where developed areas are less prevalent.

Figure 4-1a. Beaver Creek Watershed Existing Condition Curve Numbers

Figure 4-1b. Beaver Creek Watershed Existing Condition Curve Numbers

4.2.2 Peak Discharges

Table B-1 in Appendix B presents the HEC-1 model input data (area, curve number, Tc and R) and the existing condition peak discharges for the 2-, 10-, 25-, 100- and 500-year storm events calculated by the HEC-1 model for every sub-basin that contributes to runoff in the Beaver Creek watershed. Table 4-4 presents existing condition peak flow rates at selected locations.

Table 4-4. Existing Condition Peak Discharges at Selected Locations

Landmark	DA (sq. mi.)	HEC-1 Operation	Peak Discharges (cfs)				
			2-yr	10-yr	25-yr	100-yr	500-yr
BEAVER CREEK							
Fairview Road	1.59	01120C	280	690	900	1240	1620
Beeler Road (east)	4.84	03050C	615	1820	2390	3360	4340
Brown Gap Road	10.13	04190D	830	2560	3390	4965	6720
Maynardville Pike	21.25	06010P	1120	3230	4320	6570	9090
Dry Gap Rd	33.87	11060C	1330	3940	5260	7400	9970
Interstate 75	38.71	12080E	1350	4010	5340	7500	10180
Central Ave Pike	39.34	12150C	1350	4010	5340	7500	10190
Brickyard Road	48.66	14010D	1370	4120	5460	7680	10450
Clinton Highway	52.43	16010D	1350	4060	5390	7600	10440
Oak Ridge Highway	68.96	21030C	1310	3910	5200	7370	10140
Pellissippi Parkway	81.49	24180D	1280	3840	5100	7230	9910
Mouth	85.63	25210C	1270	3810	5070	7190	9830
SOUTH FORK							
Maloneyville Road	0.79	SF050P	160	400	520	810	1080
Tazewell Pike	1.22	SF110P	200	530	680	1000	1300
Mouth	1.27	SF120C	210	540	700	1010	1320
THOMPSON SCHOOL TRIBUTARY							
Thompson School Rd	0.78	TS070C	120	380	520	740	950
Mouth	1.31	TS120C	210	590	780	1120	1480
KERNS BRANCH							
Majors Road	1.99	KB130C	92	500	750	1230	1730
Emory Road	2.61	KB210P	170	610	870	1330	2010
Mouth	2.93	KB230C	220	680	940	1440	2120
COX CREEK							
Tazewell Pike	1.37	CX110P	260	710	920	1190	1460
Mouth	3.68	CX340C	560	1550	2020	2820	3650
MILL BRANCH							
Maynardville Hwy (us)	0.84	MB110D	80	350	500	740	980

Table 4-4. Existing Condition Peak Discharges at Selected Locations

Landmark	DA (sq. mi.)	HEC-1 Operation	Peak Discharges (cfs)				
			2-yr	10-yr	25-yr	100-yr	500-yr
Mouth	2.82	MB220C	170	760	1110	1760	2350
WILLOW FORK							
Brackett Road	1.52	WF170C	90	430	620	965	1340
Quarry Road	2.29	WF230P	170	590	790	1090	1320
Mouth	5.82	WF310C	360	1300	1800	2640	3490
TRAILER PARK							
Mouth	0.34	TP040D	170	360	450	580	700
ALLEN BRANCH							
Norris Freeway	1.90	AB130D	140	660	960	1440	1950
Mouth	2.66	AB190C	210	880	1230	1820	2440
NORTH FORK							
McCloud Road	0.51	NF070C	40	200	290	440	600
Andersonville Pike	1.82	NF110D	170	580	880	1370	1850
Mouth	2.80	NF190D	240	720	1000	1640	2600
HINES BRANCH							
Mynatt Drive	0.85	HB050D	290	720	940	1270	1580
Mouth	2.27	HB180C	500	1400	1880	2630	3360
CARDWELL LAKE							
Pelleaux Road	0.31	CL040C	30	140	200	290	390
Mouth	2.00	CL160C	160	670	940	1390	1830
BISHOP ROAD							
Pedigo Road	0.44	BR090C	30	170	250	380	510
Mouth	2.37	BR140D	260	1000	1380	2020	2690
HAW BRANCH							
Mouth	1.67	HW090D	430	1120	1470	2010	2520
KNOB FORK							
Fountain City Road	0.69	KF050C	160	460	610	850	1070
Callahan Road	5.02	KF270P	650	1580	1980	2650	3580
Mouth	5.89	KF320C	710	1480	1850	2430	3050
COLLIER ROAD							
Heiskell Road	0.34	CR030C	40	140	200	290	380
Mouth	1.91	CR120F	180	710	1010	1480	1920
GRASSY CREEK							
Ball Road	5.38	GC310E	830	2270	2970	4120	5270
Oak Ridge Highway	5.46	GC330C	830	2280	2970	4090	5260
Mouth	6.64	GC430C	830	2220	3150	4360	5400
MEADOW CREEK							
Ball Camp Pike	2.35	MC150D	340	890	1180	1650	2140

Table 4-4. Existing Condition Peak Discharges at Selected Locations

Landmark	DA (sq. mi.)	HEC-1 Operation	Peak Discharges (cfs)				
			2-yr	10-yr	25-yr	100-yr	500-yr
Mouth	3.68	MC260C	470	1120	1470	2040	2630
PLUMB CREEK							
Hickey Road	1.12	PC080C	280	740	960	1300	1620
Mouth	3.36	PC230C	600	1680	2190	2990	3750
SOLWAY ROAD							
Hardin Valley Road	0.35	SR030C	50	190	270	400	520
Mouth	1.16	SR090C	110	460	660	980	1290

Figure 4-2 presents a plot of drainage area versus the 100-year peak discharge for several major tributaries to Beaver Creek. The figure shows that the peak flow in a tributary increase in a linear fashion with the drainage area, indicating that peak discharges are very sensitive to inflows from the contributing drainage area. Figure 4-3 is a similar plot of drainage area versus peak discharge for Beaver Creek. A linear relationship between drainage area and peak discharge, similar to that seen in the tributaries, is seen upstream of Maynardville Highway, where existing condition peak discharges increase an average of about 325 cfs per square mile of drainage area. Some sensitivity to drainage area continues, albeit to a gradually lesser degree, until the creek has a drainage area of approximately 48 square miles, however downstream of Maynardville Highway, floodplain storage is the predominant factor governing peak discharges. The increase in peak flow with drainage area is essentially eliminated. In fact, the increase in peak discharge averages only about 10 cfs per square mile of drainage area, from Maynardville Highway to the confluence of Beaver Creek with the Clinch River.

Figure 4-2. 100-Year Existing Condition Peak Discharges Along Selected Tributaries

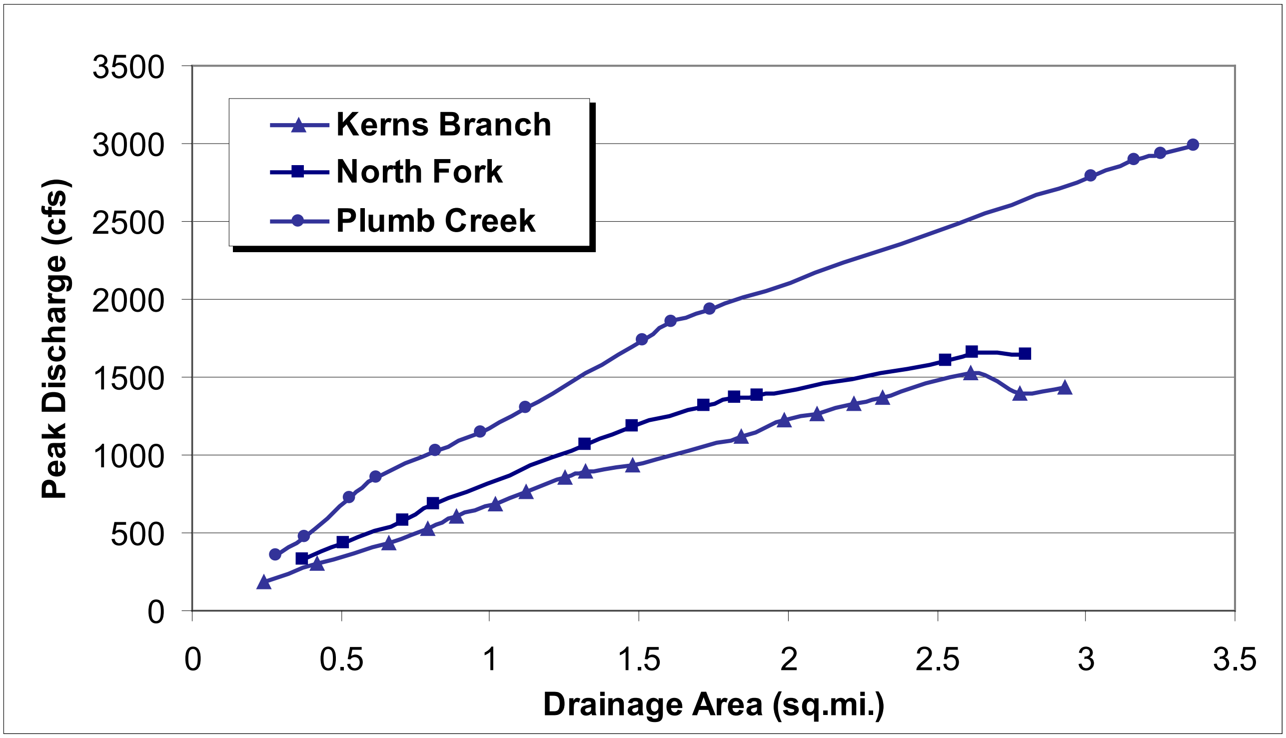
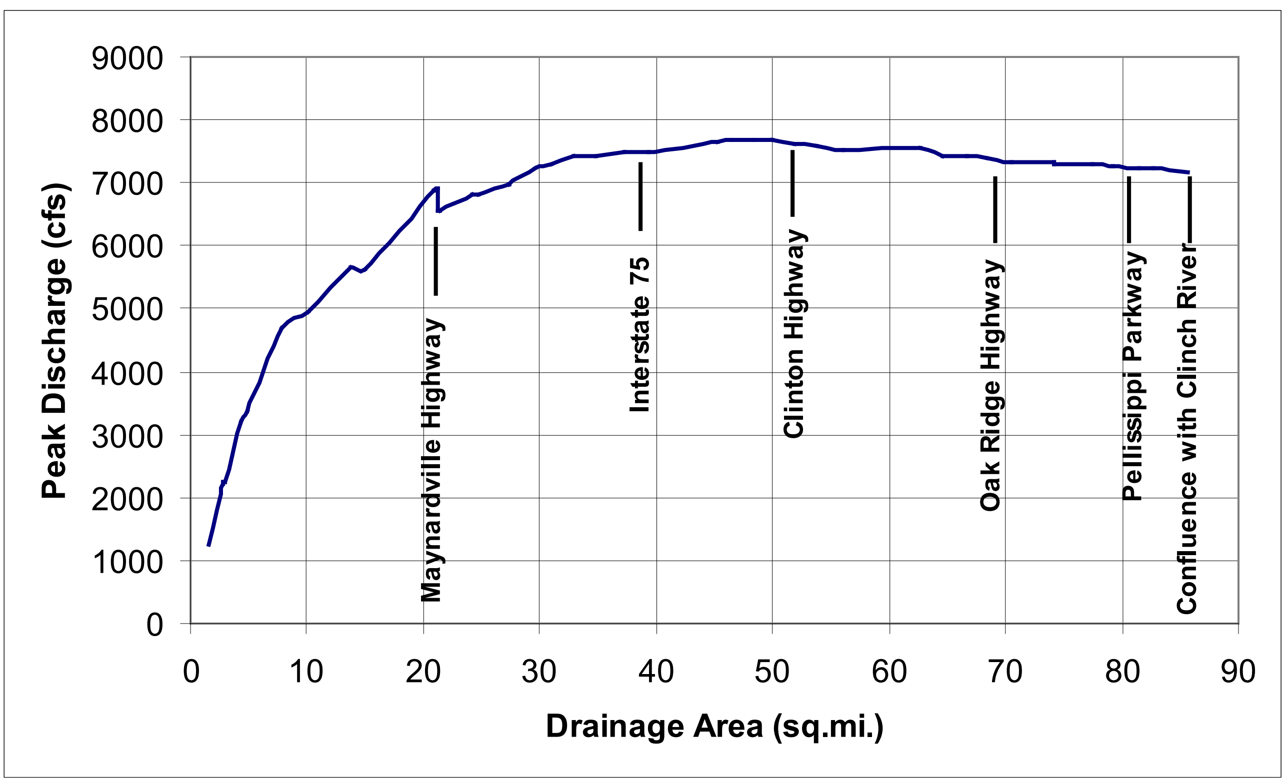


Figure 4-3. 100-Year Existing Condition Peak Discharges Along Beaver Creek

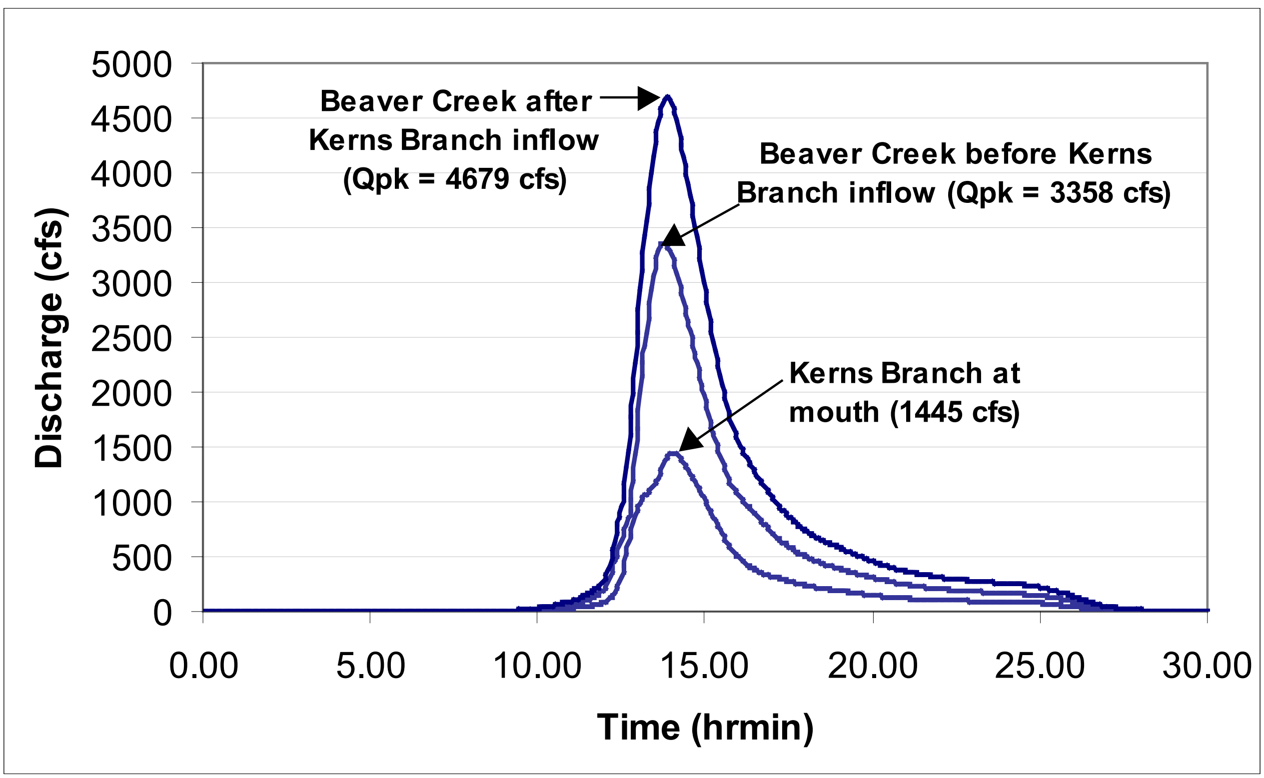


4.2.3 Watershed Timing

Understanding the relative timing of peak inflows and hydrographs as they discharge from tributary basins into the main stem is key to effective management of storm water in the Beaver Creek watershed. Downstream of Maynardville Highway, the floodplain storage has not only attenuated the peak discharge in Beaver Creek, but significantly delayed it as well, thereby lessening the influence of peak discharges from surrounding basins on the peak in the main stem. In the upstream reaches, the peaks from tributaries and the main stem are closer together, therefore the tributaries can significantly impact the main stem. Both situations are presented graphically in Figures 4-4 and 4-5.

Figure 4-4 shows the Beaver Creek runoff hydrograph just upstream of the Kerns Branch confluence with the main stem, along with the hydrograph in Kerns Branch, and the resulting hydrograph in Beaver Creek after the two inflows have combined. Because the occurrence of the two peak discharges occur closely in time, the increase in peak discharge (and also volume of flow) on the main stem after the two inflow hydrographs have combined is significant. Thus, the peak discharge on Beaver Creek is very sensitive to the added drainage area provided by Kerns Branch.

Figure 4-4. 100-Year Flood Hydrographs at the Confluence of Beaver Creek and Kerns Branch



In contrast, Figure 4-5 shows the corresponding main stem and tributary hydrographs at the confluence of Grassy Creek. Note that the Beaver Creek hydrograph has more than one peak by the time it has reached Grassy Creek due to attenuation in the floodplain and subsequent inflows from tributaries. The highest peak discharge in the Beaver Creek hydrograph corresponds to peak flood elevations. The figure shows that although Grassy Creek is the largest tributary and discharges the highest inflow to Beaver Creek, its effect on the peak discharge in the main stem is negligible because the timing of the hydrographs on the two creeks are so vastly different (approximately 16 hours). Floodplain storage on Beaver Creek has delayed its peak discharge to the point that inflows from surrounding areas are not a significant influence. In this situation, the hydrograph from Grassy Creek has discharged to the main stem and proceeded downstream well before the largest pulse of the main stem hydrograph reaches the confluence.

Figure 4-5. 100-Year Flood Hydrographs
at the Confluence of Beaver Creek and Grassy Creek

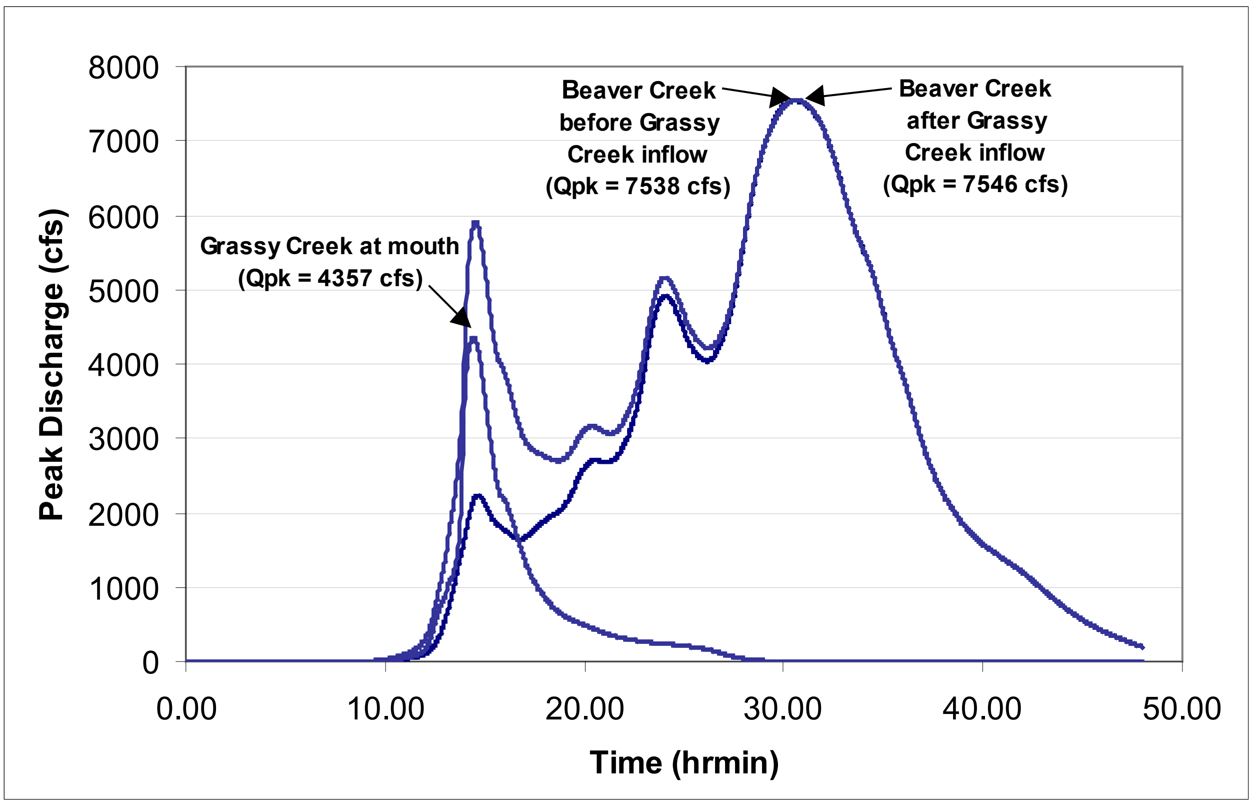


Table 4-5 presents a timing summary of the Beaver Creek watershed, along with the impact of each tributary inflow, expressed as the % increase in the peak discharge on the main stem. While the information shown in Table 4-5 was generated for the 100-year event, the relative times and impacts will differ only slightly for other events and land use conditions, unless future structural controls (e.g., regional detention ponds) are installed in the stream(s).

Table 4-5. 100-Year Existing Condition Peak Discharge Timing Summary

Tributary Name[1]	Time-to-peak at confluence (hour)		Increase in main stem peak discharge caused by tributary (%)
	Tributary	Beaver Creek	
South Fork	13.35	13.50	78%
Thompson School Trib.	13.20	13.55	43%
Kerns Branch	14.05	13.75	39%
Cox Creek	13.20	15.30	14%
Willow Fork	13.85	16.10	23%
Trailer Park Tributary	12.55	16.05	4%
North Fork	13.60	16.70	4%
Allen Branch	13.45	17.20	2%
Hines Branch	13.10	17.40	4%
Cardwell Lake Tributary	12.95	17.00	2%
Bishop Road Tributary	13.05	20.25	<1%
Knob Fork	15.05	22.95	2%
Collier Road Tributary	12.85	24.50	<1%
Grassy Creek	14.45	30.60	<1%
Meadow Creek	14.55	37.20	No increase
Plumb Creek	13.35	37.35	No increase
Solway Road Tributary	12.70	39.10	No increase

1 – Only those tributaries that discharge directly to Beaver Creek are shown.

4.2.4 Flood Elevations Analysis

Table 4-6 provides a listing of flood elevations for existing condition storm events at selected locations along Beaver Creek and its tributaries. Some general observations on flooding in Beaver Creek can be made using the results of the Beaver Creek and Beaver Creek tributary HEC-RAS models, as listed below.

1. When compared with the flood elevations determined using wooded land use conditions prior to the existing development in the watershed (discussed in Section 2.5), existing condition

flood elevations are, on average, approximately 1.5 feet higher. As expected based on the results of the pre-development model, flood elevations on the main stem for existing conditions are consistently out of bank above R.M. 10.0 starting with the 2-year, 24-hour storm event. Floodwaters are out of bank throughout the entire main stem in the 10-year, 24-hour event. Tributary flooding is generally less extensive and less frequent.

2. The typical cross section for Beaver Creek is a small channel with wide, flat floodplains. The combination of this flood channel geometry with the large area of the watershed results in the fact that the creek flows out-of-bank naturally after a storm event on a relatively frequent basis, and the extent of flooding quickly reaches the edge of the floodplain. Figure 4-6 presents the flood elevations for the 10-year and 100-year existing condition events at a typical cross-section in Beaver Creek. While the flood elevations shown in the figure differ by 3.79 feet, the locations of the edge of water (or flood boundary) for the two events are fairly close.

Figure 4-6. Typical Beaver Creek Cross-Section with Existing Condition Flood Elevations

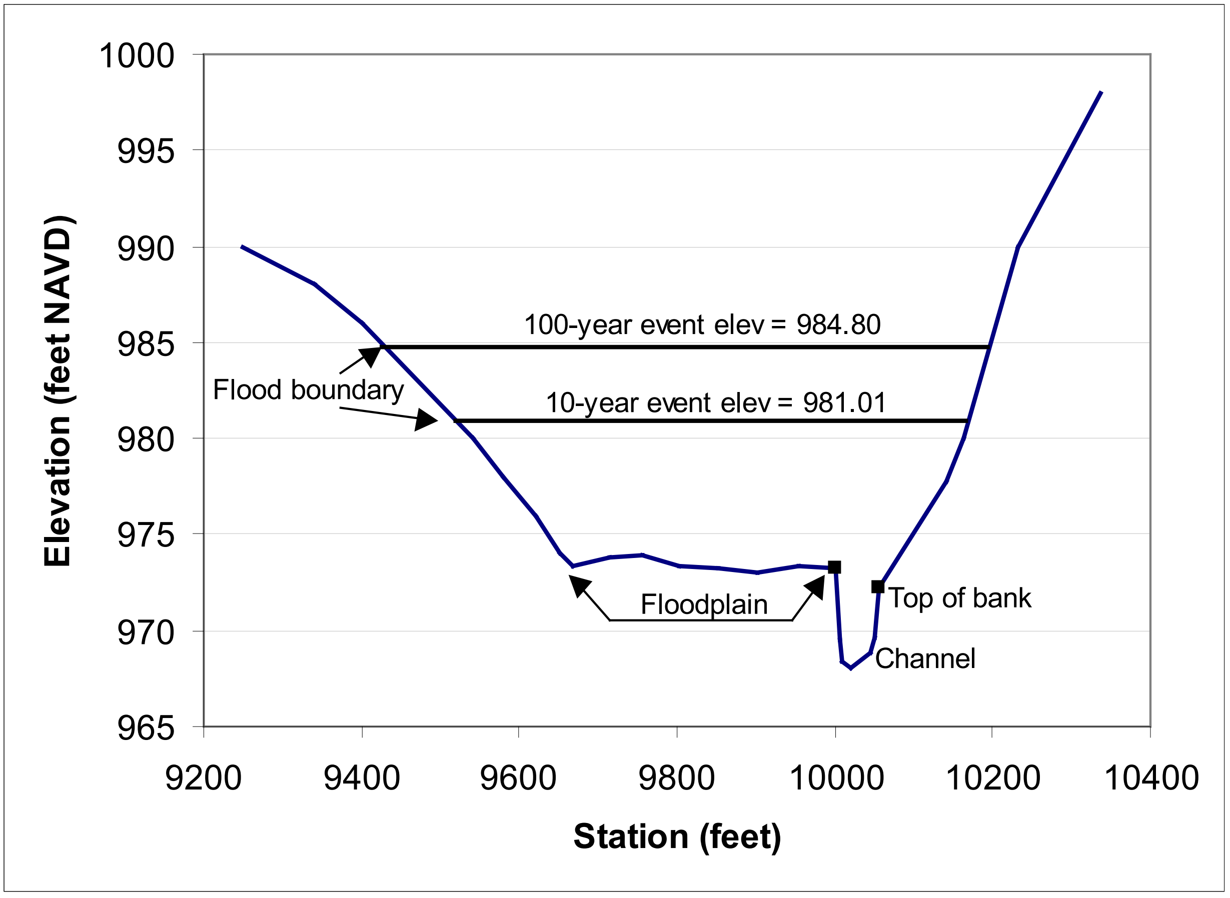


Table 4-6. Existing Condition Flood Elevations at Selected Locations

Landmark	Location (R.M.)	Elevation (ft)				
		2-yr	10-yr	25-yr	100-yr	500-yr
BEAVER CREEK						
Fairview Road	43.987	1072.33	1074.44	1074.69	1075.06	1075.55
Beeler Road (east)	42.819	1057.32	1058.96	1059.55	1060.42	1061.19
Brown Gap Road	39.877	1031.85	1034.45	1035.76	1037.64	1038.95
Maynardville Pike	37.649	1017.02	1021.52	1023.17	1026.31	1028.02
Dry Gap Rd	32.484	992.90	996.92	998.83	1001.63	1004.62
Interstate 75	30.220	987.27	991.54	993.41	995.99	999.28
Central Ave Pike	29.608	986.85	990.89	992.55	995.06	998.49
Brickyard Road	27.057	978.63	983.34	985.41	987.13	988.61
Clinton Highway	24.904	973.91	979.04	980.44	982.35	983.47
Oak Ridge Highway	15.465	944.86	950.55	952.42	954.95	957.79
Pellissippi Parkway	6.908	860.98	864.56	865.89	867.96	870.27
SOUTH FORK						
Maloneyville Road	0.929	1102.36	1105.16	1105.43	1105.81	1106.82
Tazewell Pike	0.296	1080.83	1083.17	1083.98	1085.52	1085.67
THOMPSON SCHOOL						
E. Emory Rd	0.693	1079.35	1082.16	1083.13	1085.11	1085.57
KERNS BRANCH						
Majors Road	1.640	1102.70	1106.60	1007.03	1107.62	1108.08
Emory Road	0.852	1076.91	1079.34	1080.14	1082.35	1083.75
COX CREEK						
Tazewell Pike	2.068	1086.06	1088.63	1090.12	1091.56	1094.08
MILL BRANCH						
Maynardville Hwy (us)	0.244	1023.02	1026.40	1027.95	1030.25	1033.14
WILLOW FORK						
Brackett Road	3.739	1088.26	1090.61	1091.04	1091.62	1091.94
Quarry Road	1.861	1032.84	1035.27	1035.21	1036.52	1039.44
NORTH FORK						
McCloud Road	2.008	1092.21	1094.92	1095.33	1095.77	1096.14
Andersonville Pike	0.741	1024.51	1028.00	1028.67	1029.10	1029.36
HINES BRANCH						
Mynatt Drive	1.884	1061.57	1064.33	1064.77	1065.19	1065.45
KNOB FORK						
Fountain City Road	4.178	1076.20	1079.03	1079.35	1079.72	1079.96
Callahan Road	1.515	1004.23	1008.04	1009.52	1011.44	1012.05

Table 4-6. Existing Condition Flood Elevations at Selected Locations

Landmark	Location (R.M.)	Elevation (ft)				
		2-yr	10-yr	25-yr	100-yr	500-yr
GRASSY CREEK						
Ball Road	2.145	985.94	989.94	991.14	993.16	994.36
Oak Ridge Highway	1.863	981.26	984.73	986.74	991.09	992.02
PLUMB CREEK						
Hickey Road	1.438	974.86	975.51	975.66	975.91	976.11

The 100-year and 500-year floodplain elevations calculated by the HEC-RAS models were mapped using KGIS topographic mapping. These maps are required by FEMA for flood insurance purposes, and therefore were generated primarily for the *Beaver Creek Watershed Flood Study*. The floodplain maps for main stem and tributaries are presented in that document and therefore are not presented in this report, except in the flood priority areas defined by the County and discussed in Section 7.

The mapped floodplains combined with planimetric mapping showing structures (houses, businesses, churches, schools, etc…) to get an *estimate* of the number of habitable structures located inside or touching the 100-year and/or 500-year floodplains. It is important to note that a structure positioned inside or touching a floodplain does not necessarily mean that the structure is flooded during the 100-year and/or 500-year event. The structure is considered flooded only if the lowest finished floor is inundated with water, therefore, to assess the flood potential for a given structure it is necessary to survey the lowest finished flood elevation (FFE) for comparison with flood elevations predicted by the HEC-RAS models. It was determined that 755 structures lie inside or are touching mapped floodplains for Beaver Creek and the modeled tributaries. Surveyed FFEs were obtained at 375 of those structures. Efforts to survey FFEs focused on priority areas where Knox County has received complaints of flooding problems and has identified a need to evaluate flood solution alternatives. Table 4-7 presents a summary of the results of the FFE comparison with the elevations calculated by the Beaver Creek and the tributary HEC-RAS models. The table also includes the number of buildings in the floodway, the number of structures located in the floodplains, and the number of structures surveyed.

Detailed information on the structures, both surveyed and not surveyed, that were identified as potentially threatened by flooding based on proximity to the mapped floodplains is contained in Table C-1 in Appendix C. The list contains a structure identification number, the address of the structure (if collected by the surveyor), the river mile of the structure, the surveyed FFE elevation (if surveyed), and the depth of flooding for all storm events in both the existing and future conditions (a negative depth indicates that the structure is not flooded).

Table 4-7. Existing Condition FFE Survey Results

Stream Name (general survey information)	Number of Flooded Structures					# Structures in Floodway
	2-Year	10-Year	25-Year	100-Year	500-Year	
Beaver Creek 451 structures shown in mapped floodplains 226 structures surveyed, 225 not surveyed	0	2	14	48	91	10
South Fork 11 structures shown in mapped floodplains 0 structures surveyed, 11 not surveyed	0	0	0	0	0	1
Thompson School Tributary No structures shown in mapped floodplains	0	0	0	0	0	0
Kerns Branch 5 structures shown in mapped floodplains 0 structures surveyed, 5 not surveyed	0	0	0	0	0	1
Cox Creek 4 structures shown in mapped floodplains 0 structures surveyed, 4 not surveyed	0	0	0	0	0	0
Cox Creek Tributary 10 structures shown in mapped floodplains 9 structures surveyed, 1 not surveyed	0	0	0	1	1	0
Mill Branch 8 structures shown in mapped floodplains 0 structures surveyed, 8 not surveyed	0	0	0	0	0	0
Willow Fork 13 structure shown in mapped floodplains 0 structures surveyed, 13 not surveyed	0	0	0	0	0	0
North Fork 63 structures shown in mapped floodplains 60 structures surveyed, 3 not surveyed	0	3	4	13	26	3
Hines Branch 105 structures shown in mapped floodplains 47 structures surveyed, 58 not surveyed	0	24	30	36	37	19
Knob Fork 31 structures shown in mapped floodplains 10 structures surveyed, 21 not surveyed	2	4	4	7	8	1
Grassy Creek 25 structures shown in mapped floodplains 7 structures surveyed, 18 not surveyed	0	1	2	3	5	0
Plumb Creek 29 structures shown in mapped floodplains 16 structures surveyed, 13 not surveyed	0	1	1	2	3	1
TOTALS **755 structures shown in mapped floodplains** **375 structures surveyed, 380 not surveyed**	**2**	**35**	**55**	**110**	**171**	**36**

4.2.5 Roadway Flooding

The extent of roadway flooding in the watershed was examined. Thirty-seven roadways are be overtopped and flooded (considering all modeled events) during existing condition floods in the Beaver Creek watershed. Table 4-8 provides a summary of the roadways in the Beaver Creek watershed that will overtop during a given storm event for existing conditions. Roadway names, descriptions, and classifications along with the overtopping event and the depth of water at overtopping are provided in this table. The roadways are ranked from highest to lowest importance based on road-use, frequency of overtopping, and depth of water on the road for the initial overtopping event. The ranking was done first by means of roadway classification, second by frequency of overtopping, and third by the depth of water during the overtopping event. After the ranking was completed, any road overtopping less than 0.25 feet in the 100-year or higher was eliminated.

To perform the ranking, the roadways were first separated into categories, based on the roadway definitions given in the Sector Plans developed by the MPC: interstate, major arterial (MA), minor arterial (ma), major collector (MC), and minor collector (mc). According to the Sector Plans, arterials are constructed to accommodate the highest volumes of traffic and move traffic through the area. Collectors carry traffic from the arterials and provide increased access to and circulation within residential and employment areas (MPC, varied dates). Streets not listed in the Sector Plans as an interstate, arterial or collector were deemed minor local streets and were not included in the overtopping analysis.

Table 4-8. Existing Condition Roadway Flooding – Beaver Creek Watershed

Rank	Road Name	Stream	HEC-RAS RM	Roadway Classification	Overtopping Event	Flood Depth (ft)
1	Lovell Road	Plumb	0.672	MA	2-yr	0.7
2	Emory Road	North	0.234	MA	10-yr	0.51
3	Emory Road	Willow	0.379	MA	25-yr	0.75
4	Oak Ridge Highway	Grassy	1.859	MA	100-yr	1.19
5	Maynardville Hwy North	Beaver	37.638	MA	100-yr	0.71
6	Emory Road	TSchl	0.688	MA	100-yr	0.51
7	Emory Road	Kerns	0.847	MA	500-yr	1.15
8	Maynardville Hwy South	Beaver	37.593	MA	500-yr	0.7
9	Maloneyville Road	South	0.926	ma	10-yr	0.36
10	Central Avenue Pike	Knob	1.698	ma	25-yr	0.44
11	Norris Freeway	North	0.402	ma	25-yr	0.29
12	Central Ave. Pike	Beaver	29.602	ma	500-yr	2.47
13	Tazewell Pike	Beaver	44.211	ma	500-yr	0.39
14	Cunningham Road	Hines	0.213	MC	2-yr	0.25
15	Bell Road	Willow	2.781	MC	2-yr	0.11
16	Ball Road	Grassy	2.142	MC	10-yr	2.15
17	Brown Gap Road	Cox	0.112	MC	10-yr	1.08
18	Brown Gap Road	Cox Trib	0.124	MC	10-yr	0.95
19	Andersonville Pike	Beaver	37.767	MC	10-yr	0.71
20	West Beaver Creek Drive	Grassy	0.517	MC	10-yr	0.65
21	Jim Sterchi Road	Knob	2.980	MC	10-yr	0.57
22	Mynatt Drive	Hines	1.877	MC	10-yr	0.57
23	Beaver Creek Drive	Knob	0.385	MC	10-yr	0.42
24	Rifle Range Road	Knob	3.381	MC	10-yr	0.36
25	Rifle Range Road	Knob	4.113	MC	10-yr	0.21
26	Andersonville Pike	North	0.735	MC	10-yr	0.1
27	Browns Gap Road	Beaver	39.871	MC	25-yr	1.16
28	Brickyard Road	Beaver	27.052	MC	25-yr	0.94
29	Harrell Road	Beaver	21.006	MC	100-yr	1.06
30	Callahan Drive	Knob	1.497	MC	100-yr	0.44
31	Hickey Road	Plumb	1.434	mc	2-yr	0.56
32	Majors Road	Kerns	1.637	mc	10-yr	0.9
33	McCloud Road	North	2.001	mc	10-yr	0.69
34	Dry Gap Pike	Knob	3.365	mc	10-yr	0.3
35	Fountain City Road	Knob	4.172	mc	25-yr	0.29
36	Weaver Drive	Grassy	1.772	mc	100-yr	1.27
37	Quarry Road	Willow	1.856	mc	500-yr	0.59

MA = Major Arterial, ma = minor arterial, MC = Major Collector, mc = minor collector

5 FUTURE CONDITIONS ANALYSIS

5.1 Methodology

Future conditions in the Beaver Creek watershed were simulated by modifying curve numbers, times of concentration (Tc) and storage coefficients (R) in the HEC-1 model. The curve numbers were determined using a future condition land use map, which was created by updating the undeveloped areas in the existing condition land use map in accordance with the planned land uses shown in the 15 Year Development Plans published by MPC (MPC, varied dates). Developed areas on the existing condition mapped were only adjusted to future conditions when the curve number for the land use planned by MPC was higher than existing condition curve number. While the SCS land use categories do not correspond precisely with the land use designations defined by the MPC, translation between them is fairly easy. Table 5-1 presents a listing of the SCS land uses and the corresponding MPC land use description.

Table 5-1. MPC to SCS Land Use Description Conversions

MPC Land Use Description[1]	SCS Land Use Description	SCS Land Use Examples
Agricultural and Rural Residential (max density of 1 du/ac)	Residential (Low Density)	Single-Family, Lot Size 1 acre and Greater
Low Density Residential (1-5 du/ac)	Residential (Medium Density)	Single-Family, Lot Size 1/4 to 1 Acre
Medium Density Residential (5-12 du/ac)	Residential (High Density)	Multi-Family, Apartments, Condos, Row Houses, Trailer Parks
Commercial	Commercial	Strip Commercial, Shopping Centers, Convenience Stores
Heavy Industrial	Industrial	Light Industrial, Schools, Prisons, Treatment Plants
Light Industrial	Industrial	Light Industrial, Schools, Prisons, Treatment Plants
Office	Commercial	Strip Commercial, Shopping Centers, Convenience Stores
Parks & Public Open Space	Open Land – Good	Urban Green Space, Parks, Golf Courses, Cemeteries
Public Institutional	Industrial	Light Industrial, Schools, Prisons, Treatment Plants
Slope Protection Area	Woods (Thick Cover)	Forest Litter and Brush adequately Cover Soil
Stream Protection Areas	Woods (Thin Cover)	Light Woods, Wood-Grass Combination, Tree Farm, Orchards
Technology Park	Industrial	Light Industrial, Schools, Prisons, Treatment Plants
Transportation	Impervious	Paved Parking, Shopping Malls, Major Roadways, Paved Ditches

[1] – du/ac = dwelling units per acre

For the future condition HEC-1 model, Tc's were decreased only for those sub-basins where the curve number increased by 10 units or more. Tc adjustments were made by changing the land cover type for the overland flow and shallow concentrated flow portions of the flowpath that was defined to determine the existing condition Tc. The land cover type for the overland flow portion of the time of concentration flowpath, typically woods or dense grass for an undeveloped sub-basin in the existing condition, was changed to short grass in the future condition. The land cover type of the shallow concentrated portion of the flowpath was changed from unpaved to paved. No modifications were made to the flow path lengths or slopes, or to the channeled portion of the flowpath. In keeping with the methodology used in the existing condition model, the Clark storage coefficient (R) was set equal to the time of concentration in each sub-basin. The *Beaver Creek Watershed Flood Study* contains a detailed discussion of the methods used to determine Tc and R (Ogden, 2000).

The future condition data (curve numbers, Tc, R) were used as input in the future condition HEC-1 model. Peak discharges from HEC-1 were used as input to the HEC-RAS models to determine future condition flood elevations. No other changes were made to the HEC-RAS models.

5.2 Analysis and Results

5.2.1 Land Use and Curve Numbers

The future condition land use map is shown in Figures 5-1a and 5-1b. Table 5-2 provides a breakdown of the future condition land use for each basin. The vast majority (85%) of the Beaver Creek watershed is planned for residential and other developed land uses. Residents with ¼ to 1-acre lots (i.e., medium density residential) account for 50% of the watershed, with a lower density residential land use taking the next highest percentage at 21%. The planned widening of Emory Road will help to facilitate residential development of the watershed, and continued commercial development will be needed to support the growing residential communities. Commercial areas will likely be concentrated on major roadways such as Clinton Highway, Oak Ridge Highway, I-75 interchanges and Maynardville Pike. Roadway improvements currently being performed on Pellissippi Parkway and Hardin Valley Road are precursors to the future industrial and commercial land uses intended for development along those corridors.

Figures 5-2a and 5-2b present the range of future condition curve numbers in the Beaver Creek watershed sub-basins. The average curve number for each basin is presented in Table 5-3, which also lists the change in average curve number from existing to future conditions. On a watershed-wide basis, the average area-weighted average curve number for existing conditions was determined to be 72, and increased to 77 in the future condition.

Table 5-2. Future Condition Land Use Distribution in the Beaver Creek Watershed

Basin Identifier	DISTRIBUTION OF LAND USES BY LAND USE CODE (%)												
	Res HI 1	Res MD 2	Res LO 3	Com 4	Ind 5	Dst 6	Ag 7	Open good 9	Mead 10	Thk wds 11	Thn wds 12	Imp 13	water 14
01	0	68	19	3	6	0	4	0	0	0	0	0	0
SF	0	21	67	1	0	0	0	0	0	11	0	0	0
02	0	39	6	0	0	0	0	1	0	38	15	0	1
TS	0	79	10	1	0	0	2	7	0	1	0	0	0
03	0	60	0	0	0	1	4	1	0	23	11	0	0
KB	0	57	36	0	0	1	1	1	0	4	0	0	0
04	0	75	1	0	0	2	1	0	0	13	8	0	0
CX	0	21	49	2	2	0	1	1	0	23	1	0	0
05	1	66	3	2	1	4	0	2	0	12	9	0	0
MB	0	15	72	3	0	0	2	1	0	2	5	0	0
WF	1	41	48	2	0	0	0	1	0	2	5	0	0
06	0	23	0	46	0	0	0	0	0	0	0	31	0
TP	6	40	0	32	0	0	0	0	0	20	0	2	0
07	0	32	0	51	7	0	0	0	0	0	10	0	0
NF	2	89	4	1	2	0	0	0	0	0	2	0	0
08	2	60	0	22	0	0	0	0	0	0	16	0	0
AB	0	36	60	1	0	2	0	0	0	0	1	0	0
09	0	48	0	0	0	0	0	0	0	0	52	0	0
HB	14	44	3	11	0	0	0	1	0	25	2	0	0
10	0	61	5	0	0	0	0	7	0	10	16	0	1
CL	0	89	9	0	0	0	0	0	0	0	1	0	1
11	3	74	1	2	1	1	0	0	0	4	14	0	0
BR	5	84	3	3	1	1	0	0	0	0	2	1	0
12	8	45	1	18	6	0	0	0	0	0	19	3	0
HW	2	60	1	18	0	0	0	0	1	9	4	5	0
KF	6	49	0	6	9	3	0	2	2	13	8	1	1
13	1	65	0	1	8	0	0	0	0	8	17	0	0
CR	3	94	1	0	0	1	0	0	0	0	1	0	0
14	3	68	2	9	9	0	0	0	0	1	8	0	0
15	6	51	1	17	9	1	0	1	0	6	8	0	0
16	10	65	3	12	1	1	0	0	0	0	8	0	0
17	0	81	0	0	2	0	0	0	0	2	14	0	1
GC	2	30	30	5	6	1	0	4	1	11	10	0	0
18	0	85	2	0	0	1	0	0	1	0	11	0	0
19	1	62	3	15	5	0	0	1	0	5	8	0	0
20	0	67	16	3	1	0	0	0	0	0	13	0	0
21	5	19	46	6	9	0	0	0	1	0	14	0	0
MC	2	56	21	1	5	0	0	1	0	9	5	0	0
22	0	3	0	0	63	0	0	0	0	0	34	0	0
PC	10	59	1	5	12	0	0	1	0	4	5	3	0
23	2	24	4	3	57	0	0	0	1	2	5	2	0
24	2	0	69	0	19	2	0	0	0	0	5	3	0
SR	0	3	0	5	84	0	0	0	0	0	0	8	0
25	0	3	65	0	13	0	0	0	1	5	10	0	3
Watershed	3	50	21	4	6	1	0	1	0	6	7	1	0

Figure 5-1a. Beaver Creek Watershed Future Condition Land Uses

Figure 5-1b. Beaver Creek Watershed Future Condition Land Uses

Figure 5-2a. Beaver Creek Watershed Future Condition Land Uses

Figure 5-2b. Beaver Creek Watershed Future Condition Land Uses

Table 5-3. Comparison of Existing and Future Condition Curve Numbers (by Basin)

Basin Name	Basin Identifier	Drainage Area (mi^2)	Average Curve Number		Change in CN
			Existing	Future	
Beaver Creek 01	01	1.586	77	82	5
South Fork	SF	1.273	71	76	5
Beaver Creek 02	02	0.177	73	76	3
Thompson Schl.	TS	1.310	72	79	7
Beaver Creek 03	03	0.492	74	79	5
Kerns Branch	KB	2.930	65	73	8
Beaver Creek 04	04	2.359	75	80	5
Cox Creek	CX	3.677	73	77	4
Beaver Creek 05	05	1.241	77	81	4
Mill Branch	MB	3.007	69	69	0
Willow Fork	WF	2.816	63	74	9
Beaver Creek 06	06	0.038	83	91	8
Trailer Park	TP	0.343	83	86	3
Beaver Creek 07	07	0.212	86	89	3
North Fork	NF	2.802	68	74	6
Beaver Creek 08	08	0.424	82	84	2
Allen Branch	AB	2.662	64	70	6
Beaver Creek 09	09	0.047	72	76	4
Hines Branch	HB	2.270	77	80	3
Beaver Creek 10	10	1.319	75	78	3
Cardwell Lake	CL	1.999	65	73	8
Beaver Creek 11	11	1.870	73	77	4
Bishop Road	BR	2.375	66	74	8
Beaver Creek 12	12	2.167	76	83	7
Haw Branch	HW	4.215	72	82	10
Knob Fork	KF	1.675	76	80	4
Beaver Creek 13	13	1.219	76	80	4
Collier Road	CR	1.913	67	73	6
Beaver Creek 14	14	1.618	71	77	6
Beaver Creek 15	15	1.906	76	81	5
Beaver Creek 16	16	1.805	69	77	8
Beaver Creek 17	17	2.218	69	76	7
Grassy Creek	GC	6.645	73	78	5
Beaver Creek 18	18	1.970	66	73	7
Beaver Creek 19	19	2.100	77	82	5
Beaver Creek 20	20	1.709	65	73	8
Beaver Creek 21	21	2.057	68	74	6
Meadow Creek	MC	3.677	75	79	4
Beaver Creek 22	22	0.048	78	83	5
Plumb Creek	PC	3.361	74	81	7
Beaver Creek 23	23	1.715	66	83	17
Beaver Creek 24	24	2.246	66	73	7
Solway Road	SR	1.157	66	89	23
Beaver Creek 25	25	2.979	64	71	7
Watershed Avg.	-	-	**72**	**77**	**6**

5.2.2 Peak Discharges

Table B-2 in Appendix B presents the future condition data and peak discharges for the 2-, 10-, 25-, 100- and 500-year storm events calculated by the HEC-1 model for every sub-basin in the Beaver Creek watershed. Figure 5-3 presents a plot of existing and future condition peak discharges along Beaver Creek. The average % increase in peak discharges from existing to future conditions along the main stem was 21% for the 100-year event. In comparison, the average predicted increase in the 100-year event discharge in tributaries was approximately 38%. Table 5-4 presents a comparison between the existing and future condition peak discharges for the 10-year and 100-year events at key locations along Beaver Creek and the HEC-RAS modeled tributaries.

Figure 5-3. Peak Discharges Along Beaver Creek – Existing and Future Conditions

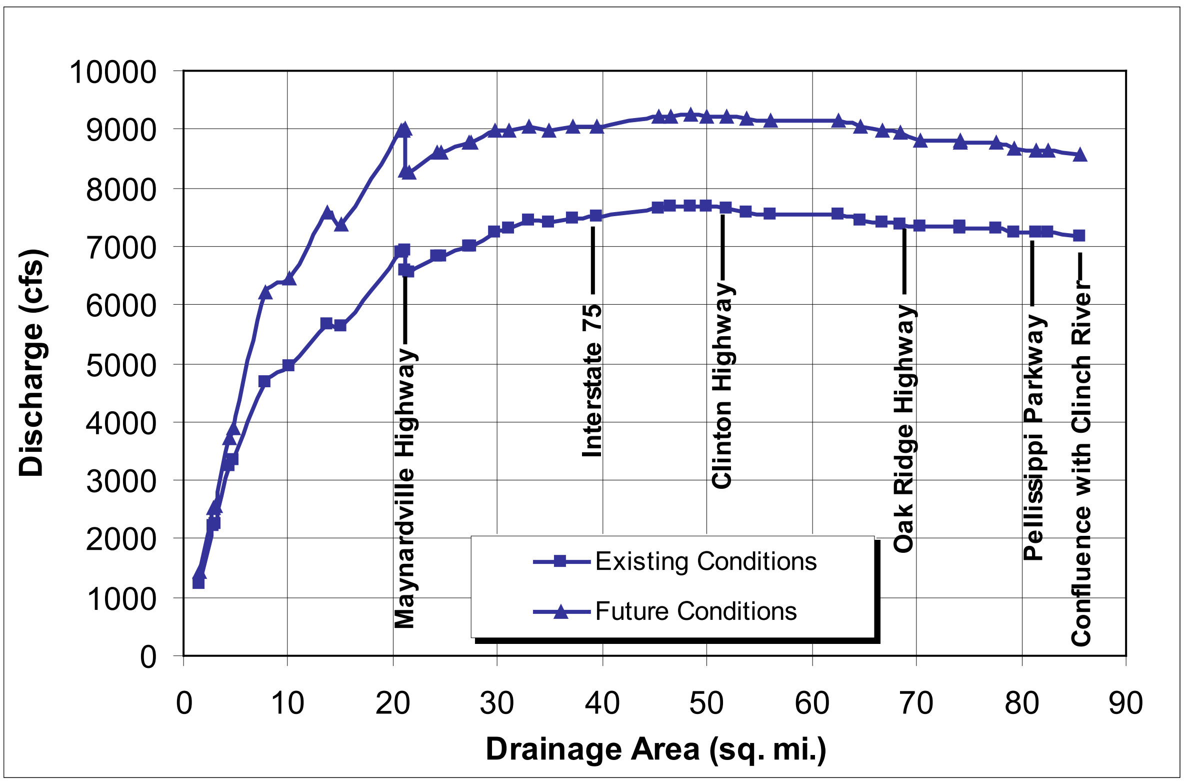


Table 5-4. Comparison of Existing and Future Condition Peak Discharges at Selected Locations

Landmark	10-Year Peak Discharges (cfs)			100-Year Peak Discharges (cfs)		
	Existing	Future	% Increase	Existing	Future	% Increase
BEAVER CREEK						
Fairview Road	690	820	18.8	1240	1420	14.5
Beeler Road (east)	1820	2220	22.0	3360	3900	16.1
Brown Gap Road	2560	3370	31.6	4960	6460	30.2
Maynardville Pike	3230	4160	28.8	6570	8280	26.0
Dry Gap Rd	3950	4940	25.1	7400	8970	21.2
Interstate 75	4020	5020	24.9	7500	9060	20.8
Central Ave Pike	4020	5020	24.9	7510	9060	20.6
Brickyard Road	4130	5140	24.5	7680	9230	20.2
Clinton Highway	4060	5080	25.1	7610	9200	20.9
Oak Ridge Highway	3910	4900	25.3	7380	8910	20.7
Pellissippi Parkway	3840	4810	25.3	7230	8630	19.4
Mouth	3820	4790	25.4	7190	8550	18.9
SOUTH FORK						
Maloneyville Road	400	460	15.0	810	940	16.0
Tazewell Pike	530	630	18.9	1000	1140	14.0
Mouth	540	640	18.5	1010	1160	14.9
THOMPSON SCHOOL TRIBUTARY						
Thompson School Rd	380	480	26.3	740	860	16.2
Mouth	590	750	27.1	1120	1360	21.4
KERNS BRANCH						
Majors Road	500	960	92.0	1230	1950	58.5
Emory Road	610	1060	73.8	1330	2280	71.4
Mouth	680	1130	66.2	1440	2400	66.7
COX CREEK						
Tazewell Pike	710	830	16.9	1190	1300	9.2
Mouth	1550	1760	13.5	2820	3150	11.7
MILL BRANCH						
Maynardville Hwy us	350	420	20.0	740	840	13.5
Mouth	760	1130	48.7	1760	2270	29.0
WILLOW FORK						
Brackett Road	430	740	72.1	960	1510	57.3
Quarry Road	590	840	42.4	1090	1340	22.9
Mouth	1300	1790	37.7	2640	3320	25.8
TRAILER PARK						
Mouth	360	380	5.6	580	610	5.2
ALLEN BRANCH						
Norris Freeway	660	970	47.0	1440	1910	32.6
Mouth	880	1220	38.6	1820	2320	27.5

Table 5-4. Comparison of Existing and Future Condition Peak Discharges at Selected Locations

Landmark	10-Year Peak Discharges (cfs)			100-Year Peak Discharges (cfs)		
	Existing	Future	% Increase	Existing	Future	% Increase
NORTH FORK						
McCloud Road	200	480	140.0	440	870	97.7
Andersonville Pike	580	1100	89.7	1370	2240	63.5
Mouth	720	1060	47.2	1640	2840	73.2
HINES BRANCH						
Mynatt Drive	740	780	5.4	1300	1340	3.1
Mouth	1440	1580	9.7	2700	2880	6.7
CARDWELL LAKE						
Pelleaux Road	140	200	42.9	290	390	34.5
Mouth	670	1190	77.6	1390	2170	56.1
BISHOP ROAD						
Pedigo Road	170	330	94.1	380	630	65.8
Mouth	1000	1660	66.0	2020	3080	52.5
HAW BRANCH						
Mouth	1120	1370	22.3	2010	2340	16.4
KNOB FORK						
Fountain City Road	460	660	43.5	850	1110	30.6
Callahan Road	1580	1960	24.1	2650	3440	29.8
Mouth	1480	1850	25.0	2430	2920	20.2
COLLIER ROAD						
Heiskell Road	140	200	42.9	290	360	24.1
Mouth	710	1100	54.9	1480	1980	33.8
GRASSY CREEK						
Ball Road	2270	2880	26.9	4120	5000	21.4
Oak Ridge Highway	2280	2880	26.3	4090	4990	22.0
Mouth	2220	3030	36.5	4360	5150	18.1
MEADOW CREEK						
Ball Camp Pike	890	1040	16.9	1650	1840	11.5
Mouth	1120	1360	21.4	2040	2380	16.7
PLUMB CREEK						
Hickey Road	740	1180	59.5	1300	1860	43.1
Mouth	1680	2320	38.1	2990	3810	27.4
SOLWAY ROAD						
Hardin Valley Road	190	700	268.4	400	1040	160.0
Mouth	460	1570	241.3	980	2370	141.8

Table 5-5 ranks the tributaries by the percent increase in peak discharge from existing to future conditions, for both the 10-year and 100-year conditions.

Table 5-5. Comparison of Peak Discharges in the Tributaries to Beaver Creek

Stream Name	10-Year Storm Event % Increase in Peak Discharge at Mouth	Stream Name	100-Year Storm Event % Increase in Peak Discharge at Mouth
Solway Road	237.0	Solway Road	142.3
Cardwell Lake	78.4	North Fork	73.4
Kerns Branch	66.8	Kerns Branch	66.4
Bishop Road	65.5	Cardwell Lake	56.7
Collier Road	54.7	Bishop Road	52.3
Mill Branch	49.2	Collier Road	34.0
North Fork	45.7	Mill Branch	29.4
Allen Branch	38.7	Allen Branch	27.9
Plumb Creek	38.3	Plumb Creek	27.5
Willow Fork	38.0	Willow Fork	26.0
Grassy Creek	36.8	Thompson School	21.1
Thompson School	27.4	Knob Fork	19.9
Knob Fork	25.1	Grassy Creek	18.2
Haw Branch	22.4	Meadow Creek	16.5
Meadow Creek	21.6	Haw Branch	16.1
South Fork	18.1	South Fork	14.9
Cox Creek	13.9	Cox Creek	11.8
Hines Branch	9.4	Hines Branch	6.9
Trailer Park	6.5	Trailer Park	4.3

5.2.3 Flood Elevations Analysis

In general, 100-year flood elevations increased an average of 1.2 feet on the main stem, and 0.7 feet on the tributaries. On Beaver Creek, the maximum 100-year increase of 2.32 ft occurs at cross-section 32.484, located just upstream of the Dry Gap Pike bridge. In the Halls-Crossroads priority area, where recent flooding has occurred, the average increase from 100-year existing to future elevations is 1.2 feet. In the Karns-Oak Ridge Highway priority area, the elevation increase averages around 1.5 feet.

Kerns Branch, Mill Branch, and Willow Fork are the tributaries where the largest increases in flood elevations from existing to future conditions were calculated. The average increase in 100-year elevations in the North Fork flood damage reach identified by Knox County is 1.2 ft. In the Hines Branch tributary, the average increase is only 0.10 feet.

Table 5-6 presents a comparison of existing and future condition flood elevations at key locations along Beaver Creek and the tributaries modeled in HEC-RAS for the 10-year and 100-year storm events.

Table 5-6. Comparison of Existing and Future Flood Elevations at Selected Locations

Landmark	10-Year Event Elevations (ft)			100-Year Event Elevations (ft)		
	Existing	Future	Increase	Existing	Future	Increase
BEAVER CREEK						
Fairview Road	1074.44	1074.8	0.4	1075.06	1075.29	0.23
Beeler Road (east)	1058.96	1059.41	0.5	1060.42	1060.94	0.52
Brown Gap Road	1034.45	1035.71	1.3	1037.64	1038.59	0.95
Maynardville Pike	1021.52	1022.98	1.5	1026.31	1027.55	1.24
Dry Gap Rd	996.92	998.36	1.4	1001.63	1003.95	2.32
Interstate 75	991.54	992.94	1.4	995.99	998.24	2.25
Central Ave Pike	990.89	992.16	1.3	995.06	997.15	2.09
Brickyard Road	983.34	984.93	1.6	987.13	988.1	0.97
Clinton Highway	979.04	980.12	1.1	982.35	983.77	1.42
Oak Ridge Highway	950.55	952.01	1.5	954.95	956.5	1.55
Pellissippi Parkway	864.56	865.76	1.2	867.96	869.5	1.54
SOUTH FORK						
Maloneyville Road	1105.16	1105.3	0.1	1105.81	1105.87	0.06
Tazewell Pike	1083.17	1083.71	0.5	1085.52	1085.52	0.00
THOMPSON SCHOOL TRIBUTARY						
Thompson School Rd	1082.16	1082.9	0.7	1085.11	1085.41	0.3
KERNS BRANCH						
Majors Road	1106.6	1107.31	0.7	1107.62	1108.24	0.62
Emory Road	1079.34	1081.01	1.7	1082.35	1084.04	1.69
COX CREEK						
Tazewell Pike	1088.63	1089.83	1.2	1091.56	1092.44	0.88
MILL BRANCH						
Maynardville Hwy us	1026.4	1028.03	1.6	1030.25	1032.22	1.97
WILLOW FORK						
Brackett Road	1090.61	1091.24	0.6	1091.62	1092.09	0.47
Quarry Road	1035.27	1035.44	0.2	1036.52	1039.54	3.02
NORTH FORK						
McCloud Road	1094.92	1095.88	1.0	1095.77	1095.88	0.11
Andersonville Pike	1028	1028.94	0.9	1029.1	1029.6	0.5
HINES BRANCH						
Mynatt Drive	1064.33	1064.43	0.1	1065.19	1065.26	0.07

Table 5-6. Comparison of Existing and Future Flood Elevations at Selected Locations

Landmark	10-Year Event Elevations (ft)			100-Year Event Elevations (ft)		
	Existing	Future	Increase	Existing	Future	Increase
KNOB FORK						
Fountain City Road	1079.03	1079.46	0.4	1079.72	1080.01	0.29
Callahan Road	1008.04	1009.45	1.4	1011.44	1012	0.56
GRASSY CREEK						
Ball Road	989.94	990.99	1.0	993.16	994.11	0.95
Oak Ridge Highway	984.73	986.44	1.7	991.09	991.81	0.72
PLUMB CREEK						
Hickey Road	975.51	975.8	0.3	975.91	976.25	0.34

The County uses the existing 500-year flood elevation plus freeboard as the regulatory benchmark for finished floor elevations in future developments. Our analysis shows that the existing 500-year elevation is higher than the future 100-year water surface elevations in most locations along Beaver Creek and in the most of the tributaries. However, there are two cross-sections on the main stem and a number of cross-sections located throughout 5 of the tributaries where the 100-year future flood elevations exceed the 500-year existing elevations. The tributaries are: Kerns Branch, Willow Fork, North Fork, Knob Fork and Plumb Creek. The cross-sections and elevations for streams where the 100-year future elevation exceeds the 500-year existing elevation are listed in Table D-1 in Appendix D. Table D-1 can be used in conjunction with the floodplain maps presented in the *Beaver Creek Watershed Flood Study* to regulate to the higher, 100-year future elevation for future development, if desired by the County.

The future condition flood elevations were compared to surveyed FFEs to determine the increase in the number of habitable structures predicted to flood during future events. Table 5-7 presents a summary of this comparison for Beaver Creek and the modeled tributaries. More detailed information on the predicted depth of future flooding for each structure is contained in a reference table (Table C-1) that comprises Appendix C. In Table C-1, a negative depth indicates that the structure is not flooded.

Table 5-7. Comparison of Existing and Future Condition FFE Flooding

Stream Name	Number of Flooded Structures (based on surveyed FFEs only)									
	Existing Condition					Future Condition				
	2-Yr	10-Yr	25-Yr	100-Yr	500-Yr	2-Yr	10-Yr	25-Yr	100-Yr	500-Yr
Beaver Creek	0	2	14	48	91	0	10	32	78	117
South Fork	0	0	0	0	0	0	0	0	0	0
Thompson School Trib.	0	0	0	0	0	0	0	0	0	0
Kerns Branch	0	0	0	0	0	0	0	0	0	0
Cox Creek	0	0	0	0	0	0	0	0	0	0
Cox Creek Trib.	0	0	0	1	1	0	0	0	1	1
Mill Branch	0	0	0	0	0	0	0	0	0	0
Willow Fork	0	0	0	0	0	0	0	0	0	0
North Fork	0	3	4	13	26	1	7	11	25	42
Hines Branch	0	24	30	36	37	0	30	30	37	42
Knob Fork	2	4	4	7	8	3	4	6	7	9
Grassy Creek	0	1	2	3	5	0	2	3	4	5
Plumb Creek	0	1	1	2	3	0	1	2	3	3
TOTALS	**2**	**35**	**55**	**110**	**171**	**4**	**54**	**84**	**155**	**219**

5.2.4 Roadway Flooding

In the future condition scenario, roadway flooding occurs (considering all storm events) at 43 locations in the Beaver Creek watershed. Table 5-8 presents a summary of the roadway overtopping analysis performed using the results of the future condition HEC-RAS models. The ranking of the roadway in existing conditions is presented in the table as well.

Table 5-8. Future Condition Roadway Flooding – Beaver Creek Watershed

Rank	Road Name	Existing Cond. Rank	Stream	HEC-RAS RM	Roadway Class.	Overtopping Event	Flood Depth (ft)
1	Lovell Road	1	Plumb	0.672	MA	2-yr	1.98
2	Emory Road	2	North	0.234	MA	10-yr	0.87
3	Emory Road	3	Willow	0.379	MA	10-yr	0.75
4	Emory Road	7	Kerns	0.847	MA	25-yr	0.25
5	Maynardville Hwy N.	5	Beaver	37.638	MA	100-yr	1.95
6	Oak Ridge Highway	4	Grassy	1.859	MA	100-yr	1.91
7	Emory Road	6	T Schl	0.688	MA	100-yr	0.53
8	Maynardville Hwy S.	8	Beaver	37.593	MA	100-yr	0.14
9	Oak Ridge Highway	Not flooded	Beaver	15.458	MA	500-yr	1.12
10	Maynardville Highway	Not flooded	Mill	0.229	MA	500-yr	0.93
11	Maloneyville Road	9	South	0.926	ma	10-yr	0.5
12	Norris Freeway	11	North	0.402	ma	10-yr	0.44
13	Central Avenue Pike	10	Knob	1.698	ma	10-yr	0.38
14	Central Avenue Pike	12	Beaver	29.602	ma	100-yr	1.13
15	Tazewell Pike	13	Beaver	44.211	ma	500-yr	0.10
16	Bell Road	15	Willow	2.781	MC	2-yr	0.65
17	Cunningham Road	14	Hines	0.213	MC	2-yr	0.47
18	Ball Road	16	Grassy	2.142	MC	10-yr	3.2
19	Andersonville Pike	19	Beaver	37.767	MC	10-yr	2.3
20	Browns Gap Road	27	Beaver	39.871	MC	10-yr	1.51
21	Brown Gap Road	17	Cox	0.112	MC	10-yr	1.42
22	West Beaver Creek Dr.	20	Grassy	0.517	MC	10-yr	1.11
23	Brown Gap Road	18	Cox Trib	0.124	MC	10-yr	1.09
24	Andersonville Pike	26	North	0.735	MC	10-yr	1.04
25	Jim Sterchi Road	21	Knob	2.980	MC	10-yr	0.86
26	Rifle Range Road	24	Knob	3.381	MC	10-yr	0.82
27	Mynatt Drive	22	Hines	1.877	MC	10-yr	0.67
28	Beaver Creek Drive	23	Knob	0.385	MC	10-yr	0.61
29	Rifle Range Road	25	Knob	4.113	MC	10-yr	0.49
30	Brickyard Road	28	Beaver	27.052	MC	10-yr	0.46
31	Harrell Road	29	Beaver	21.006	MC	25-yr	0.63
32	Callahan Drive	30	Knob	1.497	MC	25-yr	0.15
33	Dry Gap Pike	Not flooded	Beaver	32.477	MC	100-yr	2.55
34	Solway Road	Not flooded	Beaver	6.414	MC	500-yr	2.03
35	Beaver Ridge Road	Not flooded	Beaver	16.867	MC	500-yr	1.02
36	Hickey Road	31	Plumb	1.434	mc	2-yr	1.05
37	McCloud Road	33	North	2.001	mc	2-yr	0.45
38	Majors Road	32	Kerns	1.637	mc	10-yr	1.61
39	Dry Gap Pike	34	Knob	3.365	mc	10-yr	1.2
40	Fountain City Road	35	Knob	4.172	mc	10-yr	0.72
41	Coward Mill Road	Not flooded	Beaver	13.969	mc	100-yr	2.34
42	Weaver Drive	36	Grassy	1.772	mc	100-yr	1.79
43	Quarry Road	37	Willow	1.856	mc	100-yr	0.69

MA = Major Arterial, ma = minor arterial, MC = Major Collector, mc = minor collector

6 GENERAL STORM WATER MANAGEMENT ALTERNATIVES

When the flood potential for property and structures is high, mitigation measures are often considered to alleviate any expected flood damages. These mitigation measures can be categorized as structural and non-structural flood solution alternatives. Structural alternatives typically include construction or modification of a flood control structure to control floodwaters, such as a channel, levee, dam, or reservoir, but can also include localized flood protection such as flood proofing, floodwalls, etc. Non-structural alternatives typically involve little or no construction and consist of policies, planning, regulations, land acquisitions, or other measures that reduce the potential for flooding or keep individuals from building in a flooded or potentially flooded area. Structural measures are more expensive and typically used as a reaction to existing problems. Non-structural alternatives can be used as a planning tool to prevent anticipated flooding problems.

This section presents analyses and discussion of various general structural and non-structural alternatives that can be utilized by Knox County to reduce the flood potential on Beaver Creek and its tributaries. For the main stem, the discussion focuses on storm water management alternatives implemented upstream of Maynardville Highway, where peak discharges are highly sensitive to inflows from the surrounding drainage area. It is in this area where these alternatives can have the greatest impact on peak discharges and flood elevations along the creek.

6.1 Structural Alternatives

Drainage systems can be managed to control flood discharges and stages by constructing structural measures to reduce and/or control flooding levels. The two most common structural alternatives used to control flooding are detention of floodwaters using reservoirs or dams and increased conveyance of the system of channels, pipes, and streams used to transport floodwaters. Simple examples of these alternatives can be seen in a typical urban development. As land is developed, natural conveyance systems are replaced with concrete lined channels and pipes to quickly move drainage away from buildings and developed property. Unfortunately, this practice can have the effect of increase peak discharges and flood elevations downstream. In response, most municipalities, including Knox County, require new developments to use detention to alleviate peak flows for certain design storms. A portion of the site is dedicated to flood in the form of a detention pond constructed at the downstream portion of the site. Therefore, flooding has not been eliminated but rather moved to a controlled area.

When using structural alternatives, the flood potential is usually not eliminated, but simply moved either upstream (as the case of detention) or downstream (as the case of conveyance improvements). Any time structural improvements are considered, the impacts of the project upstream and downstream must be considered. Channel improvements that lower flood stages will typically decrease natural storage along a stream and potentially increase peak discharges downstream. Large regional detention ponds that significantly decrease downstream discharges will increase flood elevations and inundate areas located upstream of the pond that were not flooded previously. These factors must be considered in the planning of any flood control design. In addition, large-scale structural flood solution alternatives can alter the geomorphology of a stream and have significant environmental impacts that may not be apparent on first inspection.

Localized structural measures such as flood proofing, elevating finished floor space, and small floodwalls can be used on a site-specific basis. In comparison to larger channel improvement or regional detention alternatives, these alternatives typically do not have significant impact on upstream and downstream flooding.

6.1.1 Channel Improvements on Beaver Creek

Channel improvement is not a viable alternative to mitigate flooding on Beaver Creek. As stated previously, Beaver Creek is a highly meandering stream with wide, flat floodplains that provide significant storage and are subject to flood on a regular basis. The conveyance capacity of the channel is less than the 2-year event in most locations, therefore the floodplains are typically inundated several times a year. The floodplains also provide significant storage for less frequent events and as a result, the predicted peak discharges along Beaver Creek do not increase downstream of Brickyard Road.

Many residents have called for the straightening and widening (i.e., channel improvements) of Beaver Creek as a solution to flooding. In their view, "moving the water downstream" will decrease flood elevations along the stream. While this alternative could decrease flooding locally, flooding downstream will inevitably increase. Straightening the creek will also greatly reduce or eliminate the natural meander of the channel, decreasing the in-channel storage while increasing the channel bed slope and flow velocity. These changes will disrupt the natural sediment carrying capacity of the stream, increasing the potential for channel erosion, and causing channel stability problems. The channel will, over time, attempt to reform a more natural meander. Significant and costly measures would be required to maintain the new channel slope. Channelization was a very popular flood mitigation measure in the 1950's and 60's, and there were many Corps of Engineers sponsored channelization projects throughout the Country. Today, the Corps and others are restoring many of these streams to their natural conditions, because the result of past large-scale channelization projects has been degrading channels and stream banks.

Channel improvements also have the effect of altering of the environmental conditions in the stream, impacting the habitat for vegetative and aquatic life in the channel. These factors cannot be ignored because the State, through its Aquatic Resources Alteration Permit (ARAP) program, must approve any proposed alterations to a channel. Because of the potential for habitat degradation, it is unlikely that the State would approve any large-scale channelization project on Beaver Creek.

Table 6-1 provides a list of potential positives and negatives for channel improvement on Beaver Creek. For a significant impact on flood elevations, any channel improvement project on Beaver Creek would involve miles of stream and require extensive changes in the channel and subsequent fulfillment of ARAP required restoration measures. Cost estimates for similar projects have ranged from $3 to $5 million dollars per stream mile, making large-scale channel improvement a difficult and costly alternative. To maximize channel improvement benefits, the miles of stream altered should be minimized and the number of homes and properties benefited should be maximized. There were not any areas of concentrated flooding identified in either the existing or future condition models that could benefit from limiting the scope of channel improvements. Also, the slope of Beaver Creek is very mild and would require an lengthy improvement reach to significantly lower flood elevations. Therefore, based on the number and location of homes flooded along Beaver Creek under existing and future conditions, a project cost of this magnitude could not be justified and channel improvements were not considered for the main stem.

Table 6-1. Pros and Cons of Channel Improvements on Beaver Creek

Pros	Cons
• Decrease in flood elevations in and potentially upstream of improved areas.	• Potential for increasing flood elevations downstream of improved areas. • Significant changes to channel geomorphology and sediment capacity. • Potential for channel instability in improved areas. • High cost. • Potential for significant changes in environmental condition of the channel. • High likelihood for permitting difficulties.

6.1.2 Channel Improvements on Tributaries to Beaver Creek

Channel improvements on one or more of the tributaries to Beaver Creek is a more reasonable option than that for the main stem. First, because the tributaries are shorter, the flood problems will be fairly concentrated. Second, the tributaries tend to be straighter and steeper, and have much smaller peak discharges than the main stem. Tributary channel improvements would be smaller scale than improvements on the main stem, and will therefore be less costly. However, the potential for downstream impacts is not diminished on the tributaries and should be investigated whenever a channel improvement is considered.

For tributary channel improvements, impacts can occur on both the tributary and Beaver Creek downstream of the confluence with the tributary. Because channel improvements decrease in-channel storage, they have the effect of not only increasing peak discharges downstream, but also speeding-up the time-to-peak. Recalling from Section 4.2.3, the time-to-peak of the most upstream tributaries in Beaver Creek occur very close to the peak discharge on the main stem. Therefore, channel improvements on the tributaries upstream of Maynardville Highway are likely to have a more significant effect (either positive or negative) on peak discharges in the main stem than those located downstream of Maynardville Highway. Channel improvements on streams where the time difference between the peak discharges from the tributary and the main stem are large, such as Knob Fork, Grassy Creek and Plumb Creek, may not have any effect on the main stem.

Using the HEC-1 and HEC-RAS models, channel improvements were investigated on two tributaries to Beaver Creek where the County identified existing flood problems: North Fork and Hines Branch. Flood solution alternatives for both sites, including channel improvements, are discussed in detail in Sections 7.2 and 7.6.

6.1.3 Regional Detention Facilities

The purpose of a detention facility is to temporarily store storm water runoff and release it to the downstream conveyance system at a decreased rate. Detention facilities can range from small ponds designed to contain runoff from a localized area or single development, to large regional facilities (e.g., on-line lakes) designed to reduce peak flows on a major stream. The location and size of the facility are very important factors in effectiveness of the pond in controlling flooding in the desired area, and the impact of the pond on peak discharges in other areas. A general rule of thumb is that the facility should be located as close as possible to the location where flooding is to be controlled.

Regional detention facilities can provide the maximum reduction in peak discharges, but require large undeveloped areas set-aside for storage. Because of their size and storage capability, regional detention ponds can significantly affect the timing of the stream in which they are constructed. On Beaver Creek, regional detention would be most effective on reducing flood elevations if located in the upstream portion of the watershed, where peak discharges are very sensitive to the timing of the main stem and tributaries. However, timing of the peak discharge from the detention facility relative to the timing of inflows from tributaries is key to its effectiveness in reducing flood potential and must be considered.

Because of the nature of the watershed, regional detention on the main stem in the downstream portions of the watershed would not be as effective as detention in the upper part of the watershed. While regional detention could still be an option for the relief of flooding on tributaries, the downstream effects of the facility on the main stem should be examined closely, since the tributary discharge would be delayed and would occur closer to the peak flow in the main stem.

As part of the master planning effort for the Beaver Creek watershed, regional detention alternatives were analyzed on Beaver Creek, North Fork, and Hines Branch to mitigate existing flooding and control future flooding from anticipated developments in the watershed. These alternatives are discussed in more detail in Sections 7.1, 7.2 and 7.6.

6.1.4 Local Detention Facilities

Single local detention ponds, constructed as part of a new development, will provide some measure of protection immediately downstream of the pond, but the effects will quickly diminish as the flood wave travels further downstream. Multiple small storage facilities constructed in a basin can also eliminate flooding in localized areas, but will affect the timing of the flood hydrograph in the basin. This could cause adverse affects in different locations downstream in the basin, or on a regional level after the basin peak discharge combines with the main stem. To manage storm water effectively using local detention, one must have a complete understanding of the impact of multiple detention facilities on both the local and regional scale.

For large watersheds an analysis of multiple local detention ponds can be time-consuming and cost prohibitive using the conventional methods that are typically available in standard hydrologic models such as HEC-1. To ease the task, yet still take advantage of the capabilities and usefulness of the HEC-1 model developed for the master plan, Ogden developed a number of equations using regression analysis to simulate local detention using the sub-basin parameters used as input for the HEC-1 model (i.e., the curve number, time of concentration and Clark storage coefficient). The equations can be used to determine a "post-pond" time of concentration (Tc) and Clark storage coefficient (R) that mimic the effect of detention in the sub-basin after future development. The post-pond parameters are based on the area (A) of the sub-

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basin, the change in curve number (CN) from existing to future land use conditions, and the existing condition Tc and R. Two sets of equations were developed for simulating pre-to-post development peak discharge detention of runoff from the 25-year storm event, and the 100-year storm event. Error analysis indicates that the equations should only be used with the storm event for which they were developed.

The equations for detention of the 25-year event are as follows:

$$Tc_{pondst} = 1.1201 * Tc_{pre} + 0.0282 * (CN_{post} - CN_{pre}) + 0.2349 * A + 0.0434$$

$$R_{pondst} = 1.0334 * R_{pre} + 0.0950 * (CN_{post} - CN_{pre}) + 0.4830 * A - 0.7930$$

for drainage areas between 0.01 sq. mi. and 1.0 sq. mi.
for Tc and R values between 0.5 hr. and 1.0 hr.
for $CN_{post} > CN_{pre} + 2$

The equations for detention of the 100-year event are as follows:

$$Tc_{pondst} = 1.0344 * Tc_{pre} + 0.0234 * (CN_{post} - CN_{pre}) + 0.1933 * A + 0.1108$$

$$R_{pondst} = 1.0333 * R_{pre} + 0.0658 * (CN_{post} - CN_{pre}) + 0.3722 * A - 0.4629$$

for drainage areas between 0.01 sq. mi. and 1.0 sq. mi.
for Tc and R values between 0.5 hr. and 1.0 hr.
for $CN_{post} > CN_{pre} + 2$

An analysis of multiple local detention pond can be performed by using the post-pond Tc and R data in key sub-basins of the future condition HEC-1 model, and comparing the resulting peak discharges to that calculated by the "no-detention" future and existing conditions HEC-1 models. Of course, the peak discharges from the post-detention HEC-1 model can be used as input for the HEC-RAS models to assess the effect of detention on flood elevations. Caution must be used in the application of the local detention equations and use of the analysis results. The equations simply provide a rough analysis of the effect of multiple detention ponds on the local (i.e.., sub-basin level) and should be used for planning purposes only.

The above equations were applied to key basins in the Beaver Creek future condition HEC-1 model in order to assess the affect of local detention in the Beaver Creek watershed. The detention scenarios performed and the results of each analysis are presented in the following paragraphs.

Local Detention in South Fork, Kerns Branch, Willow Fork/Mill Branch Basins

Local detention was simulated (separately) in the South Fork, Kerns Branch and Willow Fork/Mill Branch basins to determine if more stringent detention requirements on new developments in these areas can reduce peak discharges, and therefore flooding, in the Halls-Crossroads priority area, located on Beaver Creek upstream of Maynardville Highway. The Tc and R-values were adjusted for every sub-basin in the South Fork and Kerns Branch basins to simulate detention for the 25-year storm and the 100-year storm. The results of the analysis are shown in Table 6-2.

The results in Table 6-2, one can conclude that local detention has a positive impact on peak discharges on the local (i.e., basin level). In each case, peak discharges along the tributary where local detention was applied were reduced. However, the magnitude of the effectiveness of on-site detention on the local (i.e., basin) level varies depending on the basin. Local detention in South Fork has a modest effect based on the increase from existing to future condition peak discharges of 13% with detention as opposed to 19% without detention. In Kerns Branch, local detention is much more significant. Future condition peak discharges increase only 28% with detention, as opposed to 63% without detention. The shape of the basin, and the configuration of the sub-basins and smaller tributaries within each basin play a role in the degree of effectiveness of local detention because of the timing of local hydrographs. For example, the South Fork basin is a relatively short stream with a high degree of branching, therefore peak discharges from different areas of the basin are closer together, lessening the impact of local detention. On the other hand, Kerns Branch is longer and branches very little, so peak discharges attenuate and spread apart. Further delay of peak flows through local detention has a greater effect.

On a regional level, Table 6-2 shows that local detention in the South Fork, Mill Branch and Willow Fork basins does not greatly affect the main stem. However, local detention in Kerns Branch is effective in reducing future peak discharges upstream of upstream of Maynardville Highway. The 100-year future condition peak discharge is decreased from 6215 cfs to 5329 cfs with 100-year pre-to-post detention implemented through the Kerns Branch basin. However, further analysis reveals that 100-year future FFE flood potential is removed for only eight structures (2 commercial and 6 residential). For reference purposes, the present day cost to purchase these eight properties, based on general property values of commercial structures in the Halls-Crossroads area and an estimate of residential property at $120,000 per lot, is greater than

$1,000,000. After development of the basin and realization of the future flood potential, that cost will have increased. However there are other, non-structural alternatives that may prove more effective in reducing the future flood potential on Beaver Creek. These are presented in Section 6.2. More information on structural alternatives to mitigate the existing flood potential in the Halls-Crossroads area is contained in Section 7.

Table 6-2. Effect of Local Detention in Key Basins Upstream of Maynardville Highway

Location	25-Year Peak Discharge (% increase from existing cond.)			100-Year Peak Discharge (% increase from existing cond.)		
	No Local Detention		With Local Detention	No Local Detention		With Local Detention
	Existing	Future	Future	Existing	Future	Future
Local Detention in South Fork Basin Only						
South Fork at mouth	696	829 (19%)	785 (13%)	1010	1160 (15%)	1119 (11%)
Beaver Creek Confluence with South Fork	1570	1841 (17%)	1803 (15%)	2218	2532 (14%)	2503 (13%)
Beaver Creek at Maynardville Highway	4315	5644 (31%)	5580 (29%)	6569	8279 (26%)	8198 (25%)
Beaver Creek at mouth	5070	6222 (23%)	6207 (22%)	7193	8549 (19%)	8514 (18%)
Local Detention in Kerns Branch Basin Only						
Kerns Branch at mouth	938	1529 (63%)	1202 (28%)	1445	2404 (66%)	1819 (26%)
Beaver Creek Kerns Branch Confluence	3249	4317 (33%)	3806 (17%)	4679	6215 (33%)	5329 (14%)
Beaver Creek at Maynardville Highway	4315	5644 (37%)	5286 (22%)	6569	8279 (26%)	7811 (19%)
Beaver Creek Interstate-75	5338	6440 (21%)	6411 (20%)	7497	9058 (21%)	8758 (17%)
Beaver Creek at Mouth	5072	6222 (23%)	6148 (21%)	7193	8549 (19%)	8365 (16%)
Local Detention in the Willow Fork and Mill Branch Basins Only						
Mill Branch at mouth	1111	1628 (46%)	1467 (32%)	1758	2274 (29%)	2116 (20%)
Willow Fork at mouth	1801	2349 (30%)	2177 (21%)	2635	3319 (26%)	3185 (21%)
Beaver Creek Willow Fork Confluence	4458	5902 (32%)	6075 (36%)	6883	8977 (30%)	9161 (33%)
Beaver Creek at Maynardville Highway	4315	5644 (31%)	5801 (34%)	6569	8279 (26%)	8430 (13%)
Beaver Creek at Mouth	5072	6222 (23%)	6178 (22%)	7193	8549 (19%)	8543 (19%)

Local Detention in the North Fork Basin

Knox County has identified areas along North Fork that currently have flooding problems and are in need of flood solution alternatives to reduce the future flood potential. (Structural alternatives to mitigate *existing* flood problems in North Fork are discussed in Section 7.2.) The local detention equations were applied in the North Fork basin to determine how multiple local detention can impact the future flood potential in the basin. Figure 6-1 shows the North Fork basin, sub-basin and stream network. Several scenarios using local detention throughout the basin and in only specific key sub-basins were evaluated to determine the most effective means of controlling peak discharges. The key sub-basins were chosen based on the relative timing of the North Fork basin hydrographs calculated by the future condition HEC-1 model without detention. The North Fork local detention scenarios analyzed using HEC-1 were:

1. 25-year local detention in all North Fork sub-basins;
2. 100-year local detention in all North Fork sub-basins;
3. 25- and 100-year detention in sub-basins NF020, NF030, NF070, NF080, and NF090.

The results of the North Fork local detention analyses are presented in Table 6-3. The table shows that the use of standard 25-year pre-to-post local detention ponds for future developments will reduce the future flood potential along North Fork. The results also show that, because of the timing of the basin, more stringent (i.e., 100-year pre-to-post) detention in just five key sub-basins is as effective as more stringent detention implemented throughout the basin. The future 100-year flood potential was reduced from 25 structures to 17 structures. For reference purposes, at an estimated $120,000 per house in present day dollars the cost to purchase these eight structures is $960,000. It can be concluded that increasing the detention requirements for new development in the key sub-basins to detain the 100-year event is an effective way to mitigate future flooding along North Fork.

Table 6-3. Peak Discharges and FFE Flood Potential – With and Without Local Detention

Storm Event	Peak Discharge at the mouth of North Fork (cfs) and (# Houses with FFE Flooding)			
	Existing Condition (no detention)	Future Condition (no detention)	Future with detention (all sub-basins)	Future with detention (key sub-basins)
25-Year	1002 (4)	1655 (12)	1119 (6)	1131 (6)
100-Year	1638 (13)	2841 (25)	2042 (17)	2072 (17)

Figure 6-1. ArcView Map of North Fork

6.1.5 Flood Proofing

Flood proofing is another structural flood mitigation measure that can be used to eliminate the flood potential for structures located in or near the floodplain. The most standard flood proofing options include the construction of floodwalls or berms for small-scale projects, levees for large-scale projects, and relocation or elevation of the flooded structure. The option used depends upon many factors, including the cause of flooding, the extent of flooded area near the structure, and the depth of flooding. The pros and cons to each option are summarized in Table 6-4.

Table 6-4. Pros and Cons of Typical Flood Proofing Measures

Pros	Cons
Floodwalls, berms and levees	
• Substantially reduces the flood potential. • No need to make structural modifications to homes or business.	• Requires property acquisition for easements or ownership. • Requires periodic maintenance by property owner or County. • Requires installation and maintenance of sump pumps, check valves, and pipes. • May require local, State and Federal permits. • May increase flooding elsewhere due to a loss of storage or impedance of flow. • May give property owners a false sense of security about flood protection. • Acceptance by property owners may be difficult.
Structure Relocation or Elevation	
• Substantially reduces the flood potential. • Property owners retain their existing structure.	• Can be extremely expensive for a single structure. • The potential for damage due to hydrodynamic forces during flood events may not be eliminated. • Site access problems during flood events may not be eliminated. • The potential for "post-project" problems and continued maintenance associated with the move of the structure is high. • Warranties or implied warranties after the move can be problematic and persistent.

For Beaver Creek, floodwalls and/or levees can be undesirable options because the loss of valuable floodplain storage due to the wall or levee could increase flood elevations elsewhere. In addition, the extent of flooding on Beaver Creek would probably require levees of appreciable size, making them expensive from a property acquisition and construction standpoint, and potentially difficult to maintain. Floodwalls or berms may be options for localized flooding on tributary basins, where storage is not a significant issue, flood depths tend to be lower, and the extent of flooded area is fairly localized.

While not inexpensive, floodwalls or berms tend to be cheaper than structure raising. However, the sensitivity of the local residents must also be considered when considering floodwalls or levees. Past experiences with the construction of floodwalls or berms on existing residential property indicates that homeowners may not accept it as a viable alternative for several reasons. First, the construction of the structure usually occurs on private property, sometimes in close proximity to the home. Homeowners may have concerns that the property located "on the other side of the wall" will become unusable to them, and that the structure will be unsightly and not maintained. In addition, there could be the perception by residents located near the flooded areas, whether unfounded or not, that visible flood proofing measures like floodwalls and levees reduce property values and discourage potential homebuyers. The County should take steps to inform residents that property value and sales potential are also affected if the area is known to flood and does not have protection.

Relocation or elevation are more viable, albeit unattractive, options for the main stem. Relocating or raising a flooded structure is an option that should be considered only when other alternatives are not possible (e.g., a resident may not want accept the County's offer for a property buyout). Elevating a structure can be expensive at approximately $75,000 per 2 feet in elevation for a 1200 square ft structure, as estimated by the U.S. Army Corps of Engineers (http://www.usace.army.mil/inet/functions/cw/cecwp/nfpc.htm). The process becomes more difficult and expensive as other factors are added, such as the existence of a basement, additions, or multi-story buildings. Other major drawbacks include the potential for post-project problems, the possibility of future maintenance and implied warranties.

6.2 Non-Structural Alternatives

6.2.1 Development Management

A number of effective, non-structural alternatives for storm water management purposes can be grouped into a general category called development management. Development management can, but does not necessarily, mean limiting the amount of development in an area. It can also include a number of planning or regulatory/policy measures aimed at limiting increases in runoff volume or peak discharges, or preventing the further degradation of receiving water quality.

There are a number of methods that the County can use to manage storm water runoff from new development, such as:

- land use planning and zoning requirements that limit new developments to those that typically have a low amount of impervious area (e.g., low density residential);

- buying property for the purpose of open space maintenance;

- more stringent regulatory requirements for new developments such as limits on the amount of impervious area, more stringent detention requirements (investigated in Section 6.1), allowing no increase in post-development runoff volume, stringent flood fringe encroachment requirements, etc);

- tax incentives or other inducements for existing developments that retrofit or redesign to conform to more stringent water quantity and/or quality standards.

Besides controlling future flood potential, another positive aspect of development management is that can be used by the County to comply with the NPDES Phase II permit that will be issued in March of 2003. The Phase II regulation requires that the County implement a program to prevent or minimize the impacts on stream water quality from runoff discharging from new developments and re-developments. Examples of non-structural alternatives that can be used to comply with this control measure include policies and ordinances that direct growth to certain areas, maintain or increase open spaces, protect riparian areas and wetlands, minimize impervious surfaces, etc. In the NPDES Phase II regulation, EPA suggests that the alternatives should attempt to maintain pre-development conditions.

An analysis of the capability of development management alternatives to limit future condition flood elevations was performed on the Beaver Creek watershed. The intent of the analysis was to determine the effectiveness of development management BMPs, and to identify the basin(s) where development management can be applied to have the greatest impact on limiting the future condition flood potential. Because peak discharges (and therefore flood elevations) are most sensitive to changes in the drainage areas on the upstream end of the watershed, the analysis focused on implementing development management only in basins that discharged to Beaver Creek *upstream of Maynardville Highway*, where the greatest impact could be realized.

Development management was simulated using the future condition HEC-1 model of the Beaver Creek watershed. The future condition curve number and time of concentration was replaced with existing condition data for all sub-basins located in the basin(s) where the BMPs were simulated. Therefore, in the basin(s) where development management BMPs was applied, there was no increase in the runoff volume or peak discharge from existing conditions. Future condition parameters were used in all remaining basins, thus simulating normal development in those areas as per MPC 15-Year land use predictions. To determine the effect on flood elevations, the peak discharges resulting from the HEC-1 runs were used as input to the HEC-RAS model of Beaver Creek. The 10-year, 24-hour and 100-year, 24-hour events were used for this analysis.

A number of development management scenarios were performed, varying the basin(s) where the development management was applied, and focusing on individual basins or combinations of basins that produced the least increase in existing condition peak flows and flood elevations throughout Beaver Creek. The development management scenarios determined to be most effective in controlling flood elevations are:

1. Management in all basins upstream of Maynardville Highway (main stem basins 01 through 07, tributary basins: South Fork, Thompson School, Kerns Branch, Cox Creek, Mill Branch and Willow Fork);

2. Management in tributary basins only (South Fork, Thompson School, Kerns Branch, Cox Creek, Mill Branch and Willow Fork);

3. Management in all basins upstream of Kerns Branch (main stem basins: 01, 02 and 03, tributary basins: South Fork, Thompson School and Kerns Branch).

4. Management in all basins upstream of Maynardville Highway, and downstream of Kerns Branch (main stem basins: 04, 05 and 06, tributary basins: Kerns Branch, Cox Creek, Mill Branch and Willow Fork).

Figure 6-2 presents the Beaver Creek watershed, and highlights the basins where development management was determined to be most effective. Table 6-5 presents the results of the most effective scenarios, in terms of the increase from existing to future condition flood elevations in Beaver Creek for the 100-year flood event. A smaller increase in elevation indicates a more effective management scenario. The increase in elevations for future conditions without development management is presented for comparison purposes.

Figure 6-2 – Arcview Map of Upper BC

Table 6-5. Results of the Most Effective Development Management Scenarios

Location	HEC-RAS Location	Increase in Future Condition Flood Elevation from Existing Conditions (feet) for the 100-Year Event				
		No Dev. Mang.	Development Management Scenario			
			1	2	3	4
Fairview Road	43.987	0.23	0.00	0.15	0.00	0.23
Beeler Road (east)	42.819	0.52	0.00	0.15	0.00	0.38
Brown Gap Road	39.877	0.95	0.00	0.22	0.07	0.42
Maynardville Pike	37.649	1.24	0.00	0.32	0.37	0.52
Dry Gap Rd	32.484	2.32	0.14	0.54	1.44	0.60
Interstate 75	30.220	2.25	0.14	0.49	1.17	0.50
Central Ave Pike	29.608	1.09	0.15	0.52	1.56	0.52
Brickyard Road	27.057	0.97	0.09	0.25	0.70	0.24
Clinton Highway	24.904	1.43	0.20	0.43	1.13	0.41
Oak Ridge Hwy	15.465	1.55	0.21	0.48	1.01	0.44
Pellissippi Parkway	6.908	1.22	0.22	0.42	0.76	0.39
Mouth	1.278	1.12	0.21	0.40	0.70	0.37

Note: These scenarios do not consider the impacts of flood fringe encroachments.

As expected, the most effective scenario for limiting flood elevations throughout Beaver Creek is the management of development in the entire drainage area above Maynardville Highway (Scenario 1). This has the effect of eliminating the future increases in elevation upstream of Maynardville Highway and substantially controlling flood elevations along the rest of Beaver Creek. In terms of development management on a smaller scale, Scenarios 2, 3 and 4 were also effective to varying degrees. In Scenario 2, it was found that development management in the tributaries, and Kerns Branch in particular, is more effective for overall flood elevation control than management in the main stem basins. In Scenario 3 it was determined that management in basins upstream and including Kerns Branch will provide greater control over flood elevations in the Halls-Crossroads area. Without development management upstream of Kerns Branch, the 1.24 ft rise in flood elevation that is predicted for the future 100-year event almost doubles the number of flooded structures in the Halls-Crossroads area from existing condition, increasing from 26 to 70. Implementation of a management scheme in Kerns Branch and upstream basins controls flood elevations at Maynardville Highway to only a 0.4 ft rise from existing conditions, effectively controlling the future flood potential in the area. Finally, Scenario 4 shows that control of flood elevations along the entire Beaver Creek can be realized by managing development in the basins downstream of (and including) Kerns Branch, specifically Cox Creek, and the Willow Fork/Mill Branch tributaries.

6.2.2 Floodplain Encroachment Limitations

As a community that participates in the National Flood Insurance Program (NFIP), Knox County is required to adopt the following *minimum* NFIP regulations (44 CFR § 60.3d):

1. Select and adopt a regulatory floodway based on the principle that the area chosen for the floodway must be designated to carry the base flood without increasing the water surface elevations by more than one-foot (i.e., a one-foot surcharge).

2. Prohibit encroachments within the adopted regulatory floodway unless it has been demonstrated through hydrologic and hydraulic analyses that the proposed encroachment would not result in any increase in flood levels.

The NFIP requirements were developed for the purpose of reducing the loss of life, property damage, and disaster relief costs associated with flooding by requiring improved building practices, guiding future development away from flood hazard areas, and requiring property owners to obtain flood insurance. However, one of the shortfalls in the NFIP requirements is a reliance on floodplain management boundaries that are based on existing conditions, and a misconception that the floodway delineation takes into account all of the factors that could increase flood elevations. The typical FEMA floodway delineation accounts for the hydraulic impacts of flood fringe encroachments, but not the hydrologic impacts of the loss of floodplain storage. In addition, future upstream land development is not explicitly considered in floodway delineation.

Some communities account for future effects by using a reduced maximum floodway surcharge, in most case 0.1 ft., future development flows, or a compensating cut requirement for flood fringe fill. All of these methodologies are valid regulatory mechanisms to reduce the impacts of flood fringe filling on flood elevations. Currently, Knox County accounts for impacts on future development by using the existing condition 500-year flood elevation as the baseline for finished floor requirements (i.e., the finished floor elevation for all new construction in the flood fringe must be 1-foot above the 500-year flood elevation).

The effect of building in the regulatory flood fringe was analyzed using the floodways developed for submission to FEMA in the *Beaver Creek Watershed Flood Study* (Ogden, 2000). The floodways were developed using the HEC-RAS models of Beaver Creek and its tributaries in accordance with NFIP rules (i.e., the floodway was developed using a maximum 1-foot surcharge). Storage-discharge relationships were extracted from the HEC-RAS floodway models and were used as input for the channel routings in the HEC-1 future condition model. This accounted for the reduction of storage in the floodplains caused by encroachment of new development in the flood fringe. Flood elevations can then be determined by using the peak discharges from the HEC-1 model as input to the HEC-RAS floodway models.

Four flood fringe encroachment analyses were performed using the methods explained above:

1. existing condition hydrology, encroachment to the 100-year floodway boundary with channel storage adjusted;

2. existing condition hydrology, encroachment to a line one-half the distance between the 100-year floodplain boundary and the 100-year floodway boundary (i.e., one half of the flood fringe) with channel storage adjusted;

3. future condition hydrology, encroachment to the 100-year floodway boundary with channel storage adjusted; and

4. future condition hydrology, encroachment to a line one-half the distance between the 100-year floodplain boundary and the 100-year floodway boundary (i.e., one half of the flood fringe) with channel storage adjusted.

Table 6-6 presents the results of this analysis for Beaver Creek and the modeled tributaries. It is evident that the flood elevations are quite sensitive to flood fringe encroachments. Under future conditions without flood fringe filling, flood elevations would increase about 2 feet. However, if the flood fringe is filled, which is allowed under existing regulations, the increase is over 4 feet. The elevation increase is caused by a loss of floodplain storage volume, which plays a particularly important role in controlling peak discharges on Beaver Creek. Based on this analysis, it was determined that the one-half flood fringe encroachment line is approximately equivalent to a floodway based on existing discharges and a maximum surcharge between 0.25 and 0.5 ft.

Although this particular method of regulation has not been used in other communities, it is comparable to the efforts of other communities in its objective to control the effects of future development using alternative floodplain management techniques. The proposed no fill line is intended to accomplish the same objective as a more restrictive allowable floodway rise or a future condition floodway. In short, the proposed no fill line is an accounting for the future development in the watershed. This regulatory instrument is presented as a management alternative to control future flood elevations that should be considered by Knox County.

Table 6-6. Results and Comparison of Flood Fringe Encroachment Analysis

Stream	Existing Conditions increase in elevation (ft)				Future Conditions increase in elevation (ft)			
	Full Encroachment		Half Encroachment		Full Encroachment		Half Encroachment	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Lower Beaver Creek Confluence to RM 10.870	2.09	2.66	0.46	0.88	2.83	3.91	0.11	0.37
Middle Beaver Creek RM 10.870 to 35.930	2.61	3.83	0.60	0.90	3.50	5.54	0.06	0.28
Upper Beaver Creek RM 35.930 to headwaters	1.95	2.70	0.38	0.75	2.53	3.45	0.12	0.44
Tributary to Cox Creek	0.63	0.99	0.06	0.18	0.73	1.09	0.24	0.36
Cox Creek	1.00	1.62	0.19	0.50	1.11	1.79	0.11	0.43
Grassy Creek	0.76	1.12	0.13	0.28	1.13	1.54	0.22	0.43
Hines Branch	0.73	1.16	0.21	0.45	0.85	1.28	0.18	0.49
Kerns Branch	1.15	2.17	0.16	0.30	1.72	3.13	0.18	0.38
Knob Fork	1.26	2.71	0.23	1.03	1.29	2.85	0.24	1.37
Mill Branch	0.39	1.13	0.03	0.21	0.46	1.88	0.08	0.57
North Fork	0.75	1.67	0.15	0.54	1.28	2.72	0.28	1.45
Plumb Creek	0.63	1.02	0.10	0.31	0.92	1.46	0.14	0.43
South Fork	1.37	1.92	0.12	0.31	1.62	2.70	0.14	0.35
Thompson School	0.90	1.26	0.13	0.39	1.16	1.46	0.15	0.39
Willow Fork	0.55	1.16	0.11	0.36	0.84	1.49	0.06	0.32

7 FLOOD SOLUTION ALTERNATIVES - PRIORITY AREAS

This section presents an analysis and discussion of specific flood solution alternatives for flood priority areas that have been identified by Knox County or through the results of the HEC-RAS models of Beaver Creek and its tributaries. A cost estimate for each alternative was developed, based on a conceptual alternative or design. These costs should be used for planning purposes only.

Costs are in present day (2000 dollars) and include property acquisition, construction costs including utility relocation costs, and design fees. Estimated costs for purchase of residential properties were based on housing prices in the general location of the residences. Purchase prices for commercial properties were gathered from the County tax assessor. An additional $3500 was added to each individual property purchase to account for County staff time to review, initiate and perform property purchases, and the necessary fees and expenses associated with property transfers. Property acquisition costs for drainage easements were based on the estimated area of easement and an estimated land value. Land value estimates, for both developed and undeveloped land in different areas of the County (e.g., Karns area, Halls area, etc.), were based on estimates given by several local real estate agents. Construction costs were based on estimated costs for mobilization, excavation, fill and compaction, sewer line relocation, and channel restoration. Design and construction management costs were based on a percentage of the overall construction costs.

7.1 Beaver Creek - Halls-Crossroads Priority Area

7.1.1 Background

In the past five to ten years, Knox County has received many complaints of flooding in areas of the Halls-Crossroads community. Businesses have been flooded in the Halls-Crossroads shopping area, most notably the First Tennessee Bank in Halls Plaza on Maynardville Highway and the majority of the residential flooding has occurred at houses on Marshall Drive in the Hallbrook subdivision.

Figures 7-1a and 7-1b present the existing condition floodplains and the flood potential for the 100-year and 500-year events in the flood damage reach on Beaver Creek from Maynardville Highway (RM 36.815) to Brown Gap Road (RM 39.865). Table 7-1 presents an estimate of the flood potential in the area, based on comparison of surveyed FFE's with HEC-RAS model results.

Figure 7-1a

Figure 7-1b

Table 7-1. Structures with FFE Flood Potential – Halls Crossroads Area

	Number of Houses Flooded (based on Surveyed FFE's)			
	Halls-Crossroads Area		Entire Beaver Creek	
Storm Event	Existing Condition	Future Condition	Existing Condition	Future Condition
2-yr	0	0	0	0
10-yr	6	8	17	22
25-yr	8	14	25	40
100-yr	28[1]	45	48	84
500-yr	49[1]	71	95	125

1 – two structures not shown in Figure 7-1, they are located just downstream of Maynardville Highway

Table 7-2 is a list of the addresses and the depth of flooding for all events for the 28 structures with FFE flood potential in the 100-year event.

Table 7-2. Structures with 100-Year Existing FFE Flood Potential - Halls Crossroads

Structure #	Address	FFE (ft NAVD)	Existing Condition Depth of flooding (ft) (a negative sign indicates the FFE is above the flood elevation)				
			2-Year	10-Year	25-Year	100-Year	500-year
214	7224 Maynardville Hwy	1025.69	-8.56	-4.10	-2.47	0.66	2.39
215	7212 Maynardville Hwy	1021.89	-4.76	-0.30	1.33	4.46	6.19
216	6950 Maynardville Hwy	1024.04	-5.69	-1.37	0.41	2.94	4.66
217	7114-7154 Maynardville Hwy	1025.16	-6.69	-2.44	-0.67	1.86	3.58
208	7034 Maynardville Hwy	1027.00	-8.57	-4.30	-2.53	0.01	1.73
210	7110 Maynardville Hwy	1025.94	-8.90	-4.40	-2.75	0.39	2.11
211	4522 Doris Circle	1025.44	-6.72	-2.64	-0.90	1.62	3.34
367	4520 Doris Circle	1023.41	-4.74	-0.63	1.12	3.64	5.37
220	7117-7125 Commercial Pk.	1026.98	-8.26	-4.18	-2.44	0.08	1.80
219	7131 Commercial Park	1026.78	-8.06	-3.98	-2.24	0.28	2.00
218	7139 Commercial Park	1025.83	-7.11	-3.03	-1.29	1.23	2.95
222	7140 Commercial Park	1026.78	-8.00	-3.97	-2.22	0.29	2.02
316	7305 Arlie Dr	1027.15	-7.77	-4.15	-2.46	0.02	1.75
319	7201 Arlie Dr	1026.83	-5.31	-2.67	-1.31	0.95	2.69
224	4505 Marshall Dr	1024.54	-4.62	-1.33	0.29	2.74	4.48
225	Marshall Dr	1026.00	-6.08	-2.79	-1.17	1.28	3.02

Table 7-2. Structures with 100-Year Existing FFE Flood Potential - Halls Crossroads

Structure #	Address	FFE (ft NAVD)	Existing Condition Depth of flooding (ft) (a negative sign indicates the FFE is above the flood elevation)				
			2-Year	10-Year	25-Year	100-Year	500-year
226	4500 Marshall Dr	1022.46	-1.92	1.05	2.58	4.96	6.71
227	4508 Marshall Dr	1025.23	-4.07	-1.42	0.01	2.34	4.09
228	4512 Marshall Dr	1026.58	-5.06	-2.42	-1.06	1.20	2.94
229	4600 Marshall Dr	1027.19	-5.54	-2.91	-1.57	0.66	2.40
230	Marshall Dr	1027.44	-5.51	-2.88	-1.60	0.57	2.31
231	4606 Marshall Dr	1026.25	-4.08	-1.46	-0.22	1.90	3.63
320	4626 Marshall Dr	1028.03	-4.86	-2.26	-1.16	0.79	2.52
321	4724 Zirkle Dr	1027.83	-4.33	-1.73	-0.67	1.24	2.97
328	7325 Palmyra Dr	1027.57	-3.08	-0.86	0.11	1.90	3.61
343	7137 Periwinkle Rd	1033.62	-6.20	-2.10	-1.19	0.24	2.33
132	Address unknown[1]	1015.39	-3.96	-1.12	-0.00	1.67	3.57
133	Address unknown[1]	1015.57	-4.14	-1.30	-0.18	1.49	3.39

1 – structure not shown in Figure 7-1, located downstream of Maynardville Highway

Channel improvements or bridge replacements in the Halls-Crossroads area would not be practical or completely effective for the degree of flood potential predicted. The natural tendency of Beaver Creek to flow out-of-bank and the potential for increased flooding potential downstream from conveyance improvements limit the flood solution alternatives that can be utilized. However, the results of the HEC-1 model of the Beaver Creek watershed indicate that the portion of the watershed upstream of Maynardville Highway is highly sensitive to the peak discharges and the timing of tributary inflows. For these reasons, regional detention at key sites upstream of the Halls-Crossroads area could provide some degree of flood mitigation, and therefore was analyzed as a possible flood solution alternative.

The goal of the flood solution alternatives considered was to eliminate the 100-year existing condition flood potential in the portion of the damage reach upstream of Maynardville Highway and, if feasible, reduce the flood potential for future condition events. Two alternatives were investigated to mitigate flooding in the Halls-Crossroads damage reach:

1. purchase of flood-prone properties; and
2. one or more regional detention facilities upstream of the affected area.

7.1.2 Alternative 1: Purchase of flood-prone properties

The 28 structures that face potential flooding for the existing condition 100-year storm event consist of 12 commercial properties and 16 residential properties. The value of each residential property was estimated at approximately $120,000 per lot. Commercial property values were attained from the County tax assessor's office. The estimated cost for this alternative is shown in Table 7-3. It was assumed that the structures would be demolished after purchase, and the cost for demolition, grading and re-vegetation of the site was considered. Other potential uses for the purchased structures may change these costs. The purchase of these structures would be contingent on the owner's agreement to sell.

Table 7-3. Estimated Costs, Halls-Crossroads Area Property Purchases

Task	Estimated Cost
Property purchases (16 residential)	$1,920,000
Property purchases (12 commercial)	$6,101,800
Property purchase additional costs	$98,000
Demolition and site preparation	$1,075,660
SUBTOTAL	$9,195,460
10% contingency	$919,546
TOTAL COST	**$10,115,006**

Purchase of the 28 properties does not reduce the future flood potential for nearby property owners. Seventeen additional structures located in the damage reach are predicted to flood under future conditions. Demolishing the purchased properties and excavating the areas for channel improvements or regional detention area in an effort to reduce the future flood potential for nearby houses was not considered. The area is too developed for regional detention within the damage reach, and would likely increase the flood potential for structures located upstream of the facility.

As discussed in Section 6.1.5, flood proofing is another option for situations where the homeowner does not want to move and/or flood depths are less than 2 feet. Unfortunately, due to the extent of flooding and the high peak discharges in the areas, levees or floodwalls are not feasible options for the area, and could potentially cause flooding elsewhere on Beaver Creek. A flood proofing option for residences is to raise the house. The estimated cost to raise a 1200 square foot home approximately two-feet is approximately $75,000. This option may be employed for homes with small depths of flooding. However, structure raising is not highly attractive because of the potential for structural damage and warranty problems associated with the project.

7.1.3 Alternative 2: Regional detention

Two possible regional detention sites were located, and are shown in Figure 7-2. Because peak discharges in Beaver Creek upstream of Maynardville Highway are sensitive to the inflow from Kerns Branch, a location on Beaver Creek that detained flows from Kerns Branch was chosen for regional detention. A regional facility having an embankment located at R.M. 42.054 (Site 1 in Figure 7-2), was analyzed in detail. The floodplain in this area is large and flat with little development, making it ideal for additional flood storage.

Site 2 is located at RM 0.663 on Cox Creek, downstream of Atkins Road. A dam would have to be constructed to impound water at this location. This area was chosen for regional detention more to assist the performance of the Beeler Road detention area discussed above, than to be a stand-alone flood mitigation measure.

The existing condition HEC-1 model of the Beaver Creek watershed was used to develop a conceptual design for the regional detention ponds. It was determined that the two pond locations are not mutually exclusive, that is, the effective reduction of peak discharges in the damage reach is contingent on the construction of *both* ponds. Construction of the pond at Site 1 alone will have a significant improvement on flooding for the reach downstream of the pond to the confluence with Cox Creek at river mile 39.835. However, without the construction of the pond at Site 2 on Cox Creek, the unregulated flows discharging from Cox Creek into Beaver Creek significantly reduce the effect of the pond at Site 1 and there is little flood reduction benefit on Beaver Creek beyond the confluence with Cox Creek. Therefore, the greatest impact on floodplain elevations in the damage reach can be achieved using a combination of both ponds.

The pond at Site 1 was designed to pass the 2-year peak flow unimpeded, and detain less frequent events. The conceptual design consists of a low level outlet structure with an opening of approximately 100-sq. ft. The crest of the spillway was set at 1057.8 ft, which is the peak stage for the 25-year event (i.e., the 25-year event passed through the arch). No excavation is needed to increase storage. The peak elevation in the pond for the 100-year flood event is 1060.28. The area of inundation at this elevation is shown in Figure 7-2. Purchase of several rural residential properties would be required to construct this pond.

Figure 7-2 Location of Analyzed Regional Detention Ponds for Beaver Creek

The pond at Site 2 is designed to the same specifications as the pond at Site 1. Located at Cox Creek R.M. 0.663, the conceptual design consists of a low level outlet structure with an opening of approximately 60-sq. ft. The primary spillway crest elevation is 1061.3 feet and the top of dam elevation is 1065.0 feet. The total length of the dam is 380 feet. No excavation is needed to increase storage. The peak elevation in the pond for the 100-year flood event is 1062.88. The bridge over Cox Creek at Atkins Road, located approximately 1800 feet upstream of the dam, will require re-construction to raise the road above the top of dam elevation to prevent overtopping. The area of inundation at this elevation is shown in Figure 7-2.

As a result of regional detention, peak discharges in the Halls-Crossroads area would be reduced by approximately 35%, resulting in a decrease in flood elevations of an average of 2.0 feet through the damage reach. Table 7-4 shows the effect of regional detention on the flood potential in the Halls-Crossroads damage reach and along the entire Beaver Creek. The 5 commercial and 9 residential structures for which the existing condition flood potential is eliminated for the 100-year existing condition event are circled in Figure 7-1a. While detention does not eliminate the flood potential for the area, the ponds cannot be increased in storage capability to have a greater effect without negatively impacting residents and roads near the ponds. To completely eliminate the flood potential in the Halls-Crossroads damage reach, a combination of alternatives, such as detention and property purchase, would be needed.

Table 7-4. Effects of Regional Detention on Flood Potential

	Number of Habitable Structures Flooded (based on Surveyed FFE's)							
	Halls-Crossroads Damage Reach				Entire Beaver Creek			
	Without Ponds		With Ponds		Without Ponds		With Ponds	
Flood Event	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**
2-year	0	0	0	0	0	0	0	0
10-year	6	8	1	3	17	22	2	5
25-year	8	14	3	7	25	40	8	18
100-year	28	45	14	20	48	84	32	42
500-year	49	71	30	40	95	125	57	76

An estimate of the cost to design and construct the regional detention ponds at Sites 1 and 2 was determined and is provided in Table 7-5. It should be noted that if constructed, the embankments at the downstream end of the detention ponds have the potential to fall under the Safe Dams Act and would require special safety and regulatory considerations, regular maintenance, and permitting. The potential costs associated with these issues were not included in the estimate.

Table 7-5. Estimated Costs, Beaver Creek Regional Detention Pond Alternative

Task	Site 1 Costs	Site 2 Costs
Property and R.O.W. acquisition	$2,175,000	$925,000
Design and construction	$852,783	$225,700
Site Totals	$3,027,783	$1,150,700
SUBTOTAL	**$4,178,483**	
10% contingency	$417,848	
TOTAL CONSTRUCTION COST	**$4,596,331**	

It is notable that the regional detention ponds have a significant impact on peak discharges and flood elevations well beyond the Halls-Crossroads damage reach that it was designed to improve. Peak discharges are attenuated from the ponds all the way to the mouth of the watershed. The regional ponds also significantly reduce the number of habitable structures flooded under future conditions. However, the full effect of regional detention on the true flood potential along Beaver Creek cannot be determined until FFEs for all structures located or touching the 100-year floodplain are surveyed. For example, the regional detention ponds decrease peak elevations an average of 0.8 in the area immediately downstream of Maynardville Highway. In there area, there are 47 residences located inside or touching the 100-year floodplain that do not have surveyed FFEs. The majority of these residences are located in the Levell Heights, Fountaincrest and Chervue subdivisions.

7.1.4 Conclusions

A comparison of effective costs and the reduction in flood potential of the two flood solution alternatives for Beaver Creek is presented in Table 7-6. The effective cost is the cost required to eliminate the 100-year existing condition FFE flood potential. For the regional detention alternative, this cost includes construction of the regional detention ponds and the cost of purchasing the remaining 14 properties that have a 100-year flood potential after construction of the ponds (post-project).

Table 7-6. Summary Table of Alternatives for the Halls-Crossroads Damage Reach

	No. of FFEs Flooded				Costs (in present day dollars)		
	100-Year Existing		100-Year Future				
Alternative	**Pre**	**Post**	**Pre**	**Post**	**Construction**	**Structure Acquisition**	**Effective Cost**
1. Property Purchase	28	0	45	17	$0	$10,115,006	**$10,115,006**
2. Regional Detention	28	12	45	20	$4,596,331	$6,359,986	**$10,956,316**

From a strict cost/benefit standpoint, purchasing the flooded properties is more attractive than regional detention. Additional positive and negative factors associated with each alternative that should be considered are listed in Table 7-7.

Table 7-7. Summary of Pros and Cons for Halls-Crossroads Alternatives

Alternative	Pros	Cons
1. Property Purchase	• Eliminates 100-year flood potential in the Halls-Crossroads damage reach for existing conditions • No construction of storm water facilities or associated maintenance required	• Does not lower flood stages • Does not change flood potential for future conditions • May set unwanted precedent for County buyouts of all flooded properties.
2. Regional Detention	• Reduces flood potential in Halls-Crossroads area. • Also reduces flood potential along the entire Beaver Creek. • Does reduce future flooding potential.	• More costly than straight purchase. • Does not eliminate 100-year flood potential, requires additional property purchases. • Requires purchase of non-flooded property for flood control. • The County will assume post construction maintenance responsibilities. • Potential environmental permitting requirements for construction.

7.1.5 Recommendations

All of these things considered, the following actions are recommended:

- The County should decide if action is to be taken to eliminate the existing flood potential in the Halls-Crossroads area based on the funding requirements for implementing either Alternative 1 or Alternative 2 and budget considerations.

- Should the County take action toward a property buyout, a method to prioritize purchases should be developed (see Section 8).

- Flood proofing (i.e., elevation) of structures that have FFE flood potential is not highly recommended, but could be considered in cases where the flood depths are small and/or the property owner does not accept a buyout.

- There are three structures with 100-year flooding depths less than 0.1 ft. Outright purchase of these structures may not be necessary. Limited flood proofing may prove to be more appropriate.

- A citizen meeting should be conducted to inform the impacted community of the options for flood relief and associated costs. At this point, the willingness of the impacted residents to either accept a buyout could be gauged. The County should expect detailed questioning regarding any flood-proofing measures discussed.

- Based on the MPC 15-Year Development Plan, the predicted development pattern in the area of the watershed upstream of Maynardville Highway is for the majority of the developed area predicted to be medium density residential. Regardless of the chosen alternative to alleviate the existing flood potential, future growth upstream must be anticipated. The future flood potential is not totally mitigated by any of the alternatives, therefore the County should plan appropriately for future flood impacts using non-structural BMPs to reduce the increases in future runoff volume.

7.2 North Fork Priority Area

7.2.1 Background

The Knox County Department of Engineering and Public Works has received annual complaints of flooding in the Oaken Drive area, located at approximately RM 0.971 on North Fork. Discussions with residents during a field investigation of the area indicate that high water from North Fork has threatened residences located in this and other areas on North Fork in the recent past. The flood potential in this area was examined using the results of the existing and future HEC-RAS models and flood solution alternatives were analyzed.

Figures 7-3a and 7-3b show the location of the 100-year and 500-year existing condition floodplains along North Fork and the damage reaches where flood potential were identified. Three damage reaches are:

DAMAGE REACH 1 - Lena Lane upstream of East Emory Road;

DAMAGE REACH 2 - Oaken Drive between Andersonville Pike and Ledgerwood Road (near or adjacent to Halls Middle School); and,

DAMAGE REACH 3 - Stillbrook Lane near the Temple Acres Drive crossing.

To determine the extent of the flood potential in these areas, the surveyed FFE's for residences located in the flood potential damage reaches were compared to the 100-year existing condition flood elevations. Homes that have FFE's below the 100-year flood elevations are indicated in Figures 7-3a and 7-3b. Table 7-8 presents flood potential in these damage reaches for all events in both the existing and future conditions. Halls Middle School was not surveyed, however field observations approximate FFE flooding at that location to occur during the 500-yr event.

Table 7-8. Residential Structures with FFE Flood Potential - North Fork

	Number of Houses Flooded (based on surveyed FFEs)							
	Damage reach 1 Lena Lane		Damage reach 2 Oaken Drive		Damage reach 3 Stillbrook Lane		Entire North Fork	
Storm Event	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**	**Existing**	**Future**
2-yr	0	0	0	1	0	0	0	1
10-yr	0	1	3	4	0	2	3	7
25-yr	1	1	3	5	0	4	4	12
100-yr	6	10	5	9	2	4	13	25
500-yr	16	20	5	13	4	7	26	42

Figure 7-3a. North Fork Damage Reach Areas.

Figure 7-3b. North Fork Damage Reach Areas.

Table 7-9 is a list of the addresses and the depth of flooding for all events for the 13 structures located along North Fork with FFE flood potential in the 100-year existing condition event. The structures shown in **bold** face type are located in the Oaken Drive damage reach.

Table 7-9. Structures with 100-Year Existing Condition Flood Potential – North Fork

Structure #	Address	FFE (ft NAVD)	Existing Condition Depth of flooding (ft) (a negative sign indicates no flooding)				
			2-Year	10-Year	25-Year	100-Year	500-year
NF52	7340 Melanie Lane	1017.46	-4.86	-2.06	-1.02	0.56	2.37
NF53	7509 Cathy Rd	1017.22	-4.11	-1.56	-0.78	0.80	2.61
NF8	7504 Cathy Dr.	1018.00	-4.72	-2.26	-1.56	0.02	1.83
NF10	7415 Lena Ln.	1016.20	-2.66	-0.33	0.24	1.82	3.63
NF11	7408 Lena Ln.	1018.00	-4.46	-2.13	-1.56	0.02	1.83
NF13	7401 Lena Ln.	1016.82	-4.19	-1.40	-0.38	1.20	3.01
NF33	**7404 Oaken Rd.**	**1037.87**	**-3.30**	**-1.36**	**-0.69**	**0.04**	**0.68**
NF34	**7408 Oaken Rd.**	**1037.04**	**-1.64**	**0.29**	**0.94**	**1.67**	**2.33**
NF35	**7412 Oaken Rd.**	**1037.63**	**-1.39**	**0.53**	**1.16**	**1.88**	**2.57**
NF36	**7416 Oaken Rd.**	**1038.50**	**-1.11**	**0.73**	**1.33**	**2.03**	**2.71**
NF37	**7420 Oaken Rd.**	**1040.68**	**-2.55**	**-0.85**	**-0.28**	**0.38**	**0.99**
NF40	7806 Stillbrook Ln.	1064.58	-2.29	-0.47	-0.08	0.50	0.94
NF41	7808 Stillbrook Ln.	1065.87	-2.32	-0.54	-0.06	0.54	0.98

Except for one house, potential flooding in residences along Lena Lane is limited to the 100-year and 500-year storm events. The primary source of flood potential is backwater from Beaver Creek, which extends from the mouth of North Fork to the Norris Freeway bridge, located upstream of the Lena Lane damage reach. Therefore, flood solution alternatives performed on North Fork will not reduce the flood potential for the residences in this damage reach. Flood solution alternatives for Beaver Creek upstream of the confluence are discussed in Section 7.1.

The flood potential in the Oaken Drive and Stillbrook Lane damage reaches are due to headwater conditions and could possibly be solved using structural measures, such as detention ponds or channel improvements. The flood potential in the Oaken Drive area has the highest frequency, with FFE flooding predicted at three residences for the 10-year event. The existing condition flood potential in the Stillbrook Lane damage reach is limited to the 100- and 500-yr events. However, the potential increases to more frequent events in future conditions.

Since the existing flood potential is most serious in the Oaken Drive damage reach and Knox County has already received complaints of FFE flooding in that area, flood solution alternatives considered for North Fork focused on relief of flooding in the Oaken Drive area. The goal of the analysis was to eliminate the 100-year existing condition flood potential in the Oaken Drive damage reach and, if feasible, reduce the flood potential for future condition events.

Flood proofing to mitigate flooding in the Oaken Drive damage reach, in the form of house raising above the predicted 100-year flood elevation is not an attractive option. Based on the predicted 100-year flood depths in the homes that were presented in Table 7-9, the elevation required (including freeboard) to protect against flooding in the 100-year event is greater than two-feet for three of the five homes, and greater one-foot for the remaining two homes.

As a stand-alone option, a floodwall or berm is also not an attractive flood proofing option for the Oaken Drive area. Based on the extent and depth of the 100-year floodplain in the Oaken Drive area, a floodwall to protect the entire area would be at least 800 feet in length, and more than 5-feet high at some locations. In addition, a wall would probably extend onto the property of residents that do not have an FFE flood potential. The loss of storage due in the natural floodplain could cause flooding in other areas of North Fork, impacting homes that currently do not have a predicted flood potential. Floodwalls may be a more attractive option when used in tandem with one or more of the other alternatives.

Three conceptual alternatives were considered and are discussed in detail below:

1. purchase of flood-prone properties along Oaken Drive;
2. channel conveyance improvements in North Fork;
3. one or more regional detention facilities upstream of the affected area(s).

7.2.2 Alternative 1: Purchase of flood-prone properties

As shown in Table 7-8, a total of five residences in the Oaken Drive damage reach face potential flooding for the 100-year storm event in the existing condition. The cost to purchase each property was estimated at approximately $120,000. The estimated cost for this alternative is shown in Table 7-10. It was assumed that the structures would be demolished after purchase, and the cost for demolition was considered. Other uses for the purchased houses may change these costs. The purchase of these homes would be contingent on the resident's agreement to sell their home.

Table 7-10. Estimated Costs, Oaken Drive Property Purchases

Task	Estimated Cost
Property purchases (5 properties)	$600,000
Property purchase additional costs	$17,500
Demolition and site preparation	$98,900
SUBTOTAL	$716,400
10% contingency	$71,640
TOTAL COST	**$788,040**

Purchase of the five properties does not reduce the future flood potential for nearby residents and five additional structures in the area are predicted to flood under future conditions. Demolishing the purchased properties and excavating the area for use as a regional detention area in an effort to reduce the future flood potential for nearby houses was not considered. The area is too small to provide the necessary storage to effect a reduction in flood elevations.

7.2.3 Alternative 2: Channel improvements

Improved channel conveyance was analyzed for the reach on North Fork, between the Andersonville Pike bridge, located at the downstream end, and the Ledgerwood Road culvert at the upstream end. Both structures are notably undersized based on visual inspection. This was confirmed by the HEC-RAS model, which shows that both structures are overtopped during the 10-year existing condition storm event. While improvement of the structures to the proper size and road elevation will eliminate access and safety concerns for the residents living in the area, this will not improve the flood potential in the Oaken Drive area. Specifically, backwater from the Andersonville Pike bridge extends only 250 ft upstream of the bridge and therefore is not the cause of flooding along Oaken Drive.

Channel improvements were analyzed using the North Fork HEC-RAS model. The conceptual design consists of widening and re-grading the channel to the extent that 100-year existing condition flood potential was eliminated. A field visit was performed to investigate the hydraulic and hydrologic conditions in the areas of interest. It was determined that the main channel of North Fork varies in size and efficiency through the study reach. Throughout most of the reach, between the Andersonville Pike crossing and adjacent to Halls Middle School, the bank-full top width of the main channel is approximately 20 feet wide and 2 to 5 feet deep. Trees and large accumulations of debris are present in some areas of the channel, most notably along Northgate Drive, and areas of erosion are frequently seen. This portion of the channel is shown in Figures 7-4, 7-5 and 7-6. Upstream of Halls Middle School, the main channel has been improved and is larger: 30 to 40 feet wide and approximately 6 feet deep. This portion of the channel is shown in Figure 7-7.

Figure 7-4. North Fork Upstream of Andersonville Pike (looking downstream)

Figure 7-5. North Fork between Northgate Drive and Halls Middle School (looking downstream)

Figure 7-6. North Fork between Oaken Drive and Halls Middle School (looking downstream)

Figure 7-7. North Fork Upstream of Halls Middle School (looking upstream)

The estimated footprint of the conceptual channel improvement is shown in Figure 7-8, along with the new 100-year existing condition floodplain in the Oaken Drive damage reach that is predicted after improvement. The minimization of the estimated channel improvement footprint was a primary concern during the analysis, due the close proximity of both residences and the Halls Middle School athletic fields to the study reach and the presence of a sanitary sewer line adjacent to the existing channel.

The improved reach extends from RM 0.843 to RM 1.227 and consists of a trapezoidal cut of maintained grass, having a 14 foot base, 2:1 side slopes (H: V), and a slope of 0.00361 from R.M. 0.843 to 0.971 and a slope of 0.0071 from 0.971 to 1.227. The excavation requirements for this channel are approximately 4956 cu yd, and would disturb a strip of land 30 to 45 feet wide adjacent to the channel. For the conceptual design, nearly 2100 feet of 10-inch sanitary sewer and seven manholes need to be relocated.

Figure 7-8. **100-year existing condition floodplain, post-channel improvement.**

The change in the FFE flood potential for the Oaken Drive and Lena Lane damage reaches after the implementation of the channel improvement alternative is shown in Table 7-11. Note that flood elevations drop over 3 feet for the existing 10-year event and over 2 feet for the existing 100-year event. The 100-year existing condition flood potential for the Oaken Drive damage reach is eliminated, however a future condition flood potential still remains with six homes predicted to flood. In addition the proposed channel improvement will reduce channel storage and increase peak discharges for the 100-year event in the Lena Lane damage reach approximately 15%. This results in a 0.1-foot rise in water surface elevation downstream of the channel improvement during the 100-year existing storm and one additional residence is predicted to flood during the 10-yr future storm. Peak discharges on Beaver Creek downstream of North Fork did not increase.

Table 7-11. Effect of Channel Improvement on Flood Potential in North Fork

Land Use Condition	Pre or Post Channel Improvement	Elevation (ft) at RM 1.053		Number of Flooded Homes			
				Oaken Drive		Lena Lane	
		10-year	100-year	10-year	100-year	10-year	100-year
Existing	Pre	1039.0	1040.3	3	5	0	6
	Post	1035.6	1037.7	0	0	0	6
Future	Pre	1040.0	1041.5	4	9	1	10
	Post	1037.3	1039.4	0	6	2	10

The estimated costs associated with the channel improvement alternative are shown in Table 7-12.

Table 7-12. Estimated Costs, North Fork Channel Improvement

Task	Estimated Cost
Property and R.O.W. acquisition	$99,500
Utility relocation (sanitary sewer)	$203,550
Design and construction	$214,925
SUBTOTAL	$517,975
10% contingency	$51,798
TOTAL COST	**$569,773**

7.2.4 Alternative 3: Regional detention

The objective of this flood solution alternative is to reduce the existing condition 100-year event flood elevations in the Oaken Drive damage reach through attenuation of peak discharges using regional storm water detention ponds. Three potential locations for the ponds were considered, and are shown in Figure 7-9:

1. on North Fork, adjacent to Ventura Drive upstream of Ledgerwood Road

2. on a tributary to North Fork, adjacent to Micah Drive, upstream of McCloud Road; and,

3. on North Fork, adjacent to Foothills Drive and McCloud Road.

Preliminary investigation eliminated the Site 1, due to volume and elevation restrictions, and indicated that a combination of detention at the second and third sites would maximize peak flow reductions. In addition, the second and third sites are located upstream of Stillbrook Lane damage reach and could possibly reduce the flood potential at that location, as well as in the Oaken Drive damage reach.

At Site 2, regional detention can be achieved by raising McCloud Road while reducing size of the existing culvert. The 100-yr 24-hr storm event returns an approximate peak stage of 1092 ft when impounding 37 acre-ft of water. The future 100-yr 24-hr storm event returns an approximate peak stage of 1094 ft. No residential structures are inundated in either event, however the driveway for 4333, 4337 and 4400 McCloud Road is flooded and an alternate access route would need to be located and constructed.

Regional detention at the Site 3 could be achieved by constructing an embankment across the valley between Foothills Drive and McCloud Road. A low-level outlet would provide drainage. The existing 100-yr 24-hr storm event returns an approximate peak stage of 1168 ft, when impounding 21 acre-ft of water. The future 100-yr 24-hr storm event returns an approximate peak stage of 1174 ft. No residential structures are inundated in either event.

Table 7-13 shows the effect of the combination of regional detention at Sites 2 and 3 on flood elevations and flood potential in the Oaken Drive and Stillbrook Lane damage reaches. Figures 7-3a and 7-3b show the residences for which the flood potential is reduced as a result of the detention alternative. Peak discharges for each event would be reduced by approximately 50%. Detention does not eliminate the 100-year existing condition flood potential for the area, but the ponds cannot be increased in storage capability without impacting residents and roads near the ponds. To completely eliminate the 100-year flood potential in the Oaken Drive damage reach, a combination of alternatives, such as detention and property purchases, would be needed.

Figure 7-9. Potential Locations of Regional Detention on North Fork

The effect of the analyzed detention alternative on Beaver Creek downstream of North Fork was insignificant, with an increase in peak discharge of less than 1% for the 100-year event.

Table 7-13. Effect of Regional Detention on Flood Potential in North Fork

Land Use Condition	Pre or Post Detention	Elevation (ft) at RM 1.053		Number of Flooded Homes			
				Oaken Drive		Stillbrook Lane	
		10-year	100-year	10-year	100-year	10-year	100-year
Existing	Pre	1039.0	1040.3	3	5	0	2
	Post	1038.2	1039.1	0	3	0	0
Future	Pre	1040.0	1041.5	4	9	2	4
	Post	1038.8	1039.7	3	3	0	2

An estimate of the cost to design and construct the regional detention ponds at sites two and three was determined and is provided in Table 7-14. It should be noted that if constructed, the embankments at the downstream end of the detention ponds have the potential to fall under the Safe Dams Act and would require special safety and regulatory considerations, regular maintenance, and permitting. These costs were not included in the estimate.

Table 7-14. Estimated Costs, North Fork Regional Detention Pond Alternative

Task	Site 1 Costs	Site 2 Costs
Property and R.O.W. acquisition	$52,000	$28,600
Design and construction	$420,000	$219,270
Site Totals	**$420,000**	**$219,270**
SUBTOTAL	**$639,270**	
10% contingency	$63,927	
TOTAL CONSTRUCTION COST	**$703,197**	

7.2.5 Conclusions

A comparison of costs and effectiveness of the three flood solution alternatives for Oaken Drive is presented in Table 7-15. The effective cost is the cost required to eliminate the 100-year existing condition FFE flood potential *in the Oaken Drive damage reach*. Combinations of the three flood solution alternatives were not analyzed, however they may produce varying degrees of success in reducing and/or eliminating flood potential along North Fork. All three alternatives could be considered simultaneously with the design of the regional ponds and channel improvement adjusted to meet the specified goal. In this case, however, the cost of any combination will be greater than choosing one of the stand-alone alternatives.

Table 7-15. Summary Table of Alternatives for the Oaken Drive Damage Reach

	No. of FFEs Flooded				Costs (in present day dollars)		
	100-Year Existing		100-Year Future				
Alternative	**Pre**	**Post**	**Pre**	**Post**	**Construction**	**Structure Acquisition**	**Effective Cost**
Property Purchase	5	0	10	5	$0	$788,040	**$788,040**
Channel Improvement	5	0	10	6	$569,773	$0	**$569,773**
Regional Detention	5	3[1]	10	3[2]	$703,197	$314,457	**$1,017,654**

1 - also causes a flood potential reduction of 2 structures in the Stillbrook Lane damage reach
2 - also causes a flood potential reduction of 2 structures in the Lena Lane damage reach, 2 structures in the Stillbrook Lane damage reach and 1 structure on Ventura Drive

Each flood solution alternative achieves some level of success in reducing the flood potential for the Oaken Drive area, however there are positive and negative factors associated with each alternative that should be considered. The pros and cons for each alternative are listed in Table 7-16.

7.2.6 Recommendations

Based on the analysis and cost estimate, regional detention is the least attractive alternative. The cost of this alternative is the highest and requires a combination of detention and property purchases. In addition, this alternative would also impose the largest burden on the County after construction, as the maintenance and continued permitting issues would be the greatest.

Table 7-16. Summary of Pros and Cons for Oaken Drive Alternatives

Alternative	Pros	Cons
1. Purchase Flooded Homes	• Eliminates all flood potential on Oaken Drive for existing conditions. • No construction of storm water facilities or associated maintenance required.	• Does not lower flood stages • Does not change flood potential for future conditions
2. Channel Improvements	• Eliminates all flood potential on Oaken Drive for existing conditions • Least expensive alternative • Eliminates some nuisance flooding • Reduces future condition flood potential	• Requires possibly unpopular property acquisitions • Increases downstream flood potential • Potential environmental permitting requirements for construction
3. Regional Detention	• Reduces flood potential at Oaken Drive • Also reduces flood potential at Lena Lane and Stillbrook Avenue	• Most costly alternative considered • Does not eliminate existing flooding in the Oaken Drive area. • Requires purchase of non-flooded property for flood control • The County will assume post construction maintenance responsibilities • Potential environmental permitting requirements for construction

If the County decides to take action to relieve the flood potential for the Oaken Drive area, Alternatives 1 and 2 should be considered for implementation. The purchase of flood-prone property (Alternative 1), while not the least expensive alternative, solves the *existing* flood potential problem in the Oaken Drive damage reach. The location of this area within a residential neighborhood and its close proximity to Halls Middle School would indicate an ideal location for a dry-weather park or recreation facility. However, this alternative provides no relief to nearby residents potentially impacted by flooding in the future.

The channel conveyance improvement (Alternative 2) is cost effective, in that it is the least expensive alternative and eliminates the flood potential for existing conditions. However, while the analysis predicts that the future flood potential would be reduced, the channel improvement must be designed in coordination with upstream land use expectations to maintain effective performance in the future. Discussions with residents during the field investigation indicated there would be some opposition to the channel improvement alternative by local residents if the improvement required acquisition and excavation of their property (i.e., their backyards). Resident interviews indicate that there is the perception that the construction of the athletic fields at Halls Middle School has been the primary cause of recent flooding, and residents indicated they felt that the school property should bear the brunt of any improvement. Also, the County should prepare for opposition or complaints from residents downstream. Public perception may link flooding in the Lena Lane damage reach with channel improvements in the Oaken Drive damage reach, when it may actually be due to backwater effects.

All of these things considered, the following actions are recommended:

- The County should clear the channel of debris and restore lost conveyance from debris accumulation. During the field investigation significant channel blockage was observed at RM 0.843. Debris and vegetation should be removed from the main flow channel, however, care should be taken not to remove trees and vegetation from the channel banks or outside the top of bank.

- The County should decide if action is to be taken to eliminate the existing flood potential along Oaken Drive based on the funding requirements for implementing Alternative 1 or 2 and budget considerations.

- Based on the cost alone, channel improvements should be considered further. The preliminary cost estimate indicates this alternative is $218,267 less expensive than a property purchase.

- A citizen meeting should be conducted to inform the impacted community of the options for flood relief and associated costs. At this point, the willingness of the impacted residents to either accept a buyout or sell the drainage easement necessary for the channel improvement could be gauged.

- The predicted development pattern in the North Fork basin, based on the MPC 15-Year Development Plan, is for 98% of the basin to be developed. Approximately 89% of the developed area predicted to be medium density residential. Regardless of the chosen alternative to alleviate the existing flood potential, future growth in the North Fork basin must be addressed. The future flood potential is not totally mitigated by any of the alternatives, therefore the County should plan appropriately for future flood impacts using non-structural BMPs to reduce the increases in future runoff volume.

7.3 Plumb Creek - Lovell Road Bridge Priority Area

7.3.1 Background

The road overtopping analysis presented in Sections 4 and 5 indicated the Lovell Road bridge over Plumb Creek has the highest potential of any structure in the Beaver Creek watershed for being overtopped during high frequency storm events. Table 7-17 presents the results of the Plumb Creek HEC-RAS model for all events.

Table 7-17. Lovell Road Overtopping – Plumb Creek

	Flood Elevation (ft NAVD)		Depth of Water on Roadway (ft)	
Flood Event	**Existing**	**Future**	**Existing**	**Future**
2-year	952.80	954.28	0.6	2.1
10-year	955.28	956.29	3.1	4.1
25-year	956.07	957.05	3.9	4.9
100-year	957.15	958.06	5.0	5.9
500-year	958.00	958.85	5.8	6.7

Figure 7-10 shows the location of Lovell Road bridge and the surrounding area, along with the 100-year existing condition floodplain. The bridge is located at Plumb Creek RM 0.672 near the intersection of Lovell Road with Middlebrook Pike, which are two heavily traveled roadways in Knox County. The two structures located inside the floodplain south of the intersection are a Weigel's Market (structure # PC3) and its gasoline pump station. The structures located in the floodplain to the west of the intersection (structures PC21 and PC17) are residences. As the figure shows, very few FFEs in the area were surveyed.

The HEC-RAS model of Plumb Creek indicates that the existing structure is undersized for the discharges seen in Plumb Creek. The existing structure is a bridge with an opening approximately 4 to 5-feet in height and about 30-feet wide, with a 2-feet wide pier. The calculated open flow area under the bridge is approximately 108 square feet. The elevation of the top of the roadway is 952.2 feet. The driveway culvert located just downstream of Lovell Road (dual CMP's, approximately 4 feet in diameter) is also undersized. As a reference for required size for the structures, the Hardin Valley Road stream crossing over Plumb Creek, constructed in 1997 as part of the realignment and widening of Hardin Valley Road, consists of two 15.5 x 15.5 ft concrete box culverts. This structure is located just 0.3 miles downstream of the Lovell Road bridge.

Figure 7-10 Lovell Road

Preliminary investigation using the HEC-RAS model shows that the problem at Lovell Road is primarily due to headwater conditions. Therefore, the removal or re-sizing of the driveway culvert located downstream will not alleviate the flooding at Lovell Road and the slope and geometry of the existing channel do not allow for substantial channel improvement. Regional detention upstream of the area is not a possibility either. The only large tract of undeveloped land located close enough to Lovell Road to be effective (east of Middlebrook Pike toward Bob Kirby Road) already provides storage for backwater from Plumb Creek during large events. Damming this area to detain upstream flows could worsen the problem elsewhere on Plumb Creek.

The most viable solution to the problem is to redesign the structure and raise the road. This solution is made even more attractive in light of the planned widening of Middlebrook Pike in this area, and potential re-alignment of the Lovell Road – Middlebrook Pike intersection. The Tennessee Department of Transportation (TDOT) should be consulted to determine the scope of the Middlebrook project.

7.3.2 Conceptual Design

A conceptual design for a new structure at Lovell Road was developed using the HEC-RAS model of Plumb Creek. It was determined that two 14' x 14' box culverts will pass the existing condition 100-year flood beneath the roadway, which would be raised approximately seven feet elevation 959. Increasing the design to dual 15'x 15' box culverts will allow the future condition 100-year flood to pass beneath the roadway. For this design, the top of roadway would be raised to 960 ft.

There was no consideration given to the Weigel's market and residential structures located in the floodplain. It was assumed that these structures would be removed or otherwise handled as part of the Middlebrook Pike widening project. However, it should be noted that the redesign and construction of a new structure for Lovell Road will not improve the flood situation for these structures.

The effect of improvement of the Lovell Road bridge on the upstream channel was examined. As a result of raising the road for the new culvert, flood elevations upstream increase approximately 1.0 to 1.5 feet, immediately upstream of Lovell Road. The elevation increase gradually decreases in magnitude further upstream in Plumb Creek, but extends to RM 1.008. Because there are few surveyed FFE's in the area, the effect on flood potential for structures in the floodplain could not be determined.

The estimated cost for improvement of the Lovell Road bridge over Plumb Creek is shown in Table 7-18. The cost was determined assuming no realignment of the Lovell Road – Middlebrook Pike intersection. It was assumed that Lovell Road would be elevated 8 ft to match grad at Middlebrook Pike and provide clearance for the new boxes.

Table 7-18. Estimated Costs, Lovell Road Bridge Improvement

Task	Estimated Cost
Box Culverts (2 @15 ft. x 15 ft.)	$70,000
Roadway	$135,000
Design and Management	$30,750
Contingency (10%)	$20,500
TOTAL COST	**$256,250**

7.3.3 Recommendations

Because the area will change as a result of the impending improvement of Middlebrook Pike, the County should improve the Lovell Road bridge using the results of the HEC-1 and HEC-RAS models developed for the Beaver Creek Master Plan. The County should also coordinate with TDOT to not duplicate design or construction efforts.

7.4 Plumb Creek Basin – Bob Kirby Road Priority Area

7.4.1 Background

In the past three to five years, Knox County Department of Engineering and Public Works has received complaints of roadway and property flooding in the Bob Kirby Road priority area, located in the Plumb Creek basin in west Knox County. Interviews with Knox County Engineering and Public Works staff and a relative of the resident at 1516 Bob Kirby Road indicate that the flooding of the road and property in front of the residence was not an uncommon event, but was usually fairly minor. However, a flood event in 1999 was more serious, causing the road to become impassable and threatening to flood the house.

Figure 7-11 shows the area of concern and the 100-year and 500-year existing condition floodplain calculated using the HEC-RAS model of Plumb Creek. The locations of flood complaints, ordered from upstream to downstream, are as follows:

1. a private driveway at 1401 Bob Kirby Road;
2. Chesney Road approximately 450’ southwest of the Bob Kirby Road intersection;
3. Bob Kirby Road near the intersection with Secretariat Boulevard; and,
4. residential property located at 1516 Bob Kirby Road.

The flooded areas are located on a wet weather conveyance that drains to Plumb Creek at R.M. 0.780 via the flow path shown in Figure 7-11. Both Chesney Road and Bob Kirby Road are classified as Major Collectors in the Knox County transportation network presented in the Northwest County Sector Plan developed by the MPC.

Overtopping of the private driveway and Chesney Road are caused by undersized culverts. Overtopping of Bob Kirby Road and of the property at 1516 Bob Kirby Road are caused by a several factors. During extreme flood events, backwater from Plumb Creek can extend into the area, as shown for the 100-year and 500-year events in Figure 7-11. The elevation of the backwater predicted by the HEC-RAS model is not high enough to cause roadway overtopping, however it can reduce the discharge capacity of the channel along Bob Kirby Road. Beaver dams in the backwater area or debris in the Secretariat Boulevard culverts or Bob Kirby Road channel have also been suspected of causing flood conditions. At the time of the 1999 flood event, large boulders and debris limited the capacity of the Bob Kirby Road channel. In an effort to prevent future flood problems along Bob Kirby Road, the County removed the beaver dams and cleared and widened the channel. To date, the channel has not overtopped since these actions were taken.

Figure 7-11 – Plumb Creek – Bob Kirby Road Priority Area

7.4.2 Analysis

Initial analysis focused on two detention ponds located at the upstream end of the wet weather conveyance to determine if the ponds were the cause of roadway overtopping downstream. The ponds provide detention for the Delle Meade and Kirby Glen subdivisions. Neither pond was constructed to the specifications shown on their respective design drawings. In fact, the Delle Meade pond is significantly smaller in volume than originally designed. However, HEC-1 analysis including the ponds indicates that the proper re-design and construction of the ponds would not relieve the roadway overtopping problems downstream. It was also determined that improvement of the detention ponds to eliminate the overtopping of the driveway at 1401 Bob Kirby Road could not be performed without impacting the residents living near the ponds.

Although two potentially useful locations were identified, regional detention as a flood solution alternative was not considered at any location along the conveyance. The resident at 1401 Bob Kirby Road stated she would oppose installation of a regional detention facility upstream of the driveway to the residence. And the cost for the required property acquisition and construction for a regional detention pond located upstream of the Chesney Road culvert would greatly exceed any benefit the facility would provide.

Alternative drainage paths were not considered either. Topographic maps indicate that overflow drainage from the channel downstream of the Chesney Road culvert can also discharge to the north, along the driveway at 1501 Bob Kirby Road and down a steep embankment that discharges directly to Plumb Creek near HEC-RAS cross-section 1.162. This secondary drainage path is identified in Figure 7-11, and currently receives runoff from a portion of the Westbrooke subdivision. A flood solution alternative that would develop this route as the primary path for runoff was not considered due to the likely high expense of the alternative (easement acquisition, channel development, etc.), and the potential legal consequences of diverting runoff from the natural drainage path in the area.

The most viable flood solution alternative therefore, was the improvement of culverts and channels along to wet weather conveyance to mitigate flooding. The HEC-1 model of Plumb Creek was refined throughout the area of interest to determine peak flows at the overtopped roadways and assist in the development of conceptual designs for any culvert or channel improvements. No survey was performed for this effort. Data such as existing roadway elevations and culvert inverts were estimated using topographic mapping and visual observations. In accordance with Knox County's current roadway drainage design criteria, the goal of the analysis was to eliminate overtopping of private driveways for the 10-yr existing storm event, and at public roadways for the 25-yr existing storm event. The pre- (i.e., current) and post-project configurations of the culverts and channels that require improvement are listed, in order from upstream to downstream, in Table 7-19.

Table 7-19. Conceptual Culvert/Channel Improvements, Bob Kirby Road Priority Area

Location	Pre-Project Configuration	Post-Project Improvement	Design Event
1401 Bob Kirby Road	24” CMP	Two 36” CMPs	10-yr existing
Chesney Road	24” CMP	Three 36” CMPs	25-yr existing
1501 Bob Kirby Road	24” CMP	Three 36” CMPs Raise driveway 1.5 ft	10-yr existing
1505 Bob Kirby Road	Four 12” CMPs	Three 36” CMPs	10-yr existing
Secretariat Boulevard	Two 36” CMPs	Three 36” CMPs	25-yr existing
Bob Kirby Road Channel	4.5’ avg. width 2.5 ft avg. depth steep side slopes	Stabilize side slopes and bed through vegetation and regrading	25-yr existing

Installation of three 36” culverts at Chesney Road will likely cause the overtopping of two private driveways located at 1501 and 1505 Bob Kirby Road. Although there are no known complaints of driveway overtopping at these locations, field observations and analysis indicate they overtop in their existing condition whenever peak flows are sufficient to overtop Chesney Road. Like Chesney Road, the driveways have very low road profiles and small diameter culverts that are insufficient to pass the 2-year storm events. The driveway at 1501 Bob Kirby Road would need to be raised approximately 1.5 feet to accommodate the proposed culverts, however care should be taken in the final design of the culvert under this driveway to prevent backwater conditions upstream of the culvert.

Significant erosion of the channel bottom and side slopes of the Bob Kirby Road channel was noted during a field inspection. The existing capacity of the channel is sufficient to carry the discharges from the 25-year flood, however the channel will require additional maintenance to preserve the 25-year capacity. Channel stabilization methods (re-grade the side slopes, establish vegetative cover, etc.) should be implemented to prevent further degradation and potential filling of the improved channel.

7.4.3 Additional Considerations

The Chesney Road culvert discharges into a channel that bounds the northeast corner of the Westbrooke subdivision. An earthen berm bounds the left bank of the channel to prevent overflow from the channel into the subdivision. Based on channel geometry data estimated in the field and 2-foot contours from existing topographic mapping, analysis indicates that the existing channel will accommodate the peak discharges for the 25-year existing condition event. However, if improvements are made it is highly recommended that the berm and channel be surveyed and examined more closely to determine the necessity for, and magnitude of, any improvement.

The effects of the conceptual culvert improvements on peak discharges in Plumb Creek were also examined. Peak discharges for the 10-year event increase approximately 30 cfs due to the increased conveyance from the wet weather drainage, resulting in an approximate 0.1-foot rise in the water surface at RM 0.858. Peak discharges on Beaver Creek downstream of Plumb Creek did not increase.

7.4.4 Total Project Cost

The costs for the analyzed culvert and channel improvements are presented in Table 7-20.

Table 7-20. Estimated Costs, Bob Kirby Road Priority Area

Location	Post-Project Improvement	Cost
1401 Bob Kirby Road	Two 36" CMPs	$8,205
Chesney Road	Three 36" CMPs	$13,455
1501 Bob Kirby Road	Three 36" CMPs Raise driveway 1.5 ft	$13,570
1505 Bob Kirby Road	Three 36" CMPs	$9,260
Secretariat Boulevard	Three 36" CMPs	$17,250
Bob Kirby Road Channel	Stabilize side slopes and bed through vegetation and regrading	$14,490
SUBTOTAL		$76,230
10% Contingency		$7,623
TOTAL COST		**$83,853**

The costs shown in Table 7-20 are based on the labor and materials required to improve the drainage assuming the improvement at 1401 Bob Kirby Road is made. Improvement of the culvert at that location eliminates drainage over the driveway and therefore reduces the peak discharge. If the improvement is not made, peak discharges downstream of 1401 Bob Kirby Road are higher and one additional 36-inch CMP will need to be installed under Chesney Road and Secretariat Boulevard, and the channel bounding the Westbrooke subdivision will likely require improvement.

7.4.5 Recommendations

- The County should decide if action is to be taken to eliminate the existing flood problems in the Plumb Creek basin based on the funding requirements listed in Table 7-20.

- Regardless of the actions taken elsewhere in this study area, the County should stabilize and maintain the channel along Bob Kirby Road, downstream of Secretariat Boulevard. Field observations and resident interviews indicate that the initial clearance of debris from the channel by the County was effective in eliminating frequent flooding of the road and property at 1516 Bob Kirby Road. This reduction in flood potential should not be lost due to on-going erosion and sedimentation in the channel.

- Medium-density residential development is the predicted future land use type for the majority of the study area, based on the MPC 15-Year Development Plan, is medium-density residential. Future local detention facilities constructed in any new developments must be effective to keep peak discharges in the drainageway at a manageable level. The County should take steps to review and inspect drainage plans and as-built configurations for future development in the area.

7.4.6 The Spring at 1516 Bob Kirby Road

Information on Eldridge spring located on the property at 1516 Bob Kirby Road was gathered through interviews with County staff and a close relative of the owner of the property. The relative has lived on Bob Kirby Road within walking distance of the spring for over 40 years and therefore could provide a historical background. In the past, the spring discharged to a small channel and flowed unimpeded through the 36-inch CMP under Bob Kirby Road. Estimates of the rate of discharge from the spring have ranged from 600 gallons per minute (gpm) to 2000 gpm. The relative believes that discharge from the spring does fluctuate with the general hydrologic conditions of the area (i.e., wet or dry), but it has never threatened to flood the nearby house or property. The spring was used for drinking water for nearby homes.

In recent years, water ponds in the area between the spring and the culvert, widening the channel and backing up the water into the area of the spring. The resident states that the original ponding occurred when beaver dams, located downstream of the Bob Kirby Road culvert, caused backwater to extend to the spring. However, the impounded water did not dissipate after the beaver dams were removed. In addition, County staff cleared the culvert of debris in late 1999, again with no effect on the ponded water. The relative complains that the area of impoundment continues to gradually grow and has become a breeding ground for mosquitoes and rodents, and that the quality of the water at the spring has degraded to the point that it can no longer be used for drinking water. The relative has plans to build a new house on the property, at a location near the west edge of the existing pond.

Visual observations of culvert under Bob Kirby Road and downstream channel generally confirm the order of magnitude of the flow rate from the spring. The extent of the pond is somewhat larger in area than shown on planimetric mapping. The culvert is essentially clear of debris, and no blockages were found that could cause ponding upstream. During storm events, the culvert also discharges storm water runoff from a surrounding undeveloped drainage area of approximately 30 acres. HEC-1 analysis indicates that the capacity of the 36-inch culvert is sufficient to carry the maximum quoted flow rate from the spring of 2000 gpm (approximately 4.5 cfs), along with the 100-year existing condition peak discharge from the surrounding drainage area.

The ponded area upstream of the culvert has few trees and shrubs to stabilize the channel banks. The relative of the resident indicated that, prior to the ponding, the area around the spring and stream channel was maintained by the resident in a park-like manner (regularly mowed, clear of debris, etc.). These maintenance practices, combined with the lack of stabilizing vegetation and an extended period of backwater caused by the beaver dams, suggest that the original channel gradually degraded and filled with sediment during the period of backwater. The slope of the channel decreased and the banks widened to create a pond as opposed to a narrow stream channel.

Eliminating the pond and returning the area to a channelized stream would require re-grading and re-creating a stream channel, stabilizing the channel, and filling and vegetating the currently ponded area. There will be ARAP permitting issues associated with such a project, and potential other permitting problems if the ponded area is considered a wetland. The estimated cost associated with such a project is shown in Table 7-21. A rough estimate of potential costs for dealing with these issues was included in this estimate.

Table 7-21. Estimated Costs, Spring at 1516 Bob Kirby Road

Task	Estimated Cost
Channel improvements and stabilization	$11,738
Fill of currently ponded area and vegetation	$37,045
Expenses, fees to deal with permitting issues	$5,000
SUBTOTAL	$52,783
10% Contingency	$5,278
TOTAL COST	**$58,061**

A second alternative is to simply leave the existing pond as is, stabilize the banks to prevent further degradation, and advise the resident on sound maintenance practices. A rough estimate for the cost of this alternative is between $2,000 and $15,000, depending upon the extent of the project. Some factors to consider include the amount of vegetation needed for bank stabilization and whether any grading is needed to effect a higher drainage rate in an effort to keep the pond clean of decaying vegetation.

All things considered, it can be concluded, based on resident interviews and the results of the HEC-1 model, that flooding is not an issue at the spring at 1516 Bob Kirby Road. The question of whether or not the existence of the pond is an issue that the County should address can not be determined by models or technical analysis, and must be resolved between the County and the current resident. Should the County decide to take action, stabilizing the banks of the existing pond and advising the resident on pond maintenance practices is the recommended alternative from a cost/benefit standpoint.

7.5 Beaver Creek –Karns Priority Area

7.5.1 Background

The Knox County Department of Engineering and Public Works has received annual complaints of yard and crawlspace flooding at residential structures adjacent to Beaver Creek near Oak Ridge Highway. There have been no reported instances of finished floor flooding, however crawlspace flooding is reported frequently. Flooding occurs between RM 16.190 and RM 15.834.

Figure 7-12 shows the existing condition 100-year and 500-year floodplains and the flood potential for all habitable structures located in the area. The figure also shows that the roadway crosses several oxbows in Beaver Creek. The land inside the oxbows is low, poorly drained, and serves as a natural floodplain storage area.

Based on the floodplain mapping, field investigation and field survey, ten habitable structures are located in the 500-year floodplain and two of these structures are located in the 100-year floodway. Comparison of FFE elevations with HEC-RAS model results indicates that of the ten structures, four have FFE flood potential for the 100-year event and six additional structures have FFE flood potential for the 500-year event. The flood potential for all events in the Karns damage reach is summarized in Table 7-22.

Table 7-22. Flood Potential – Karns Priority Area

	Number of Houses Flooded (based on surveyed FFEs)	
Storm Event	**Existing**	**Future**
2-year	0	0
10-year	1	2
25-year	2	2
100-year	4	5
500-year	10	11

Figure 7-12

Table 7-23 is a list of the addresses and the flood depths for all events for the 4 structures located along in the priority area that have flood potential in the 100-year existing condition event.

Table 7-23. Structures with 100-Year Existing Condition Flood Potential - Karns Area

Structure #	Address	FFE (ft NAVD)	Existing Condition Depth of flooding (ft) (a negative sign indicates no flooding)				
			2-Year	10-Year	25-Year	100-Year	500-year
142	8021 Oak Ridge Hwy	954.97	-8.74	-3.27	-1.49	0.98	3.75
146	8008 Oak Ridge Hwy	956.03	-9.43	-4.01	-2.23	0.25	3.04
148	7946 Oak Ridge Hwy	956.80	-6.52	-1.26	0.49	2.87	5.29
149	7941 Oak Ridge Hwy	954.13	-3.85	1.41	3.16	5.54	7.96

7.5.2 Analysis

The cause of flooding in the area is headwater in Beaver Creek. Of the potential flood solution alternatives (i.e., property purchase, flood proofing, channel improvements, and regional detention), property purchase is the only viable possibility for the area. A flood proofing measure, such as a levee along Beaver Creek, is not practical from a hydraulic standpoint because of the oxbows and the natural tendency of the creek to relocate. It would also eliminate valuable flood storage from the Creek, potentially impacting structures located elsewhere along the creek. An estimate of the base cost to raise a 1200 square foot home approximately two-feet is approximately $75,000, therefore, based on the depth of flooding at some structures (over 5 feet), raising the flooded houses could be a highly expensive option, and probably not feasible at some locations. In addition, the raised homes would still be left with safety and access problems, flooded property and potential future damage due to hydrostatic pressures during flood events. A berm or floodwall would only be practical at structure #12 (shown in Figure 7-12), where a structure located on the west side of the structure could prevent flooding without eliminating floodplain storage.

Regional detention is not viable or cost effective due to the large storage area that would be required to hold the volume of water that discharges through the lower third of Beaver Creek. Any open areas upstream of the damage reach that have sufficient area for such a regional facility are bordered by residential developments that could be negatively impacted.

Channel improvements are not practical because the water surface elevation needed to keep structures from flooding for the 100-year event is less than the water surface elevation immediately upstream of Oak Ridge Highway. Therefore, any channel improvements would have to extend downstream of the roadway and would include installation of a larger hydraulic opening at Oak Ridge Highway. Modification of the bridge alone would be more expensive than the combined cost of the residential structures that the channel improvement project would protect. In addition, the existing bridge does not cause excessive backwater and does not warrant replacement.

Therefore the only viable alternative for flood mitigation is purchase of flooded properties. The four structures that have a 100-year existing flood potential consist of three residential properties and one commercial property (the Nantucket Nursery & Garden located at 7941 Oak Ridge Highway). The estimated cost to purchase each prioritized property was estimated at approximately $120,000 per property. The cost for the commercial property is the value or the property quoted by the County tax assessor. The total estimated cost for this alternative is shown in Table 7-24. It was assumed that the structures would be demolished after purchase, and the cost for demolition was considered. Other uses or fates for the purchased structures may change these costs. Of course, the purchase of these structures would be contingent on the owner's agreement to sell.

Table 7-24. Estimated Costs, Karns Area Property Purchases

Task	Estimated Cost
Property purchases (3 residential)	$360,000
Property purchases (1 commercial)	$101,200
Property purchase additional costs	$10,500
Demolition and site preparation	$77,625
SUBTOTAL	$549,325
10% contingency	$54,932
TOTAL COST	**$604,258**

7.5.3 Recommendations

Should the County decide to take action to relieve flooding in the Karns area on Beaver Creek, a property buyout is the recommended alternative.

7.6 Hines Branch Priority Area

7.6.1 Background

The Knox County Department of Engineering and Public Works has received complaints of flooding in the Mynatt Drive area, located at approximately RM 1.967 on Hines Branch. Flooding in 1998 threatened businesses located along Maynardville Highway and moved several trailer homes located along the stream off of their foundations. The flood potential in this area was examined using the results of the existing and future HEC-RAS models and flood solution alternatives were analyzed.

Figure 7-13 shows the location of the 100-year and 500-year existing condition floodplains along Hines Branch and the damage reach where flooding has been a problem. Structures with FFE flood potential within the damage reach consist of a number of commercial properties located on Maynardville Highway and mobile homes located off of Mynatt Drive, particularly in Northridge Estates Mobile Home Park and Fountain City Mobile Home Park. Approximately 80 mobile homes are located in or touching the 100-year and/or 500-year floodplain, however FFEs were surveyed for only a select few. The flood potential for mobile homes not surveyed was estimated based on known FFEs of surveyed homes and visual inspection at the site.

To determine the extent of the flood potential in these areas, the surveyed FFE's and estimated FFEs were compared to flood elevations from the HEC-RAS model. The structures that have FFE's below the 100-year and 500-year flood elevations are indicated in Figure 7-13. Table 7-25 presents flood potential in the damage reach for all events in both the existing and future conditions.

Table 7-25. Structures with FFE Flood Potential – Hines Branch

	Number of Structures Flooded (based on surveyed and estimated FFEs)					
	Maynardville Highway area		Mynatt Drive area[1]		Entire Hines Branch	
Storm Event	Existing	Future	Existing	Future	Existing	Future
2-yr	0	0	0	0	0	0
10-yr	2	3	31	36	34	40
25-yr	3	3	61	61	65	65
100-yr	4	4	71	71	76	76
500-yr	4	4	73	73	79	80

1 - Due to the impermanent nature of mobile homes, the majority of FFE flood potential values for mobile homes in the Mynatt Drive area have been estimated based on selected surveyed structures.

Figure 7-13. Hines Branch Damage Reach

The flood potential in the Hines Branch damage reach is due to hydraulic conditions within the stream and could possibly be solved using structural measures, such as detention ponds or channel improvements. The flood potential in the Mynatt Drive area poses the greater safety concern because of the higher frequency of flooding. Flooding is predicted at thirty-one mobile homes for the 10-year event.

Table 7-26 is a list of the addresses and the flood depths for all events for the surveyed structures located along in the priority area that have flood potential in the 100-year existing condition event.

Table 7-26. Structures with 100-Year Existing Condition Flood Potential -Hines Branch

Structure #	Address	FFE (ft NAVD)	Existing Condition Depth of flooding (ft) (a negative sign indicates no flooding)				
			2-Year	10-Year	25-Year	100-Year	500-year
HB12	6617 Maynardville Hwy.	1060.41	-6.11	0.78	1.18	1.75	2.19
HB23	6615 Maynardville Hwy.	1062.10	-7.64	-0.87	-0.45	0.15	0.61
HB25	6533 Maynardville Hwy.	1062.31	-1.63	-0.07	0.32	0.87	1.36
HB26	6525 Maynardville Hwy.	1062.31	-1.60	0.05	0.47	1.07	1.60
HB42	6517 Maynardville Hwy.	1061.50	-0.69	1.02	1.47	2.12	2.67
HB43	6517 Maynardville Hwy.	1061.60	-0.79	0.92	1.37	2.02	2.57
HB39	Fountain City MHP lot 34B	1061.87	-0.69	1.09	1.60	2.31	2.88
HB35	Fountain City MHP lot 34	1061.42	-0.18	1.63	2.17	2.91	3.52
HB10	3631 Rothmoor Dr.	1064.12	-2.74	-0.83	-0.25	0.53	1.15
HB11	3715 Mynatt Rd.	1062.38	-1.00	0.91	1.49	2.27	2.89
HB27	Northridge Estates MHP Lot 53	1068.54	-3.24	-1.27	-0.59	0.32	1.06
HB29	Northridge Estates MHP Lot 51	1067.69	-0.98	0.59	1.19	2.04	2.69
HB30	Northridge Estates MHP Lot 70	1068.81	-1.77	-0.06	0.63	1.61	2.41
HB31	Northridge Estates MHP Lot 39	1070.25	-1.41	0.37	0.98	1.84	2.57
Remaining 65 mobile homes		Not Surveyed					

The goal of the analysis was to eliminate the 100-year existing condition flood potential in the Hines Branch damage reach and, if feasible, reduce the flood potential for future condition events. Three conceptual alternatives were considered and are discussed in detail below:

1. purchase of flood-prone properties;
2. channel and culvert/bridge improvements; and
3. one or more regional detention facilities upstream of the affected area(s).

7.6.2 Alternative 1: Purchase of flood-prone properties

As shown in Table 7-25, a total of 75 structures in the Hines Branch damage reach face potential flooding for the 100-year storm event in the existing *and* future conditions, therefore purchase of all properties would eliminate the flood potential for both conditions. The estimated cost for purchase of all properties is shown in Table 7-27. The 75 structures are comprised of 6 commercial buildings (including a gas/service station) and 69 mobile homes. The value of each commercial property was gathered from the County tax assessor and the value of each mobile home lot was estimated at $25,000 per lot. It was found that the property at 6617 Maynardville Highway consists of the two commercial structures associated with Ace Auto Sales (Structure No. HB42 and HB43) and 32 mobile homes, so the purchase price of these 32 mobile homes was assumed to be included in the value for the entire property. Additional costs associated with relocating mobile homes to new locations were not considered.

It was assumed that the commercial structures would be demolished after purchase, and the cost for demolition was considered. Other uses or fates for the purchased properties may change these costs. Of course, the purchase of these properties would be contingent upon the owner's agreement to sell their property.

The estimate for demolition and site preparation shown in Table 7-27 includes costs associated with the removal of the underground storage tank(s) (UST) at with the gas station. It was assumed there has been no leakage from the tank and contamination of nearby soils. By visual inspection, the station appears to be many years old, therefore the UST could be old and degraded. Leakage from the tank will greatly increase the total cost of this option because of the environmental clean-up issues associated with UST removal.

Table 7-27. Estimated Costs, Hines Branch Property Purchases

Task	Estimated Cost
Property purchases (37 mobile homes)	$925,000
Property purchases (6 commercial) Includes 32 mobile homes	$2,500,500
Property purchase additional costs	$147,000
Demolition and site preparation	$540,270
SUBTOTAL	$3,187,770
10% contingency	$318,777
TOTAL COST	**$3,506,547**

7.6.3 Alternative 2: Channel and culvert/bridge conveyance improvements

Improved channel and culvert conveyance was analyzed for the reach on Hines Branch, between RM 1.155 and the upstream end of the detailed study at RM 2.225. Four culverts and one bridge are located within the Maynardville Hwy and Mynatt Drive damage reaches, and each produce backwater effects that increase water surface elevations and therefore flood potential. The culverts are listed, from downstream to upstream, in Table 7-28.

Table 7-28. Culvert/Bridge Information, Hines Branch Damage Reach

No.	General Location	HEC-RAS Location	Type/Size	Event Overtopped
1	Under Amoco Gas Station at 6621 Maynardville Highway	RM 1.424	8.8' x 9.5' concrete box culvert	10-yr existing
2	Shotsman Lane	RM 1.562	6' diameter CMP	10-yr existing
3	Mynatt Drive	RM 1.877	bridge 89 sq. ft. opening	10-yr existing
4	Trailer Park driveway #1	RM 1.978	60" diameter CMP (slightly crushed)	2-yr existing
5	Trailer Park driveway #2	RM 2.009	60" diameter CMP (slightly crushed)	2-yr existing

The Amoco station culvert is approximately 350 feet in length and produces a significant rise in the flood elevation upstream of the culvert. The elimination this and the other four structures and embankments was analyzed to simulate improvement to zero-rise structures. This does not eliminate FFE flooding, which indicates the need for channel improvements.

Channel improvements were analyzed using the Hines Branch HEC-RAS model. The conceptual channel design consists of widening and re-grading the channel to the extent that the 100-year existing condition flood potential was eliminated. A field visit was performed to investigate the hydraulic and hydrologic conditions in the areas of interest. It was determined that Hines Branch varies in size and efficiency through the study reach. Throughout the Maynardville Highway damage reach the stream is highly channelized with a bank-full top width approximately 70 feet wide and 10 to 15 feet deep. Bedrock outcroppings were noted at the downstream of the culvert at the Amoco station. This portion of the channel is shown in Figures 7-14 and 7-15. Within the Mynatt Drive damage reach, the main channel is smaller: 15 to 20 feet wide and approximately 4 feet deep. This portion of the channel is shown in Figure 7-16.

The estimated footprint of the conceptual channel and culvert improvement is shown in Figure 7-17. The minimization of the estimated channel improvement footprint was a primary concern during the analysis, due the close proximity of both residences and commercial properties to the existing channel. The basic improved channel consists of a trapezoidal cut of maintained grass, having a 12 foot base, 2:1 side slopes (H: V), and a slope of 0.0070 from R.M. 1.155 to 2.225. The excavation requirements for this channel are approximately 42750 cu yd, and would disturb a strip of land 30 to 115 feet wide adjacent to the channel. Excavation in some areas of the channel may be difficult due to the presence of bedrock.

Figure 7-14. Hines Branch at the downstream face of the Amoco Station culvert

Figure 7-15. Hines Branch upstream of the Amoco Station culvert (looking upstream)

Figure 7-16. Hines Branch upstream of the Trailer Park Driveway #1 culvert (looking upstream)

Figure 7-17. **100-year existing condition floodplain, post-channel improvement.**

All five of the hydraulic structures located within the Maynardville Highway and Mynatt Drive damage reaches will require improvement to reduce backwater effects. The suggested improvements for the hydraulic structures for the conceptual design are shown in Table 7-29. The conceptual structures were sized to eliminate FFE flooding in the 100-year existing condition. Note that the conceptual design for structures 1, 2 and 3 exceeds the standard drainage design criteria for Knox County roadways (i.e., designed for the 25-year event). Designing for the 25-year event will not be sufficient to reduce the flood potential in the Hines Branch damage reaches.

Table 7-29. Conceptual Culvert/Bridge Design, Hines Branch Damage Reach

No.	General Location	HEC-RAS Location	Conceptual Type/Size	Event Overtopped
1	Under Amoco Gas Station at 6621 Maynardville Highway	RM 1.424	Two 10' x 12' concrete box culverts	None
2	Shotsman Lane	RM 1.562	Two 8' x 14' concrete box culverts	100-yr existing
3	Mynatt Drive	RM 1.877	bridge 172 sq.ft. opening	100-yr existing
4	Trailer Park driveway #1	RM 1.978	12' x 6' concrete box culvert	10-yr existing
5	Trailer Park driveway #2	RM 2.009	12' x 6' concrete box culvert	10-yr existing

The change in the FFE flood potential for the Maynardville Hwy and Mynatt Drive damage reaches after the implementation of the channel and culvert/bridge improvements is shown in Table 7-30. Note that flood elevations drop over 5 feet for the existing condition 10-year event and over 3 feet for the existing condition 100-year event. The future condition flood potential in the Maynardville Highway and Mynatt Drive damage reaches is also eliminated. This alternative also eliminates roadway overtopping of Maynardville Highway for all existing condition events.

Table 7-30. Effect of Channel Improvement on Flood Potential in Hines Branch

Land Use Condition	Pre or Post Channel Improvement	Elevation (ft) at RM 1.777		Number of Flooded Structures			
				Maynardville Hwy		Mynatt Drive	
		10-year	100-year	10-year	100-year	10-year	100-year
Existing	Pre	1062.95	1064.17	2	4	31	71
	Post	1057.31	1060.64	0	0	0	0
Future	Pre	1063.05	1064.25	3	4	36	71
	Post	1057.49	1060.90	0	0	0	0

A negative aspect to the proposed channel improvement is that it will reduce channel storage and increase peak discharges approximately 6% for the 100-year event in the Maynardville Highway damage reach. This results in a 0.3-foot rise in water surface elevation downstream of the channel improvement during the 10-yr existing condition event and causes an increased flood depth by 0.3 feet at one structure. The frequency of flooding does not increase, and no additional structures are flooded. Peak discharges on Beaver Creek downstream of Hines Branch did not increase as a result of the channel improvement.

The estimated costs associated with the channel improvement alternative are shown in Table 7-31.

Table 7-31. Estimated Costs, Hines Branch Channel Improvements

Task	Estimated Cost
Property and R.O.W. acquisition	$441,900
Design and construction	$2,819,229
SUBTOTAL	$3,261,199
10% Contingency	$326,120
TOTAL CONSTRUCTION COST	**$3,587,319**

7.6.4 Alternative 3: Regional detention of storm water runoff

The objective of this flood solution alternative is to reduce the 100-year flood potential using a regional detention pond. Extensive development prevents construction of a regional detention pond in the damage reach. However, a feasible location for a pond was located just upstream of the mobile home parks, as shown in Figure 7-13. Detention at this site can be achieved by constructing an embankment across the valley between Mynatt Drive and Rifle Range Road. A low-level outlet would provide drainage. The existing 100-yr 24-hr storm event returns an approximate peak stage of 1097 ft, when impounding 59 acre-ft of water. Peak discharges on Beaver Creek increased less than 1% for the 100-year event as a result of regional detention on Hines Branch.

Table 7-32 presents the effect of the regional detention alternative on flood potential in the Hines Branch damage reaches. The 56 structures for which the 100-year flood potential is removed are indicated in Figure 7-13. The analysis indicates that the pond greatly reduces the 100-year existing condition flood potential for mobile homes located in the Hines Branch damage reach, with the flood potential removed for all but 15 mobile homes and 3 commercial structures. The pond is not effective in totally eliminating the flood potential because of the high volume of runoff that is discharged to the stream downstream of the pond within the damage reach. These inflows increase peak discharges throughout the damage reach and reduce the effectiveness of the pond as the flood hydrograph moves downstream. No additional viable locations for regional detention could be found to reduce these discharges, therefore to completely eliminate the flood potential in both reaches, a combination of alternatives will be needed.

Table 7-32. Effect of Regional Detention on Flood Potential in Hines Branch

Land Use Condition	Pre or Post Detention	Elevation (ft) at RM 1.777		Number of Flooded Structures			
				Maynardville Hwy		Mynatt Drive	
		10-year	100-year	10-year	100-year	10-year	100-year
Existing	Pre	1062.95	1064.17	2	4	31	71
	Post	1062.24	1063.29	0	3	6	15
Future	Pre	1063.05	1064.25	3	4	36	71
	Post	1062.44	1063.45	0	3	6	22

An estimate of the cost to design and construct the regional detention pond at this site was determined and is provided in Table 7-33. It should be noted that if constructed, the embankment at the downstream end of the detention pond has the potential to fall under the Safe Dams Act and would require special safety and regulatory considerations, regular maintenance, and permitting. These costs were not included in the estimate.

Table 7-33. Estimated Costs, Hines Branch Regional Detention Pond Alternative

Task	Cost
Property and R.O.W. acquisition	$101,500
Design and construction	$829,116
SUBTOTAL	$930,616
10% contingency	$93,062
TOTAL CONSTRUCTION COST	**$1,023,678**

7.6.5 Conclusions

A comparison of effective costs and the reduction in flood potential of the two flood solution alternatives for Hines Branch is presented in Table 7-34. The effective cost is the cost required to eliminate the 100-year existing condition FFE flood potential. For the regional detention alternative, this cost includes construction of the regional detention ponds and the cost of purchasing the remaining properties that have a 100-year flood potential after construction of the ponds (post-project).

Table 7-15. Summary Table of Alternatives for the Hines Branch Damage Reach

	No. of FFEs Flooded				Costs (in present day dollars)		
	100-Year Existing		100-Year Future				
Alternative	**Pre**	**Post**	**Pre**	**Post**	**Construction**	**Structure Acquisition**	**Effective Cost**
Property Purchase	75	0	75	0	$0	$3,506,547	**$3,506,547**
Channel Improvement	75	0[1]	75	0[1]	$3.587,319	$0	**$3,587,319**
Regional Detention	75	18	75	25	$1,203,678	$1,230,438	**$2,254,115**

1 - increases the flood depth at the 1 structure by 0.3 feet, the frequency of flooding for the structure does not increase

Each flood solution alternative achieves some level of success in reducing the flood potential for the priority area, however there are positive and negative factors associated with each alternative that should be considered. The pros and cons for each alternative are listed in Table 7-35.

7.6.6 Recommendations

If the County decides to take action to relieve the flood potential for Hines Branch, regional detention should be given the most consideration. While regional detention (Alternative 3) alone provides the least benefit in reduction of flood potential, this alternative in combination with property buyouts and/or flood proofing will be an effective option. After construction of the pond, mobile home properties that are still located closest to the channel and have higher depths of flooding should be purchased (for safety reasons). Raising some mobile homes that have minimal flood depths can be an option. Floodwalls or berms may also be an option for the mobile home park area, but should be analyzed in detail to determine if the loss of storage would increase the flood potential downstream.

Channel improvements should be avoided. While the analysis predicts that the existing and future flood potential would be eliminated, the cost is high and could increase greatly due to the suspected close proximity of bedrock beneath the channel bed. In addition, channel improvements must be designed in coordination with upstream land use expectations to maintain effective performance in the future.

Table 7-35. Summary of Pros and Cons for Hines Branch Alternatives

Alternative	Pros	Cons
1. Purchase Flooded Property	• Eliminates all flood potential on Hines Branch damage reaches for existing and future conditions. • No construction of storm water facilities or associated maintenance required.	• Does not lower flood stages. • Does not reduce the roadway overtopping frequency for Maynardville Highway, Mynatt Drive and Shotsmans Lane. • High number of property buyouts (75) may set unwanted precedent. • Potential liability associated with a UST at Amoco gas station (purchased property).
2. Channel/Culvert Improvements	• Eliminates all flood potential in damage reaches for existing conditions. • Eliminates some nuisance flooding. • Reduces future condition flood potential.	• Requires possibly unpopular property acquisitions. • Slightly increases downstream flood potential (1 structure). • Potential environmental permitting requirements for construction. • Potential difficulties and increased costs for channel excavation due to bedrock. • Potential difficulties and increased costs associated with UST removal at Amoco gas station.
3. Regional Detention	• Least expensive alternative. • Substantially reduces the flood potential in the Mynatt Drive area.	• Does not eliminate flood potential for 100-year existing condition event in either damage reach, requires additional property purchases to do so. • Requires purchase of non-flooded property for flood control. • The County will assume post construction maintenance responsibilities. • Potential environmental permitting requirements for construction. • Potential liability associated with a UST at Amoco gas station (purchased property).

All of these things considered, the following actions are recommended:

- The County should decide if action is to be taken to eliminate the existing flood potential along Hines Branch based on the funding requirements for implementing Alternative 3 and budget considerations.

- Based on the cost alone, regional detention in combination with property buyouts and/or flood proofing should be considered further. Regional Detention also reduces the frequency of flooding for the remaining properties that are flooded.

- The County should be meet with the property owners to inform them of the options for flood relief and the associated costs. At this point, the willingness of the impacted property owners to either accept a buyout or sell the drainage easement necessary for the channel improvement could be gauged.

- The predicted development pattern in the Hines Branch basin upstream of the damage reaches, based on the MPC 15-Year Development Plan, is for medium density residential areas. Ridge tops and steep slopes will be left undeveloped. While the future flood potential is not as high in Hines Branch as in other priority areas, the alternative chosen for mitigation of existing flooding must consider future growth upstream of the damage reach. The County should plan appropriately for future flood impacts using non-structural BMPs to reduce the potential for development in future floodplains.

7.7 Cox Creek Tributary – 6427 Cedar Breeze Lane

7.7.1 Background

In the spring of 1992, the first floor of 6427 Cedar Breeze Lane flooded during an intense storm event. The house is located adjacent to Cox Creek Tributary. HWMs for the event were estimated based on videotape footage of the flooding inside and outside the residence. From the videotaped evidence, it was estimated that the flood elevation was approximately 1073.3 feet, resulting in about 0.9 feet of water inside the house. The flood event prompted Knox County to further examine the flood potential for the residence on Cedar Breeze Lane and other houses located along Cox Creek Tributary.

Figure 7-18 shows the area of concern on Cox Creek Tributary. FFEs were surveyed at 6427 Cedar Breeze Lane and at a number of houses on Bay Circle Drive that are adjacent to Cox Creek Tributary. Comparison of the surveyed FFEs to the flood elevations predicted by the existing and future condition HEC-RAS models show the house at 6427 Cedar Breeze Lane is predicted to flood in the 100-year and 500-year existing and future storm events. There is no FFE flood potential at the other structures examined. Although the footprint of other residences located along Cox Creek Tributary may lie partially in or close to the predicted floodplains, the FFEs of these houses are above the calculated flood elevations. Table 7-36 presents the depth of flooding at the residence on Cedar Breeze Lane for all modeled storm events.

Table 7-36. Predicted Depth of FFE Flooding - 6427 Cedar Breeze Lane

Storm Event	Existing	Future
2-year	0.0	0.0
10-year	0.0	0.0
25-year	0.0	0.0
100-year	0.3	0.5
500-year	0.8	1.0

The HEC-RAS models of Cox Creek Tributary indicate that potential flooding at Cedar Breeze Lane is due to storage of water behind the culvert under the roadway, located off the southeast corner of the house. The existing culvert consists of two 60-inch diameter CMP's. Field investigation shows that the culverts are in good condition.

Figure 7-18

Adequate rainfall information for the spring 1992 storm event was not available, therefore the actual event could not be modeled using the HEC-1 and HEC-RAS models of Cox Creek Tributary, and the reason for the flooding could not be determined. The flood elevations predicted by the HEC-RAS models do not indicate a high frequency flood potential for the structure, and extreme flooding was not experienced at other locations in Knox County during the event. For these reasons, it is suspected that the flooding of the house was the result of a blocked culvert. Further investigation using the HEC-RAS model indicate that a partial blockage of only one of the 60-inch CMP's can cause FFE flooding at the residence during the 10-year storm event.

7.7.2 Flood solution alternatives

Structural alternatives for flood relief at Cedar Breeze Lane were briefly considered, but eliminated for several reasons. First, the flood potential for 6427 Cedar Breeze Lane could possibly be reduced through enlargement of the culvert on Cedar Breeze Lane and raising the roadway. However, opening the culverts would also increase the FFE flood potential for residences downstream of the Cedar Breeze Lane stream crossing. Therefore, resizing the culverts was not considered because of the potential for more numerous and costly impacts downstream.

Regional detention upstream of the Cedar Breeze Lane stream crossing was also discussed. However, to reduce peak discharges for the 100-year and large events, the pond would need to have considerable storage volume, greatly increasing the cost for property acquisition, construction and maintenance of the pond. In addition, the relative timing of the peak flows of the Cox Creek Tributary and Cox Creek at the confluence of the two streams is such that a delay in the peak discharge from the Tributary would effectively increase the peak discharge on Cox Creek. This could subsequently cause an increase flood elevations at the Halls Crossroads area on Beaver Creek.

Purchase of the property at Cedar Breeze Lane is a viable alternative to relieve flooding at the site. A property purchase would eliminate the existing and future condition flood potential for the Cox Creek Tributary, and the resident has indicated a willingness to sell. Table 7-37 shows the estimated cost for purchase of the property and removal of the house.

Table 7-37. Estimated Costs, Cedar Breeze Lane Property Purchase

Task	Estimated Cost
Purchase of residence	$75,000
Demolition, waste removal and regrading	$20,000
TOTAL COST	**$95,000**

Flood proofing by raising or relocating the house is another option that can substantially reduce the flood potential. However, the cost to raise or move the structure will be very close to or greater than the cost for a straight property buyout, and raising the home would not eliminate access and safety concerns during a flood event. Potential future problems associated with movement of an existing structure are also a concern.

7.7.3 Recommendations

Should the County decide to take action to relieve flooding at 6427 Cedar Breeze Lane, a property buyout is the recommended alternative.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

Conclusions that can be made based on the data gathered in the Beaver Creek watershed and the analyses and results of the HEC-1 and HEC-RAS models are as follows:

1. Flooding in Beaver Creek is a natural condition. Based on the analysis prepared for this master plan that considered undeveloped conditions for the entire watershed, Beaver Creek was out of bank at many locations during the 2-year event. Furthermore, the difference between existing flood elevations and flood elevations for undeveloped conditions is approximately 1.5 feet.

2. Once water is out of bank on Beaver Creek, the extent of flooding will quickly reach the edge of the floodplain. For example, while the depth of flooding differs between the 10-year and 100-year event, the floodplains on Beaver Creek are very similar.

3. Water quality throughout most of the Beaver Creek watershed was found to be poor. Sediment, agricultural runoff, urban runoff and non-storm water discharges have degraded the water quality of Beaver Creek and its tributaries.

4. There are significant areas of soils with slow infiltration rates (hydrologic soil groups C and D) in the watershed. Nearly 50% of the watershed is composed of soil types C and D. The majority of the slowly draining soils are located on the south side of Beaver Creek.

5. Discharges, and therefore flood elevations, on Beaver Creek were found to be most sensitive to runoff and potential runoff alterations upstream of Maynardville Pike. Several structural and non-structural mitigation measures could be used in these areas to minimize future development impacts on Beaver Creek flooding.

6. Flood storage is an integral, natural flood management function of the Beaver Creek floodplains. Because of the long, narrow nature of the watershed and the low gradient, flat, wide floodplains, peak discharges attenuate greatly as the flood wave proceeds downstream. Loss of floodplain storage will reduce attenuation and increase peak discharge rates and associated flood elevations.

7. There are approximately 755 habitable structures located inside the mapped existing condition floodplains (100-year and 500-year). Of these structures, 451 are located along Beaver Creek and 304 are located along tributaries. Thirty-six structures are located in the floodway.

8. Finished flood elevations were surveyed at 375 of the 755 habitable structures located in the existing condition floodplains on Beaver Creek and the tributaries. Of the 375 surveyed structures, 110 were found to have FFE flood potential for the 100-year existing condition flood. This number increases to 155 for the 100-year future condition flood.

9. Many of the structures that have significant FFE flood potential are located in priority damage reach areas that were identified by the County for analysis of specific flood solution alternatives. Alternatives were analyzed with the goal of mitigating the 100-year existing condition flood potential for the priority areas. An estimate of the cost for each alternative was developed. The analyzed flood solution alternatives for priority areas are discussed in detail in Section 7.

10. The reduction of existing flood elevations on Beaver Creek using structural controls was found to be very difficult and costly. Channel improvements were briefly analyzed and found to be too large in scope, cost, and environmental and geomorphologic impacts to be viable alternatives for Beaver Creek proper. Regional detention in the upper third of Beaver Creek was analyzed in detail and determined to be effective in mitigating future flood elevation increases but not effective in removing all existing structures with FFE flooding from the floodplain. Flood proofing measures, such as raising flooded structures or constructing levees, could be considered in cases where flood depths are small and the property owner will not accept other options. In short, large-scale structural flood mitigation measures on Beaver Creek are not cost-effective in reducing or eliminating existing flooding.

11. Structural alternatives such as channel improvements, regional detention and flood-proofing to mitigate existing flooding problems on the tributaries were found to be more feasible and less-costly.

12. Local detention measures should not be expected to mitigate increased discharges on a basin or watershed scale. However, analyses indicate that more stringent local detention requirements in key areas can be effective in controlling future peak discharge and flood elevation increases on a more local level. The location of the key areas and the degree of effectiveness is highly dependent on configuration of the drainageways in the basin.

13. Non-structural alternatives are the least costly and most effective way to reduce the future flood potential for the watershed. Development management in key areas, especially upstream of Maynardville Highway, can be effective in limiting the increase in future condition flood potential in the Halls-Crossroad area and along the

remainder of Beaver Creek. Using a ½-flood fringe encroachment limit for development in the floodplain was also determined to be an effective control on the increase in flood elevations due to future development.

3.1 Recommendations

The major component of this master plan was to recognize and provide solutions for potential for future flooding and water quality problems in the Beaver Creek watershed. Existing flooding problems (and future flooding consequences at these locations) were also studied and recommendations for flood solution alternatives in specific priority areas are given after the discussion of each area presented in Section 7. However, the majority of Beaver Creek is undeveloped and facing future development pressures. The following is a list of recommended actions to mitigate future flooding and water quality problems in Beaver Creek.

1. Institute regulatory controls on new development and re-development upstream of Maynardville Highway to control future runoff peaks and volumes. This area was identified as the key location for the control of future flooding on Beaver Creek. If it is anticipated that wide-spread development management by the County will not be accepted by citizens and developers, limit the scale of the strictest management of new development to basins betweens Kerns Branch and Maynardville Highway. Then have less stringent, but more than the normal requirements for the remainder of the watershed upstream of Maynardville Highway.

2. Develop regulations to limit flood fringe filling on Beaver Creek and its tributaries. Floodplain storage was determined to be a highly critical component of flood management on Beaver Creek. Consider using a ½ flood fringe encroachment requirement throughout the watershed, where the flood fringe has been mapped. Also, use higher FFE requirements where the HEC-RAS models developed for the master plan predict that future flood elevations will be higher than the existing 500-year elevations. Consult Appendix D for that information.

3. If property purchase is an option the County chooses to mitigate existing flooding, consider a prioritization system for the purchase of flooded properties. Purchases could be prioritized based on the following factors:

    - flood history;

    - predicted flooding of finished floor for the 25-year (or more frequent event) existing conditions event;

- location of the habitable structure in the existing floodway;

- predicted flooding of finished floor for the 100-year event existing conditions; and

- predicted frequency of flooding for future conditions with the 100-year event providing the threshold event for protection.

7. Make available the hydrologic and hydraulic models of Beaver Creek and the tributaries developed for this master plan. Require developers to use them to determine the impact of specific developments on flooding downstream. This is especially important in the reaches that have existing flooding problems (the Halls-Crossroads area on Beaver Creek, North Fork, Beaver Creek in Karns, and Hines Branch).

8. Develop a program to educate Beaver Creek watershed residents and business owners on the general findings of the master plan and the impending NPDES Phase II regulations to gain support for more stringent regulations that the County may choose to implement. Educational topics can include:

   - the natural tendency for Beaver Creek to flow outside of its banks and inundate the floodplains;

   - the importance of undeveloped, natural floodplains for flood storage and management and water quality preservation;

   - why non-structural controls can reduce flood potential, increase water quality and comply with federal regulatory controls; and

   - the impact of residential, commercial and industrial development on water quality, and ways to reduce impacts.

9. The County should encourage the use of effective water quality BMPs for existing businesses, communities, and farms in the watershed. In light of the impending NPDES Phase II regulations, the County should work with local developers to implement pilot post-construction water quality BMPs as the opportunity arises. Grants are available from a variety of sources for such projects, as long as they occur prior to Phase II permitting (March 10, 2003).

10. The County should implement and maintain a strong erosion control program for construction activities. For rural and other non-urban areas (e.g., cattle farms), the

County should work with the local NRCS office to implement effective BMPs to control stream bank degradation and erosion.

11. Wetlands and other sensitive areas should be identified and protected as they provide natural water quality buffers and flood storage. The County should continue to support and participate in the current Beaver Creek conservation easement program to increase the chances of success with water quality initiatives.

12. Commercial storm drains and other potential illicit (non-storm water) discharges should be investigated and eliminated.

13. General land use patterns and water quality should be examined in the watershed to isolate areas for priority water quality BMP implementation.

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APPENDIX A
Beaver Creek Watershed Basin and Sub-basin Naming Convention

A naming convention was developed for the watersheds in Knox County to facilitate use of the flood study models and maps within the County's GIS system. In addition, a useful sub-basin naming scheme is critical in keeping the HEC-1 model organized, easing model setup and user navigation during analysis. The naming convention is utilized in this report to discuss model results, therefore it is explained in the following paragraphs.

Watersheds in Knox County were assigned long names that correspond to the creek of interest: Beaver Creek, Ten Mile Creek, Turkey Creek, etc. Watersheds were also assigned a two-character code. The code for Beaver Creek is BV. In addition, each basin delineated in the watershed was assigned a two-character code, based on the surface feature to which the basin drains. Basins that drained directly to the main stem (e.g., Beaver Creek) were assigned a two-*digit* number from upstream to downstream. Basins that drained to tributaries were assigned a two-*letter* code based on the assigned name for the tributary on the USGS quadrangle map or a local feature in that basin.

<u>Example:</u>

Beaver Creek watershed, most downstream basin on Beaver Creek	BV25
Beaver Creek watershed, North Fork basin (tributary)	BVNF

Each sub-basin is additionally assigned a three-digit code. The first two digits are used initially and the third digit is set to zero and reserved for possible future divisions of the sub-basin (e.g., 010, 150). In most cases, sub-basins are numbered from upstream to downstream. Therefore, the sub-basins in the most upstream part of the basin should have lower sub-basin numbers. The watershed and basin identifiers are used along with the three-digit sub-basin code to provide a unique identifier for each sub-basin.

<u>Example:</u>

Beaver Creek watershed, North Fork basin, first sub-basin	BVNF010
Beaver Creek watershed, basin 07, twelfth sub-basin	BV07120

The last piece of the naming convention is specification of the HEC-1 computation operation. Several computational operations can be performed in HEC-1, and must be identified in the HEC-1 data set. The operation identifier is limited to 6 alpha-numeric characters. A single-letter code is used to identify each operation.

Code	Operation
H	Compute a hydrograph from sub-basin parameters.
C	Combine two or more computed hydrographs. Subsequent combines, if necessary, are D, E, etc.
R	Route a hydrograph through a sub-basin. Subsequent routings are X, Y, etc.
P	Route a hydrograph through a detention pond. A subsequent detention routing, if necessary is Q.

Therefore, each computational operation in the HEC-1 model is identified using basin and sub-basin identifiers and code letter of the operation being performed, giving a total of 6 alpha-numeric characters. The watershed identifier is not used since the HEC-1 model is unique for the watershed. Examples of operation identifiers in the Beaver Creek HEC-1 model are listed below.

Example:

Compute the hydrograph from sub-basin BVNF010	NF010H
Route the hydrograph through BV07120	07120R

APPENDIX B
Beaver Creek Sub-basin Data and Peak Discharges

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
BASIN 01									
01010	0.137	75	0.613	0.61	30	90	120	160	210
01020	0.13	76	0.525	0.52	40	100	130	180	220
01030	0.153	80	0.765	0.76	40	110	140	180	220
01040	0.133	78	0.683	0.68	40	90	120	160	200
01050	0.143	77	0.733	0.73	40	90	120	160	200
01060	0.107	79	0.563	0.56	40	90	110	150	180
01070	0.046	78	0.42	0.42	20	40	60	80	90
01080	0.11	74	0.512	0.51	30	80	100	140	180
01090	0.205	78	0.575	0.57	60	160	210	280	340
01100	0.246	77	0.607	0.61	70	180	230	310	390
01110	0.101	78	0.438	0.44	40	90	120	160	200
01120	0.075	80	0.507	0.51	30	70	90	120	140
BASIN 02									
02010	0.084	75	0.39	0.39	30	70	100	130	160
02020	0.093	71	0.397	0.4	20	70	90	130	160
BASIN 03									
03010	0.115	77	0.692	0.69	30	80	100	140	170
03020	0.081	73	0.317	0.32	30	70	100	140	170
03030	0.108	73	0.415	0.41	30	80	110	160	200
03040	0.115	74	0.373	0.37	40	100	130	180	230
03050	0.073	73	0.363	0.36	20	60	80	110	140
BASIN 04									
04010	0.216	75	1.012	1.01	40	100	130	180	230
04020	0.115	78	0.42	0.42	40	110	140	190	230
04030	0.138	80	0.628	0.63	50	110	140	180	230
04040	0.067	71	0.512	0.51	10	40	60	80	100
04050	0.141	75	0.368	0.37	50	130	170	230	280
04060	0.218	75	0.408	0.41	70	190	240	330	410
04070	0.177	72	0.353	0.35	50	140	190	270	340
04080	0.158	73	0.32	0.32	50	140	190	260	330
04090	0.084	73	0.392	0.39	20	70	90	120	160
04100	0.104	75	0.523	0.52	30	80	100	140	170
04110	0.148	80	0.682	0.68	50	110	140	190	230
04120	0.048	71	0.402	0.4	10	40	50	70	80
04130	0.157	78	0.933	0.93	40	90	110	150	190
04140	0.091	79	0.46	0.46	40	80	110	140	180

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
04150	0.063	79	0.522	0.52	20	50	70	90	110
04160	0.084	71	0.452	0.45	20	60	80	110	140
04170	0.166	72	0.667	0.67	30	90	120	170	220
04180	0.118	77	0.433	0.43	40	110	140	180	230
04190	0.066	73	0.565	0.56	20	40	60	80	100
BASIN 05									
05010	0.106	77	0.315	0.31	50	110	150	200	240
05020	0.123	78	0.6	0.6	40	90	120	160	200
05030	0.065	77	0.425	0.42	20	60	80	100	130
05040	0.107	74	0.393	0.39	30	90	120	160	200
05050	0.105	78	0.687	0.69	30	70	90	130	160
05060	0.161	74	0.502	0.5	40	120	150	210	270
05070	0.124	80	0.532	0.53	50	110	140	190	230
05080	0.109	75	0.387	0.39	40	100	130	170	210
05090	0.092	72	0.36	0.36	20	80	100	140	180
05100	0.093	77	0.475	0.47	30	80	100	140	170
05110	0.156	86	0.578	0.58	80	160	200	250	300
BASIN 06									
06010	0.038	83	0.232	0.23	30	60	70	100	110
BASIN 07									
07010	0.212	86	0.285	0.28	160	320	400	520	610
BASIN 08									
08010	0.199	87	0.498	0.5	110	230	280	360	420
08020	0.225	78	0.548	0.55	70	180	230	310	390
BASIN 09									
09010	0.047	72	0.382	0.38	10	40	50	70	90
BASIN 10									
10010	0.057	71	0.412	0.41	10	40	60	80	100
10020	0.072	75	0.618	0.62	20	50	60	90	110
10030	0.179	78	0.883	0.88	40	100	140	180	230
10040	0.237	73	0.495	0.49	60	170	220	310	390
10050	0.12	75	0.678	0.68	30	80	100	130	170
10060	0.17	76	0.687	0.69	40	110	140	190	240
10070	0.271	74	0.763	0.76	50	150	200	270	340
10080	0.213	75	0.647	0.65	50	140	180	250	310
BASIN 11									
11010	0.184	67	0.68	0.68	20	80	110	160	210
11020	0.127	68	0.518	0.52	20	70	90	140	180
11030	0.178	73	0.403	0.4	50	140	190	260	330
11040	0.112	69	0.437	0.44	20	70	100	140	180
11050	0.139	78	0.675	0.68	40	100	120	170	210

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
11060	0.144	72	0.822	0.82	20	70	90	130	160
11080	0.264	72	0.387	0.39	70	200	270	380	480
11090	0.138	79	0.707	0.71	40	100	120	170	210
11100	0.033	80	0.762	0.76	10	20	30	40	50
11110	0.281	70	0.468	0.47	60	180	240	340	440
11120	0.166	75	0.693	0.69	40	100	130	180	230
11130	0.104	78	0.795	0.8	30	60	80	110	140
BASIN 12									
12010	0.1	79	0.653	0.65	30	80	100	130	160
12020	0.085	79	0.562	0.56	30	70	90	120	150
12030	0.224	71	0.638	0.64	40	120	160	230	300
12040	0.14	75	0.403	0.4	50	120	160	220	270
12050	0.213	78	0.32	0.32	100	240	300	410	500
12060	0.075	76	0.755	0.75	20	40	60	80	100
12070	0.179	78	0.647	0.65	50	130	170	220	280
12080	0.093	84	0.865	0.87	30	70	80	110	130
12090	0.136	74	0.528	0.53	30	100	130	170	220
12100	0.24	77	0.762	0.76	60	150	190	260	330
12110	0.116	73	0.263	0.26	40	120	160	210	270
12120	0.171	77	0.657	0.66	50	120	150	210	260
12130	0.232	72	0.493	0.49	50	160	210	290	370
12150	0.105	75	0.72	0.72	20	60	80	110	140
12160	0.058	69	0.688	0.69	10	30	40	50	70
BASIN 13									
13010	0.158	71	0.993	0.99	20	60	90	120	160
13020	0.175	76	0.625	0.63	50	120	160	210	260
13030	0.213	75	0.52	0.52	60	160	210	280	350
13040	0.175	73	0.328	0.33	60	160	210	290	360
13050	0.162	79	0.503	0.5	60	140	180	240	300
13060	0.14	82	0.582	0.58	60	120	160	210	250
13070	0.114	76	0.508	0.51	30	90	120	160	200
13080	0.082	72	0.722	0.72	10	40	60	80	100
BASIN 14									
14010	0.144	76	0.583	0.58	40	100	140	180	230
14020	0.097	71	0.562	0.56	20	60	80	110	140
14030	0.179	67	0.567	0.57	20	90	120	170	230
14040	0.125	79	0.618	0.62	40	100	120	160	200
14050	0.063	70	0.41	0.41	10	40	60	80	110
14070	0.058	65	0.392	0.39	10	30	40	60	90
14080	0.128	65	0.547	0.55	10	60	80	120	160
14090	0.211	66	0.403	0.4	30	120	170	240	320

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
14100	0.067	69	0.338	0.34	20	50	70	90	120
14110	0.187	72	0.432	0.43	50	140	180	250	320
14120	0.092	78	0.317	0.32	40	100	130	180	210
14130	0.196	67	0.54	0.54	30	100	140	200	260
14140	0.071	88	0.552	0.55	40	80	100	120	140
BASIN 15									
15010	0.108	81	0.843	0.84	30	70	90	120	150
15020	0.176	67	0.563	0.56	20	80	120	170	220
15030	0.185	74	0.752	0.75	40	100	140	190	240
15040	0.104	79	0.423	0.42	40	100	130	170	210
15050	0.114	79	0.702	0.7	30	80	100	140	170
15060	0.185	71	0.572	0.57	40	110	150	210	260
15070	0.144	72	0.693	0.69	30	80	100	150	190
15080	0.155	72	0.685	0.69	30	80	110	160	200
15090	0.241	78	0.383	0.38	100	240	310	420	510
15100	0.094	87	0.787	0.79	40	80	100	130	150
15110	0.144	76	0.393	0.39	50	130	170	230	290
15120	0.175	83	0.578	0.58	70	160	200	260	320
15130	0.081	83	0.533	0.53	40	80	100	130	160
BASIN 16									
16010	0.077	79	0.315	0.31	40	90	110	150	180
16020	0.205	68	0.402	0.4	40	130	180	260	330
16030	0.207	72	0.693	0.69	40	110	150	210	270
16040	0.236	76	0.625	0.63	60	160	210	290	360
16050	0.131	68	0.417	0.42	20	80	110	160	200
16060	0.115	68	0.627	0.63	20	50	80	110	140
16070	0.138	69	0.552	0.55	20	80	100	150	190
16080	0.275	59	0.623	0.62	10	70	110	180	250
16100	0.035	64	0.6	0.6	0	10	20	30	40
16110	0.083	61	0.693	0.69	0	20	40	60	80
16120	0.162	68	0.452	0.45	30	100	130	190	240
16130	0.066	69	0.49	0.49	10	40	50	80	100
16140	0.075	80	0.407	0.41	30	80	100	130	160
BASIN 17									
17010	0.125	78	0.648	0.65	40	90	120	160	190
17020	0.184	74	0.525	0.52	50	130	170	240	300
17030	0.182	80	0.727	0.73	60	130	170	220	270
17040	0.108	77	0.61	0.61	30	80	100	140	170
17050	0.086	78	0.605	0.61	30	60	80	110	140
17060	0.309	63	1.552	1.55	10	60	80	120	170

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
17070	0.126	63	0.663	0.66	10	40	60	100	130
17080	0.197	74	0.682	0.68	40	120	160	210	270
17090	0.102	66	0.62	0.62	10	40	60	90	120
17100	0.157	69	0.682	0.68	20	70	100	140	190
17110	0.185	63	0.855	0.86	10	50	80	120	160
17120	0.036	62	0.56	0.56	0	10	20	30	40
17130	0.263	65	1.02	1.02	20	80	110	160	210
17140	0.088	61	1.053	1.05	0	20	30	40	60
17150	0.07	67	0.657	0.66	10	30	40	60	80
BASIN 18									
18010	0.14	69	0.556	0.56	20	80	100	150	190
18020	0.068	66	0.353	0.35	10	40	60	80	110
18030	0.115	64	0.353	0.35	10	60	90	130	180
18040	0.144	64	0.533	0.53	10	60	90	130	170
18050	0.105	66	0.652	0.65	10	40	60	90	120
18060	0.1	62	0.64	0.64	10	30	50	70	100
18070	0.078	65	0.358	0.36	10	40	60	90	120
18080	0.034	65	0.308	0.31	0	20	30	40	60
18090	0.251	64	0.797	0.8	20	80	120	170	230
18100	0.157	74	0.691	0.69	30	90	120	170	210
18110	0.24	66	0.84	0.84	20	80	120	170	230
18120	0.202	66	0.482	0.48	30	100	140	210	270
18130	0.094	66	0.32	0.32	20	60	80	120	160
18140	0.242	65	0.598	0.6	20	100	140	210	280
BASIN 19									
19010	0.103	74	0.998	1	20	50	60	90	110
19020	0.114	77	0.768	0.77	30	70	90	120	150
19030	0.089	83	0.587	0.59	40	80	100	130	160
19050	0.085	77	0.487	0.49	30	70	90	120	150
19060	0.087	78	0.392	0.39	40	90	110	150	180
19070	0.05	77	0.535	0.54	20	40	50	70	80
19080	0.042	81	0.44	0.44	20	40	60	70	90
19090	0.07	76	0.508	0.51	20	50	70	100	120
19100	0.023	75	0.428	0.43	10	20	20	30	40
19110	0.065	76	0.592	0.59	20	50	60	80	100
19120	0.041	79	0.525	0.52	20	40	40	60	70
19130	0.056	77	0.72	0.72	10	40	50	60	80
19140	0.067	78	0.573	0.57	20	50	70	90	110
19150	0.162	75	0.567	0.57	40	110	150	200	250
19160	0.108	77	0.41	0.41	40	100	130	170	210

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
19170	0.191	73	0.452	0.45	50	140	190	260	330
19190	0.068	72	0.612	0.61	10	40	50	80	100
19200	0.078	77	0.685	0.69	20	50	70	90	110
19210	0.075	77	0.657	0.66	20	50	70	90	110
19220	0.147	79	0.538	0.54	50	120	160	210	260
19230	0.287	78	0.592	0.59	90	220	280	380	470
19240	0.092	81	0.35	0.35	50	110	140	180	220
BASIN 20									
20010	0.171	69	0.69	0.69	20	80	110	160	200
20020	0.117	65	0.543	0.54	10	50	70	110	140
20030	0.179	65	0.535	0.54	20	80	110	170	220
20040	0.102	63	0.478	0.48	10	40	60	90	120
20050	0.319	63	0.437	0.44	30	140	200	310	410
20060	0.105	62	0.628	0.63	10	40	50	80	100
20070	0.259	72	0.73	0.73	40	140	180	250	320
20080	0.113	64	0.405	0.41	10	60	80	120	160
20090	0.196	64	0.453	0.45	20	90	130	200	260
20100	0.148	63	0.573	0.57	10	60	80	120	160
BASIN 21									
21010	0.26	72	0.527	0.53	60	170	220	310	400
21020	0.077	70	0.372	0.37	20	60	80	110	140
21030	0.233	61	0.652	0.65	10	70	100	160	220
21040	0.134	63	1.009	1	10	40	50	80	100
21050	0.294	66	0.492	0.49	40	150	200	300	390
21060	0.074	65	0.457	0.46	10	40	50	80	100
21070	0.03	63	0.472	0.47	0	10	20	30	40
21080	0.232	67	0.535	0.54	30	120	160	230	300
21090	0.17	72	0.368	0.37	50	140	180	250	320
21100	0.115	62	0.447	0.45	10	50	70	100	140
21110	0.16	64	0.552	0.55	20	70	90	140	190
21120	0.222	80	0.523	0.52	80	200	250	340	410
21130	0.056	78	0.471	0.47	20	50	60	90	100
BASIN 22									
22010	0.048	78	0.382	0.38	20	50	60	80	100
BASIN 23									
23010	0.166	70	0.787	0.79	20	80	100	140	180
23020	0.221	66	0.945	0.94	20	70	100	150	190
23030	0.128	62	0.72	0.72	10	40	60	90	120
23040	0.21	59	0.887	0.89	10	40	70	110	150
23050	0.065	65	0.42	0.42	10	30	50	70	90

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
23060	0.077	79	0.335	0.34	40	80	110	150	180
23070	0.111	67	0.396	0.4	20	70	90	130	170
23080	0.218	66	1.673	1.67	10	50	60	90	120
23090	0.307	71	0.527	0.53	60	190	250	360	460
23100	0.212	63	0.878	0.88	10	60	90	130	180
BASIN 24									
24010	0.072	72	0.431	0.43	20	50	70	100	120
24020	0.149	63	0.318	0.32	20	80	120	170	230
24030	0.067	65	0.333	0.33	10	40	60	80	110
24050	0.214	63	0.645	0.64	20	80	110	160	220
24060	0.107	73	0.227	0.23	40	120	150	210	260
24070	0.111	64	0.926	0.93	10	30	50	70	90
24080	0.139	65	0.662	0.66	10	50	80	110	150
24090	0.224	67	0.83	0.83	20	80	120	170	220
24100	0.08	65	0.535	0.54	10	40	50	70	100
24110	0.042	64	0.377	0.38	0	20	30	50	60
24130	0.207	61	0.805	0.81	10	50	80	120	170
24150	0.267	65	0.985	0.99	20	80	110	160	220
24160	0.152	64	0.562	0.56	10	60	90	130	180
24170	0.216	67	0.833	0.83	20	80	110	160	210
24180	0.148	67	0.578	0.58	20	70	100	140	180
24190	0.051	80	0.385	0.39	20	50	70	90	110
BASIN 25									
25010	0.072	68	0.588	0.59	10	40	50	70	90
25020	0.11	71	0.662	0.66	20	60	80	110	140
25030	0.249	64	0.535	0.54	20	100	150	220	300
25050	0.117	63	0.715	0.71	10	40	60	80	110
25070	0.127	63	0.298	0.3	20	70	100	150	200
25080	0.187	62	0.518	0.52	10	70	100	160	210
25090	0.15	63	0.485	0.49	10	60	90	140	180
25100	0.16	60	0.581	0.58	10	50	70	110	160
25110	0.164	62	1.02	1.02	10	40	60	90	120
25120	0.209	63	0.545	0.54	20	80	120	180	240
25140	0.164	65	0.825	0.82	10	60	80	120	150
25150	0.236	64	0.707	0.71	20	80	120	180	240
25170	0.237	64	0.423	0.42	30	120	160	250	330
25180	0.112	61	1.048	1.05	0	20	40	60	80
25190	0.183	62	0.462	0.46	20	70	110	160	220
25200	0.099	57	0.61	0.61	0	20	40	60	80
25210	0.403	67	1.861	1.86	20	80	110	160	220

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
ALLEN BRANCH BASIN (AB)									
AB010	0.269	61	0.688	0.69	20	80	120	180	240
AB020	0.068	62	0.433	0.43	10	30	40	60	90
AB030	0.169	61	0.662	0.66	10	50	80	120	160
AB040	0.194	69	0.673	0.67	30	90	130	180	230
AB060	0.193	63	0.538	0.54	20	80	110	160	220
AB070	0.173	61	0.525	0.52	10	60	90	140	190
AB080	0.126	65	0.32	0.32	20	80	110	160	210
AB090	0.166	63	0.367	0.37	20	80	120	180	240
AB100	0.161	60	0.402	0.4	10	60	90	140	200
AB110	0.13	64	0.567	0.57	10	50	80	110	150
AB120	0.183	62	0.45	0.45	20	80	110	170	230
AB130	0.066	68	0.392	0.39	10	40	60	80	110
AB140	0.19	67	0.448	0.45	30	100	150	210	280
AB150	0.171	72	0.488	0.49	40	120	150	220	270
AB170	0.135	64	0.493	0.49	10	60	90	130	170
AB180	0.18	64	0.59	0.59	20	70	100	150	200
AB190	0.088	74	0.407	0.41	30	70	100	130	160
BISHOP ROAD BASIN (BR)									
BR010	0.293	65	0.467	0.47	30	140	200	300	390
BR020	0.269	64	0.43	0.43	30	130	180	280	360
BR030	0.223	63	0.497	0.5	20	90	130	200	270
BR040	0.242	62	0.377	0.38	20	110	160	240	330
BR050	0.137	64	0.585	0.59	10	50	80	120	150
BR060	0.188	70	0.435	0.44	40	120	170	240	300
BR070	0.088	72	0.573	0.57	20	50	70	100	130
BR090	0.216	61	0.477	0.48	20	80	120	180	250
BR100	0.108	68	0.537	0.54	20	60	80	110	140
BR110	0.162	69	0.988	0.99	20	60	80	120	150
BR120	0.105	75	0.512	0.51	30	80	100	140	180
BR130	0.159	67	0.72	0.72	20	60	90	130	170
BR140	0.061	74	0.502	0.5	20	40	60	80	100
BR160	0.124	65	0.347	0.35	20	70	100	150	200
CALDWELL LAKE BASIN (CL)									
CL010	0.138	64	0.537	0.54	10	60	80	120	160
CL020	0.149	64	0.43	0.43	20	70	100	150	200
CL030	0.142	69	0.667	0.67	20	70	90	130	170
CL040	0.171	65	0.423	0.42	20	90	120	180	240
CL050	0.093	66	0.463	0.46	10	50	70	100	130
CL060	0.205	66	0.503	0.5	30	100	140	210	270

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
CL070	0.245	65	0.442	0.44	30	120	170	260	340
CL080	0.09	63	0.433	0.43	10	40	60	90	120
CL100	0.14	63	0.567	0.57	10	50	80	120	160
CL120	0.189	61	1.155	1.15	10	40	60	90	120
CL130	0.153	65	0.55	0.55	20	70	100	140	180
CL140	0.082	74	0.345	0.34	30	70	100	140	170
CL150	0.115	62	0.902	0.9	10	30	40	70	90
CL160	0.087	66	0.397	0.4	10	50	70	100	130
COLLIER ROAD BASIN (CR)									
CR010	0.216	67	0.678	0.68	20	90	130	190	240
CR020	0.1	68	0.537	0.54	20	50	70	100	140
CR030	0.125	66	0.667	0.67	10	50	70	100	140
CR050	0.173	63	0.51	0.51	20	70	100	150	200
CR060	0.264	69	0.492	0.49	50	150	210	300	390
CR070	0.186	67	0.552	0.55	20	90	130	180	240
CR080	0.182	65	0.505	0.5	20	80	120	180	230
CR090	0.165	66	0.498	0.5	20	80	110	170	220
CR100	0.153	68	0.547	0.55	20	80	110	160	200
CR110	0.115	70	0.268	0.27	30	100	140	190	240
CR120	0.234	68	0.327	0.33	50	160	220	320	420
COX CREEK BASIN (CX)									
CX010	0.225	76	0.715	0.71	50	140	180	250	310
CX020	0.231	70	0.55	0.55	40	130	180	250	320
CX030	0.164	73	0.595	0.59	40	100	140	190	240
CX040	0.067	76	0.502	0.5	20	50	70	90	120
CX050	0.156	75	0.39	0.39	50	140	180	250	300
CX060	0.088	77	0.472	0.47	30	80	100	130	160
CX070	0.08	70	0.202	0.2	30	80	110	150	190
CX080	0.053	71	0.285	0.28	20	50	60	90	110
CX090	0.135	76	0.49	0.49	40	110	140	190	240
CX100	0.131	67	0.403	0.4	20	80	110	160	200
CX110	0.036	77	0.513	0.51	10	30	40	50	60
CX120	0.121	74	0.375	0.38	40	100	140	190	240
CX130	0.064	70	0.348	0.35	20	50	60	90	120
CX140	0.037	78	0.37	0.37	20	40	50	60	80
CX150	0.08	69	0.215	0.21	20	80	100	140	180
CX160	0.08	78	0.38	0.38	30	80	100	140	170
CX170	0.074	75	0.282	0.28	30	80	100	140	170
CX180	0.135	74	0.333	0.33	50	120	160	230	280
CX190	0.145	74	0.415	0.41	40	120	160	220	270

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
CX200	0.126	78	0.428	0.43	50	120	150	200	250
CX210	0.233	71	0.412	0.41	50	170	220	320	400
CX220	0.122	71	0.34	0.34	30	100	130	180	230
CX230	0.112	74	0.478	0.48	30	80	110	150	190
CX240	0.081	71	0.378	0.38	20	60	80	120	150
CX250	0.101	77	0.38	0.38	40	100	130	170	210
CX260	0.143	78	0.528	0.53	50	120	150	200	250
CX270	0.088	68	0.507	0.51	10	50	70	100	120
CX280	0.082	73	0.368	0.37	20	70	90	130	160
CX290	0.174	74	0.438	0.44	50	140	180	250	310
CX300	0.061	71	0.355	0.35	20	50	60	90	110
CX310	0.07	68	0.482	0.48	10	40	50	80	100
CX320	0.101	78	0.355	0.35	40	100	140	180	220
CX330	0.029	75	0.335	0.34	10	30	40	50	60
CX340	0.052	70	0.352	0.35	10	40	50	80	100
GRASSY CREEK BASIN (GC)									
GC010	0.085	75	0.542	0.54	20	60	80	110	140
GC020	0.164	84	0.673	0.67	70	140	180	230	280
GC030	0.171	71	0.553	0.55	30	100	140	190	250
GC040	0.176	73	0.63	0.63	40	110	140	200	250
GC050	0.133	82	0.712	0.71	50	100	130	170	210
GC060	0.215	72	0.635	0.63	40	120	160	230	290
GC070	0.236	66	0.865	0.87	20	80	110	160	220
GC080	0.156	73	0.568	0.57	40	100	130	180	230
GC090	0.18	73	0.562	0.56	40	120	160	220	270
GC100	0.13	76	0.527	0.53	40	100	130	180	220
GC110	0.085	72	0.728	0.73	20	40	60	80	110
GC120	0.141	76	0.657	0.66	40	90	120	170	210
GC130	0.172	62	0.685	0.69	10	50	80	120	160
GC140	0.114	67	0.667	0.67	10	50	70	100	130
GC150	0.125	79	0.76	0.76	40	80	110	140	180
GC160	0.207	60	0.915	0.92	10	50	70	110	150
GC170	0.136	69	0.7	0.7	20	60	90	120	160
GC180	0.176	67	0.732	0.73	20	70	100	140	190
GC190	0.244	61	0.882	0.88	10	60	90	140	190
GC200	0.165	66	0.558	0.56	20	80	110	160	200
GC210	0.12	71	0.858	0.86	20	50	70	100	130
GC220	0.101	67	0.798	0.8	10	40	50	80	100
GC230	0.129	77	0.628	0.63	40	90	120	160	200
GC240	0.277	77	0.942	0.94	60	150	190	260	330

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
GC250	0.289	72	1.035	1.03	40	120	160	220	280
GC260	0.223	77	0.813	0.81	50	130	170	230	290
GC270	0.142	77	0.713	0.71	40	90	120	160	200
GC280	0.169	69	0.847	0.85	20	70	90	130	170
GC290	0.075	77	0.58	0.58	20	60	70	100	120
GC300	0.216	76	0.613	0.61	60	150	200	270	330
GC310	0.12	75	0.647	0.65	30	80	100	140	170
GC320	0.176	76	0.642	0.64	40	120	160	210	260
GC330	0.082	76	0.505	0.5	20	60	80	120	140
GC340	0.046	74	0.438	0.44	10	40	50	70	80
GC350	0.135	74	0.612	0.61	30	90	110	160	200
GC360	0.12	76	0.813	0.81	30	70	90	120	150
GC370	0.111	76	0.568	0.57	30	80	100	140	180
GC380	0.143	74	1.192	1.19	20	60	80	100	130
GC390	0.154	74	0.527	0.53	40	110	140	200	250
GC400	0.062	82	0.612	0.61	20	50	70	90	110
GC410	0.174	77	0.437	0.44	60	150	200	270	330
GC430	0.124	73	1.078	1.08	20	50	70	100	120
GC440	0.112	73	0.6	0.6	20	70	90	130	160
GC450	0.134	89	0.617	0.62	70	140	170	220	260
HINES BRANCH BASIN (HB)									
HB010	0.203	78	0.38	0.38	80	200	260	350	430
HB020	0.136	76	0.313	0.31	60	140	180	250	310
HB030	0.129	81	0.392	0.39	60	140	180	240	290
HB040	0.114	73	0.478	0.48	30	80	110	150	190
HB050	0.154	83	0.44	0.44	80	170	210	280	330
HB060	0.115	67	0.465	0.47	20	60	90	130	160
HB070	0.131	77	0.357	0.36	290	730	940	1280	1590
HB080	0.081	87	0.353	0.35	60	110	140	180	210
HB090	0.184	74	0.455	0.46	50	140	190	260	320
HB100	0.116	80	0.415	0.41	50	120	150	200	240
HB110	0.125	78	0.443	0.44	50	120	150	200	240
HB120	0.074	83	0.367	0.37	40	90	110	150	180
HB130	0.072	78	0.36	0.36	30	70	100	130	160
HB140	0.069	76	0.268	0.27	30	80	100	140	170
HB150	0.138	79	0.31	0.31	70	160	200	270	330
HB160	0.216	75	0.39	0.39	70	190	250	340	420
HB170	0.125	80	0.548	0.55	50	110	140	180	220
HB180	0.088	75	0.467	0.47	30	70	90	120	160
HAW BRANCH BASIN (HW)									

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
HW010	0.196	81	0.462	0.46	90	190	250	330	400
HW020	0.251	77	0.433	0.43	90	220	290	390	490
HW030	0.106	78	0.65	0.65	30	80	100	130	160
HW040	0.181	75	0.327	0.33	70	180	230	310	390
HW050	0.107	74	0.392	0.39	30	90	120	160	200
HW060	0.211	76	0.512	0.51	60	160	210	290	360
HW070	0.209	80	0.467	0.47	90	200	250	340	410
HW080	0.225	66	0.527	0.53	30	110	150	220	290
HW090	0.189	75	0.768	0.77	40	110	140	200	240
KERNS BRANCH BASIN (KB)									
KB010	0.179	56	0.422	0.42	0	50	80	130	180
KB020	0.106	59	0.455	0.46	0	40	50	80	120
KB030	0.131	58	0.503	0.5	0	40	60	90	130
KB040	0.128	59	0.495	0.49	10	40	60	100	130
KB050	0.241	57	0.657	0.66	10	50	80	140	190
KB060	0.128	59	0.502	0.5	10	40	60	100	130
KB070	0.106	61	0.465	0.47	10	40	60	90	120
KB080	0.125	63	0.693	0.69	10	40	60	90	120
KB090	0.103	64	0.39	0.39	10	50	80	110	150
KB100	0.156	63	0.572	0.57	10	60	80	130	170
KB110	0.24	57	0.545	0.54	10	60	100	150	220
KB120	0.072	62	0.447	0.45	10	30	40	70	90
KB130	0.154	71	0.718	0.72	20	80	100	150	190
KB140	0.123	62	0.572	0.57	10	40	60	100	130
KB150	0.153	75	0.737	0.74	30	90	120	160	200
KB160	0.103	74	0.583	0.58	20	70	90	120	160
KB190	0.123	71	0.725	0.73	20	60	80	120	150
KB200	0.1	75	0.615	0.62	20	70	90	120	150
KB210	0.137	76	0.5	0.5	40	110	140	190	240
KB220	0.176	80	0.572	0.57	60	150	190	250	310
KB230	0.146	77	0.868	0.87	30	80	110	150	180
KNOB FORK BASIN (KF)									
KF010	0.255	75	0.415	0.41	80	220	280	390	480
KF020	0.137	75	0.392	0.39	40	120	160	220	270
KF030	0.081	66	0.492	0.49	10	40	60	80	110
KF040	0.092	73	0.61	0.61	20	60	80	100	130
KF050	0.128	64	0.667	0.67	10	50	70	100	130
KF060	0.14	62	0.643	0.64	10	50	70	100	140
KF070	0.247	77	0.68	0.68	60	170	220	290	360
KF080	0.098	62	0.707	0.71	10	30	40	70	90

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
KF090	0.176	81	0.592	0.59	70	150	190	250	310
KF100	0.111	77	0.61	0.61	30	80	100	140	180
KF110	0.054	73	0.683	0.68	10	30	40	60	70
KF120	0.031	57	0.388	0.39	0	10	20	20	30
KF130	0.244	66	0.638	0.64	30	100	140	210	280
KF140	0.047	66	0.453	0.45	10	20	40	50	70
KF150	0.1	58	0.597	0.6	0	30	40	60	90
KF160	0.037	58	0.487	0.49	0	10	20	30	40
KF170	0.14	81	0.788	0.79	40	100	120	170	200
KF180	0.062	79	0.688	0.69	20	40	60	80	90
KF190	0.188	72	0.583	0.58	40	110	150	210	270
KF200	0.095	82	0.547	0.55	40	90	110	150	180
KF210	0.14	73	0.405	0.41	40	110	150	200	250
KF220	0.095	84	0.513	0.51	50	100	120	160	190
KF230	0.202	63	0.555	0.56	20	80	110	170	230
KF240	0.134	61	0.662	0.66	10	40	60	90	130
KF250	0.103	84	0.648	0.65	40	90	110	150	180
KF260	0.106	58	0.652	0.65	0	30	40	60	90
KF270	0.107	71	0.49	0.49	20	70	90	130	170
KF280	0.223	76	0.473	0.47	70	180	240	320	400
KF290	0.169	78	0.528	0.53	60	140	180	240	300
KF300	0.154	74	0.893	0.89	30	80	100	140	180
KF310	0.247	77	0.623	0.62	70	180	230	310	380
KF320	0.072	75	0.718	0.72	20	40	60	80	100
MILL BRANCH BASIN (MB)									
MB020	0.161	65	0.53	0.53	20	70	100	150	200
MB030	0.172	64	0.567	0.57	20	70	100	150	200
MB040	0.162	61	0.507	0.51	10	60	80	130	180
MB050	0.138	60	0.56	0.56	10	40	60	100	140
MB070	0.209	64	0.54	0.54	20	90	120	190	250
MB080	0.077	65	0.405	0.41	10	40	60	80	110
MB090	0.136	61	0.402	0.4	10	60	80	130	170
MB100	0.179	64	0.53	0.53	20	80	110	160	220
MB110	0.088	65	0.36	0.36	10	50	70	100	140
MB120	0.298	61	0.428	0.43	20	120	170	270	360
MB130	0.053	59	0.39	0.39	0	20	30	50	60
MB140	0.21	58	0.5	0.5	10	60	90	150	210
MB150	0.12	58	0.577	0.58	0	30	50	80	110
MB160	0.143	58	0.722	0.72	0	30	50	80	110
MB180	0.132	60	0.71	0.71	10	40	50	80	110

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
MB190	0.149	66	0.692	0.69	20	60	80	120	160
MB200	0.161	67	0.642	0.64	20	70	100	140	190
MB210	0.109	72	0.443	0.44	30	80	100	150	180
MB220	0.119	72	0.358	0.36	30	100	130	180	230
MEADOW CREEK BASIN (MC)									
MC010	0.199	65	0.78	0.78	20	70	100	140	190
MC020	0.082	77	0.582	0.58	20	60	80	110	130
MC030	0.22	72	0.683	0.68	40	120	160	220	290
MC040	0.122	74	0.607	0.61	30	80	100	140	180
MC050	0.188	75	1.098	1.1	30	80	110	150	190
MC060	0.038	77	0.568	0.57	10	30	40	50	60
MC070	0.199	76	0.668	0.67	50	130	170	230	290
MC080	0.093	75	0.745	0.75	20	50	70	100	120
MC090	0.221	69	1.275	1.27	20	70	90	130	170
MC100	0.144	78	0.655	0.66	40	100	130	180	220
MC110	0.133	76	0.477	0.48	40	110	140	190	240
MC120	0.208	64	0.892	0.89	10	60	90	130	180
MC130	0.105	75	0.867	0.87	20	60	70	100	120
MC140	0.133	73	0.558	0.56	30	90	120	160	200
MC150	0.149	78	0.495	0.49	50	130	160	220	270
MC160	0.118	77	0.81	0.81	30	70	90	120	150
MC170	0.139	77	0.613	0.61	40	100	130	180	220
MC180	0.176	76	0.963	0.96	30	90	120	160	200
MC190	0.161	75	1.245	1.25	20	70	80	120	150
MC200	0.07	75	0.88	0.88	10	40	50	70	80
MC210	0.147	75	0.512	0.51	40	110	140	200	250
MC220	0.196	79	0.435	0.44	80	190	240	320	390
MC230	0.075	78	0.675	0.68	20	50	70	90	110
MC240	0.121	84	0.475	0.47	60	130	160	210	250
MC250	0.157	80	0.612	0.61	50	130	160	220	260
MC260	0.083	74	0.58	0.58	20	60	70	100	130
NORTH FORK BASIN (NF)									
NF020	0.212	61	0.403	0.4	20	90	130	200	270
NF030	0.157	63	0.547	0.55	10	60	90	130	180
NF040	0.179	65	0.482	0.48	20	80	120	180	240
NF050	0.141	65	0.393	0.39	20	80	110	160	210
NF060	0.189	67	0.488	0.49	30	100	140	200	260
NF070	0.146	62	0.598	0.6	10	50	70	110	150
NF080	0.192	64	0.707	0.71	20	70	100	140	190
NF090	0.101	70	0.473	0.47	20	60	90	120	160

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
NF100	0.165	72	0.41	0.41	40	120	170	230	290
NF110	0.235	78	0.357	0.36	100	240	310	420	510
NF120	0.1	67	1.06	1.06	10	30	40	60	80
NF130	0.171	64	0.422	0.42	20	80	120	180	240
NF140	0.066	68	0.473	0.47	10	40	50	80	100
NF150	0.199	67	0.747	0.75	20	80	110	160	210
NF160	0.083	62	0.577	0.58	10	30	40	60	90
NF170	0.086	75	0.78	0.78	20	50	60	90	110
NF180	0.091	69	0.51	0.51	20	50	70	100	130
NF190	0.183	76	0.653	0.65	50	120	160	220	270
NF210	0.106	67	0.518	0.52	10	50	80	110	140
PLUMB CREEK BASIN (PC)									
PC010	0.075	79	0.597	0.6	20	60	80	100	120
PC020	0.205	78	0.413	0.41	80	200	250	340	420
PC030	0.096	79	0.625	0.63	30	70	90	130	150
PC040	0.09	73	0.27	0.27	30	90	120	160	200
PC050	0.156	77	0.265	0.26	80	180	240	320	390
PC060	0.201	71	0.592	0.59	40	120	160	220	280
PC070	0.143	67	0.39	0.39	20	90	120	170	220
PC080	0.152	73	0.468	0.47	40	110	150	200	260
PC090	0.1	80	0.455	0.46	40	100	120	160	200
PC100	0.14	78	0.553	0.55	50	110	140	200	240
PC110	0.257	78	0.662	0.66	70	180	240	320	390
PC120	0.123	79	0.65	0.65	40	90	120	160	190
PC130	0.163	68	0.777	0.78	20	70	90	130	170
PC140	0.087	65	0.778	0.78	10	30	40	60	80
PC150	0.144	66	0.81	0.81	10	50	70	110	140
PC160	0.26	67	0.777	0.78	30	100	140	200	270
PC170	0.195	72	0.853	0.85	30	90	120	170	220
PC180	0.176	74	0.968	0.97	30	80	110	150	190
PC190	0.197	79	1.125	1.13	40	100	130	170	210
PC200	0.064	81	0.433	0.43	30	70	80	110	140
PC210	0.135	79	0.862	0.86	30	80	110	140	180
PC220	0.092	75	0.495	0.49	30	70	90	130	160
PC230	0.11	73	0.62	0.62	20	70	90	120	160
SOUTH FORK BASIN (SF)									
SF010	0.183	69	0.602	0.6	30	90	130	180	240
SF020	0.088	76	0.577	0.58	20	60	80	110	140
SF030	0.098	76	0.575	0.57	30	70	90	130	160
SF040	0.1	72	0.5	0.5	20	70	90	120	160

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
SF050	0.071	76	0.508	0.51	20	60	70	100	120
SF060	0.134	76	0.457	0.46	40	110	140	200	240
SF070	0.118	67	0.48	0.48	20	60	90	130	160
SF080	0.112	64	0.297	0.3	20	70	100	140	180
SF090	0.075	69	0.403	0.4	20	50	70	100	120
SF100	0.123	71	0.493	0.49	30	80	110	150	190
SF110	0.12	72	0.512	0.51	30	80	110	150	190
SF120	0.051	75	0.358	0.36	20	50	60	80	100
SOLWAY ROAD BASIN (SR)									
SR010	0.095	61	0.277	0.28	10	50	70	110	150
SR020	0.142	65	0.337	0.34	20	80	120	170	230
SR030	0.109	68	0.472	0.47	30	130	190	280	370
SR040	0.086	72	0.3	0.3	40	190	270	400	520
SR050	0.208	74	0.528	0.53	50	150	190	270	330
SR060	0.196	63	0.485	0.49	20	80	120	180	240
SR080	0.19	66	0.403	0.4	30	110	150	220	290
SR090	0.131	63	0.893	0.89	10	40	50	80	110
TRAILER PARK BASIN (TP)									
TP010	0.111	77	0.42	0.42	40	100	130	180	220
TP020	0.092	81	0.39	0.39	40	100	130	170	200
TP030	0.08	91	0.535	0.54	50	100	120	150	170
TP040	0.06	88	0.618	0.62	30	60	80	100	110
THOMPSON SCHOOL BASIN (TS)									
TS010	0.134	60	0.647	0.65	10	40	60	90	120
TS020	0.092	67	0.387	0.39	20	60	80	110	140
TS030	0.151	73	0.595	0.59	30	90	130	180	220
TS040	0.11	71	0.537	0.54	20	70	90	130	160
TS050	0.172	74	0.728	0.73	40	100	130	180	220
TS060	0.119	74	0.697	0.7	20	70	90	130	160
TS070	0.125	74	0.62	0.62	30	80	100	140	180
TS080	0.071	72	0.517	0.52	20	50	60	90	110
TS090	0.104	75	0.38	0.38	40	90	120	170	210
TS100	0.114	79	0.515	0.51	40	100	130	170	210
TS110	0.041	77	0.46	0.46	10	40	50	60	80
TS120	0.077	75	0.555	0.56	20	50	70	100	120
WILLOW FORK BASIN (WF)									
WF010	0.218	59	0.603	0.6	10	60	90	140	200
WF020	0.145	57	0.667	0.67	0	30	50	80	110
WF030	0.11	61	0.515	0.51	10	40	60	90	120
WF040	0.164	59	0.53	0.53	10	50	80	120	160

Table B-1. Beaver Creek Existing Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
WF050	0.086	58	0.5	0.5	0	20	40	60	80
WF060	0.19	61	0.468	0.47	10	70	100	160	220
WF080	0.079	59	0.412	0.41	0	30	40	70	90
WF090	0.156	59	0.568	0.57	10	40	70	110	150
WF100	0.121	67	0.35	0.35	20	80	110	160	200
WF130	0.135	72	0.545	0.54	30	80	110	160	200
WF170	0.115	76	0.933	0.93	20	60	80	110	130
WF180	0.112	64	0.593	0.59	10	40	60	90	120
WF190	0.159	73	0.655	0.66	30	90	120	170	220
WF200	0.123	75	0.825	0.82	20	70	90	120	150
WF210	0.142	78	0.805	0.81	40	90	110	150	190
WF220	0.102	79	0.663	0.66	30	80	100	130	160
WF230	0.13	78	0.742	0.74	40	90	110	150	180
WF240	0.143	79	0.697	0.7	40	100	130	180	220
WF250	0.117	77	0.962	0.96	20	60	80	110	140
WF260	0.09	73	0.477	0.48	20	60	80	120	150
WF270	0.088	73	0.74	0.74	20	50	60	90	110
WF280	0.081	77	0.592	0.59	20	60	80	100	130
WF290	0.071	79	0.407	0.41	30	70	90	120	150
WF300	0.06	75	0.403	0.4	20	50	70	90	120
WF310	0.07	78	0.532	0.53	20	60	70	100	120

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
BASIN 01									
01010	0.137	80	0.525	0.52	50	120	150	200	240
01020	0.13	85	0.683	0.68	60	120	150	190	230
01030	0.153	83	0.42	0.42	20	50	60	80	100
01040	0.133	79	0.613	0.61	40	110	140	180	220
01050	0.143	82	0.765	0.76	50	110	140	190	230
01060	0.107	81	0.563	0.56	40	90	120	160	190
01070	0.046	81	0.607	0.61	90	200	260	350	420
01080	0.11	81	0.512	0.51	40	100	130	170	210
01090	0.205	85	0.438	0.44	60	120	150	190	220
01100	0.246	83	0.733	0.73	50	110	140	190	230
01110	0.101	85	0.575	0.57	100	200	250	330	390
01120	0.075	83	0.507	0.51	40	80	90	120	150
BASIN 02									
02010	0.084	78	0.39	0.39	30	80	110	140	180
02020	0.093	74	0.397	0.4	30	80	100	140	180
BASIN 03									
03010	0.115	84	0.692	0.69	50	100	120	160	190
03020	0.081	78	0.317	0.32	40	90	120	150	190
03030	0.108	78	0.415	0.41	40	100	130	180	220
03040	0.115	77	0.373	0.37	40	110	150	200	240
03050	0.073	77	0.363	0.36	30	70	90	130	160
BASIN 04									
04010	0.216	81	1.012	1.01	60	130	160	220	260
04020	0.115	82	0.42	0.42	60	120	160	210	250
04030	0.138	82	0.628	0.63	50	120	150	190	240
04040	0.067	82	0.317	0.32	40	80	110	140	170
04050	0.141	82	0.368	0.37	80	160	210	270	330
04060	0.218	80	0.408	0.41	100	220	280	380	460
04070	0.177	77	0.353	0.35	70	180	230	310	380
04080	0.158	77	0.32	0.32	70	170	220	290	360
04090	0.084	78	0.392	0.39	30	80	110	140	180
04100	0.104	82	0.523	0.52	40	100	120	160	200
04110	0.148	83	0.682	0.68	60	120	150	200	240
04120	0.048	78	0.402	0.4	20	50	60	80	100
04130	0.157	82	0.933	0.93	40	100	130	170	210
04140	0.091	83	0.46	0.46	40	100	120	160	190
04150	0.063	83	0.522	0.52	30	60	80	100	120
04160	0.084	76	0.452	0.45	30	70	90	120	160

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
04170	0.166	77	0.667	0.67	40	110	150	200	250
04180	0.118	82	0.433	0.43	60	130	160	210	250
04190	0.066	76	0.565	0.56	20	50	60	90	110
BASIN 05									
05010	0.106	82	0.315	0.31	60	140	170	220	270
05020	0.123	82	0.6	0.6	50	110	140	180	220
05030	0.065	80	0.425	0.43	30	60	80	110	130
05040	0.107	77	0.393	0.39	40	100	130	180	220
05050	0.105	81	0.687	0.69	40	80	100	140	170
05060	0.161	79	0.502	0.5	60	140	180	240	300
05070	0.124	82	0.532	0.53	50	120	150	190	240
05080	0.109	80	0.387	0.39	50	120	150	200	240
05090	0.092	77	0.36	0.36	40	90	120	160	200
05100	0.093	84	0.475	0.47	50	100	120	160	200
05110	0.156	87	0.578	0.58	80	160	200	260	300
BASIN 06									
06010	0.038	91	0.232	0.23	40	70	90	110	130
BASIN 07									
07010	0.212	89	0.285	0.28	190	350	430	540	630
BASIN 08									
08010	0.199	88	0.498	0.5	120	230	290	360	430
08020	0.225	80	0.548	0.55	80	190	250	330	400
BASIN 09									
09010	0.047	76	0.382	0.38	20	40	60	80	100
BASIN 10									
10010	0.057	73	0.412	0.41	20	40	60	80	100
10020	0.072	81	0.618	0.62	30	60	80	100	120
10030	0.179	82	0.883	0.88	50	120	150	200	240
10040	0.237	75	0.495	0.5	70	180	240	320	400
10050	0.12	77	0.678	0.68	30	80	100	140	180
10060	0.17	78	0.687	0.69	50	120	150	200	250
10070	0.271	78	0.763	0.76	70	180	230	300	380
10080	0.213	80	0.647	0.65	70	160	210	280	340
BASIN 11									
11010	0.184	73	0.68	0.68	40	100	140	190	240
11020	0.127	72	0.518	0.52	30	80	110	150	200
11030	0.178	78	0.403	0.4	70	170	220	300	370
11040	0.112	78	0.263	0.26	60	140	180	240	290
11050	0.139	81	0.675	0.68	50	110	140	180	220
11060	0.144	79	0.822	0.82	40	90	120	160	200
11080	0.264	77	0.387	0.39	100	250	320	440	540

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
11090	0.138	84	0.707	0.71	50	120	140	190	230
11100	0.033	86	0.762	0.76	10	30	40	40	50
11110	0.281	72	0.468	0.47	60	190	260	360	460
11120	0.166	79	0.693	0.69	50	120	150	200	250
11130	0.104	81	0.795	0.8	30	70	90	120	150
BASIN 12									
12010	0.1	83	0.653	0.65	40	90	110	140	170
12020	0.085	82	0.562	0.56	40	80	100	130	160
12030	0.224	79	0.347	0.35	100	240	310	420	510
12040	0.14	80	0.403	0.4	60	150	190	250	300
12050	0.213	81	0.32	0.32	120	260	330	440	520
12060	0.075	82	0.755	0.75	20	60	70	90	110
12070	0.179	83	0.647	0.65	70	150	190	250	300
12080	0.093	87	0.865	0.87	40	70	90	120	140
12090	0.136	85	0.263	0.26	100	210	260	340	400
12100	0.24	91	0.454	0.45	180	320	390	490	570
12110	0.116	83	0.205	0.2	90	190	240	310	370
12120	0.171	85	0.515	0.51	90	180	220	290	350
12130	0.232	79	0.493	0.49	90	210	270	360	440
12150	0.105	83	0.572	0.57	40	100	120	160	190
12160	0.058	84	0.54	0.54	30	60	70	90	110
BASIN 13									
13010	0.158	76	0.993	0.99	30	80	100	140	180
13020	0.175	79	0.625	0.63	60	130	170	230	280
13030	0.213	80	0.52	0.52	80	190	240	320	390
13040	0.175	79	0.328	0.33	80	200	250	340	410
13050	0.162	82	0.503	0.5	70	160	200	260	320
13060	0.14	84	0.582	0.58	60	130	170	220	260
13070	0.114	86	0.484	0.48	60	130	160	210	240
13080	0.082	78	0.722	0.72	20	60	70	100	120
BASIN 14									
14010	0.144	82	0.583	0.58	60	130	160	210	260
14020	0.097	77	0.562	0.56	30	70	100	130	160
14030	0.179	80	0.334	0.33	90	210	260	350	430
14040	0.125	86	0.618	0.62	60	120	150	190	230
14050	0.063	72	0.41	0.41	20	50	60	90	110
14070	0.058	71	0.392	0.39	10	40	60	80	100
14080	0.128	72	0.423	0.42	30	100	130	180	220
14090	0.211	72	0.403	0.4	50	160	210	300	380
14100	0.067	73	0.338	0.34	20	60	80	110	140
14110	0.187	72	0.432	0.43	50	140	180	250	320

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
14120	0.092	83	0.317	0.32	60	120	150	200	240
14130	0.196	74	0.409	0.41	60	160	210	290	360
14140	0.071	90	0.552	0.55	40	80	100	130	150
BASIN 15									
15010	0.108	86	0.843	0.84	40	80	110	140	160
15020	0.176	80	0.291	0.29	100	220	280	370	450
15030	0.185	89	0.462	0.46	120	230	280	360	420
15040	0.104	83	0.423	0.42	50	120	150	190	230
15050	0.114	82	0.702	0.7	40	90	110	150	180
15060	0.185	74	0.572	0.57	40	120	160	220	280
15070	0.144	72	0.693	0.69	30	80	100	150	190
15080	0.155	73	0.685	0.69	30	90	120	160	200
15090	0.241	80	0.383	0.38	110	260	330	440	530
15100	0.094	92	0.787	0.79	50	90	110	140	160
15110	0.144	79	0.393	0.39	60	150	190	250	310
15120	0.175	84	0.578	0.58	80	170	210	270	320
15130	0.081	85	0.533	0.53	40	80	100	140	160
BASIN 16									
16010	0.077	82	0.315	0.31	50	100	120	160	200
16020	0.205	72	0.402	0.4	50	160	210	290	370
16030	0.207	79	0.693	0.69	60	150	190	260	310
16040	0.236	81	0.625	0.63	80	190	240	320	400
16050	0.131	73	0.417	0.42	40	100	140	190	230
16060	0.115	80	0.346	0.35	60	130	160	220	270
16070	0.138	79	0.29	0.29	70	170	210	280	340
16080	0.275	72	0.475	0.47	60	190	250	360	450
16100	0.035	69	0.6	0.6	0	20	20	40	40
16110	0.083	72	0.486	0.49	20	60	80	100	130
16120	0.162	79	0.342	0.34	80	180	230	310	370
16130	0.066	83	0.242	0.24	50	100	120	160	200
16140	0.075	82	0.407	0.41	40	80	100	140	160
BASIN 17									
17010	0.125	83	0.648	0.65	50	110	140	180	210
17020	0.184	81	0.525	0.52	80	170	220	280	340
17030	0.182	82	0.727	0.73	60	140	180	230	280
17040	0.108	82	0.61	0.61	40	90	120	160	190
17050	0.086	82	0.605	0.61	30	70	90	120	150
17060	0.309	72	0.515	0.51	70	200	270	380	480
17070	0.126	72	0.475	0.47	30	90	120	160	210
17080	0.197	79	0.682	0.68	60	140	180	240	300

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
17090	0.102	73	0.609	0.61	20	60	80	120	150
17100	0.157	75	0.682	0.68	40	100	130	180	220
17110	0.185	72	0.278	0.28	60	170	230	320	400
17120	0.036	73	0.282	0.28	10	40	50	60	80
17130	0.263	72	0.378	0.38	70	210	280	380	480
17140	0.088	71	0.756	0.76	10	40	60	80	100
17150	0.07	74	0.515	0.51	20	50	70	90	110
BASIN 18									
18010	0.14	74	0.556	0.56	30	100	120	170	220
18020	0.068	72	0.353	0.35	20	60	80	100	130
18030	0.115	72	0.276	0.28	40	110	140	200	250
18040	0.144	73	0.296	0.3	50	140	180	250	310
18050	0.105	72	0.652	0.65	20	60	80	110	140
18060	0.1	72	0.337	0.34	30	80	110	160	200
18070	0.078	72	0.343	0.34	20	60	90	120	150
18080	0.034	72	0.304	0.3	10	30	40	60	70
18090	0.251	72	0.434	0.43	60	180	240	340	430
18100	0.157	78	0.691	0.69	40	110	140	190	230
18110	0.24	73	0.69	0.69	50	140	180	250	320
18120	0.202	71	0.482	0.48	40	130	180	250	320
18130	0.094	72	0.32	0.32	30	80	110	150	190
18140	0.242	72	0.434	0.43	60	180	240	330	420
BASIN 19									
19010	0.103	77	0.998	1	20	50	70	90	120
19020	0.114	84	0.768	0.77	40	90	110	150	180
19030	0.089	86	0.587	0.59	40	90	110	140	170
19050	0.085	84	0.487	0.49	40	90	110	150	180
19060	0.087	81	0.392	0.39	40	100	120	160	190
19070	0.05	84	0.535	0.54	20	50	60	80	100
19080	0.042	86	0.44	0.44	20	50	60	80	100
19090	0.07	83	0.508	0.51	30	70	90	120	140
19100	0.023	91	0.427	0.43	20	30	40	50	60
19110	0.065	76	0.592	0.59	20	50	60	80	100
19120	0.041	84	0.525	0.52	20	40	50	70	80
19130	0.056	88	0.399	0.4	40	80	90	120	140
19140	0.067	83	0.573	0.57	30	60	80	100	120
19150	0.162	81	0.567	0.57	60	140	180	240	290
19160	0.108	85	0.404	0.4	60	130	160	210	250
19170	0.191	77	0.452	0.45	70	170	220	290	360
19190	0.068	75	0.612	0.61	20	40	60	80	100

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
19200	0.078	85	0.362	0.36	50	100	130	160	190
19210	0.075	85	0.338	0.34	50	100	120	160	190
19220	0.147	84	0.538	0.54	70	150	180	240	290
19230	0.287	81	0.592	0.59	110	240	310	410	500
19240	0.092	88	0.35	0.35	70	130	160	210	240
BASIN 20									
20010	0.171	74	0.69	0.69	40	100	130	180	230
20020	0.117	72	0.279	0.28	40	110	140	200	250
20030	0.179	73	0.308	0.31	60	160	220	300	380
20040	0.102	72	0.45	0.45	20	70	100	140	170
20050	0.319	73	0.338	0.34	100	280	370	510	640
20060	0.105	73	0.355	0.35	30	90	120	160	210
20070	0.259	78	0.73	0.73	70	170	220	300	370
20080	0.113	68	0.405	0.41	20	70	100	140	180
20090	0.196	70	0.453	0.45	40	130	170	240	310
20100	0.148	69	0.573	0.57	20	80	110	150	200
BASIN 21									
21010	0.26	76	0.527	0.53	80	200	260	350	440
21020	0.077	76	0.372	0.37	30	70	100	130	160
21030	0.233	66	0.652	0.65	20	100	140	200	260
21040	0.134	71	0.785	0.79	20	60	80	120	150
21050	0.294	68	0.492	0.49	50	160	220	320	420
21060	0.074	68	0.457	0.46	10	40	60	80	110
21070	0.03	71	0.364	0.36	10	20	30	40	60
21080	0.232	70	0.535	0.54	40	130	180	260	330
21090	0.17	74	0.368	0.37	50	150	200	270	330
21100	0.115	71	0.326	0.33	30	90	130	180	220
21110	0.16	81	0.414	0.41	80	170	220	280	340
21120	0.222	89	0.506	0.51	140	260	320	410	480
21130	0.056	88	0.468	0.47	40	70	80	110	130
BASIN 22									
22010	0.048	83	0.382	0.38	30	60	70	90	110
BASIN 23									
23010	0.166	84	0.59	0.59	70	160	200	250	300
23020	0.221	74	0.329	0.33	80	200	270	370	460
23030	0.128	73	0.241	0.24	50	130	180	240	300
23040	0.21	83	0.29	0.29	140	290	360	470	560
23050	0.065	73	0.223	0.22	30	70	90	130	160
23060	0.077	91	0.325	0.32	70	120	150	190	220
23070	0.111	84	0.393	0.39	60	130	170	220	260

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
23080	0.218	89	0.637	0.64	120	220	270	350	410
23090	0.307	91	0.404	0.4	240	440	530	670	780
23100	0.212	83	0.526	0.53	100	210	260	340	410
BASIN 24									
24010	0.072	80	0.232	0.23	40	100	130	170	200
24020	0.149	68	0.318	0.32	30	110	150	210	270
24030	0.067	76	0.324	0.32	30	70	90	120	150
24050	0.214	66	0.645	0.64	20	90	130	180	240
24060	0.107	75	0.227	0.23	50	120	160	220	270
24070	0.111	67	0.926	0.93	10	40	50	80	100
24080	0.139	66	0.662	0.66	20	60	80	120	160
24090	0.224	69	0.83	0.83	30	90	130	180	240
24100	0.08	67	0.535	0.54	10	40	60	80	100
24110	0.042	76	0.191	0.19	20	60	70	100	120
24130	0.207	81	0.378	0.38	100	230	290	390	470
24150	0.267	71	0.985	0.99	30	110	140	200	260
24160	0.152	74	0.303	0.3	60	150	200	270	330
24170	0.216	73	0.833	0.83	40	110	140	200	250
24180	0.148	80	0.376	0.38	70	160	200	270	330
24190	0.051	92	0.284	0.28	50	90	110	140	160
BASIN 25									
25010	0.072	77	0.305	0.31	30	80	100	140	170
25020	0.11	83	0.308	0.31	70	150	180	240	280
25030	0.249	69	0.535	0.54	40	140	190	270	340
25050	0.117	66	0.715	0.71	10	50	60	90	120
25070	0.127	66	0.298	0.3	20	80	120	170	220
25080	0.187	74	0.296	0.3	70	180	240	330	410
25090	0.15	88	0.268	0.27	130	250	300	380	450
25100	0.16	83	0.314	0.31	100	210	270	350	410
25110	0.164	75	0.342	0.34	60	160	200	280	340
25120	0.209	67	0.545	0.55	30	100	140	210	270
25140	0.164	67	0.825	0.82	20	60	90	120	160
25150	0.236	68	0.707	0.71	30	100	140	200	270
25170	0.237	66	0.423	0.42	30	130	180	270	350
25180	0.112	66	1.048	1.05	10	30	50	70	90
25190	0.183	66	0.462	0.46	20	100	130	200	260
25200	0.099	63	0.331	0.33	10	50	80	110	150
25210	0.403	71	1.861	1.86	30	100	140	190	240
ALLEN BRANCH BASIN (AB)									
AB010	0.269	69	0.522	0.52	40	150	210	300	380

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
AB020	0.068	68	0.433	0.43	10	40	60	80	100
AB030	0.169	69	0.504	0.5	30	100	130	190	240
AB040	0.194	75	0.673	0.67	40	120	160	220	270
AB060	0.193	68	0.538	0.54	30	100	140	200	260
AB070	0.173	66	0.525	0.52	20	80	120	170	220
AB080	0.126	68	0.32	0.32	30	90	120	180	230
AB090	0.166	67	0.367	0.37	30	100	140	210	270
AB100	0.161	69	0.307	0.31	40	120	170	240	310
AB110	0.13	66	0.567	0.57	20	60	80	120	160
AB120	0.183	67	0.45	0.45	30	100	140	200	270
AB130	0.066	71	0.392	0.39	20	50	60	90	120
AB140	0.19	70	0.448	0.45	40	120	170	240	300
AB150	0.171	78	0.488	0.49	60	150	190	260	310
AB170	0.135	74	0.371	0.37	40	120	160	210	260
AB180	0.18	74	0.445	0.44	50	140	190	260	320
AB190	0.088	81	0.407	0.41	40	90	120	160	190
BISHOP ROAD BASIN (BR)									
BR010	0.293	72	0.271	0.27	100	280	370	520	650
BR020	0.269	73	0.33	0.33	80	240	320	440	550
BR030	0.223	72	0.396	0.4	60	170	230	320	400
BR040	0.242	72	0.305	0.31	70	210	280	400	500
BR050	0.137	77	0.304	0.3	60	150	190	260	320
BR060	0.188	79	0.319	0.32	90	220	280	370	450
BR070	0.088	72	0.573	0.57	20	50	70	100	130
BR090	0.216	72	0.36	0.36	60	180	230	330	410
BR100	0.108	73	0.537	0.54	20	70	100	130	170
BR110	0.162	75	0.988	0.99	30	80	100	140	180
BR120	0.105	82	0.512	0.51	50	100	130	170	200
BR130	0.159	74	0.464	0.46	40	120	160	220	280
BR140	0.061	80	0.502	0.5	20	60	70	100	120
BR160	0.124	77	0.256	0.26	60	150	190	260	310
CALDWELL LAKE BASIN (CL)									
CL010	0.138	70	0.537	0.54	20	80	110	150	200
CL020	0.149	76	0.305	0.31	60	160	200	270	340
CL030	0.142	74	0.667	0.67	30	90	110	160	200
CL040	0.171	73	0.327	0.33	50	150	200	280	350
CL050	0.093	73	0.338	0.34	30	80	110	150	190
CL060	0.205	74	0.288	0.29	80	200	270	370	460
CL070	0.245	73	0.33	0.33	80	220	290	400	500
CL080	0.09	72	0.32	0.32	30	80	100	140	180

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
CL100	0.14	74	0.278	0.28	50	140	190	260	320
CL120	0.189	72	0.47	0.47	40	130	180	240	310
CL130	0.153	73	0.367	0.37	40	130	170	240	290
CL140	0.082	77	0.345	0.34	30	80	110	150	180
CL150	0.115	73	0.31	0.31	40	110	140	190	240
CL160	0.087	74	0.296	0.3	30	80	110	150	190
COLLIER ROAD BASIN (CR)									
CR010	0.216	73	0.678	0.68	40	120	160	230	290
CR020	0.1	76	0.289	0.29	40	110	140	190	230
CR030	0.125	74	0.388	0.39	40	100	140	190	240
CR050	0.173	72	0.398	0.4	40	130	180	240	310
CR060	0.264	75	0.492	0.49	80	200	260	360	450
CR070	0.186	74	0.411	0.41	60	150	200	280	340
CR080	0.182	73	0.374	0.37	50	150	200	280	350
CR090	0.165	72	0.498	0.5	40	110	150	200	260
CR100	0.153	73	0.547	0.55	40	100	130	180	230
CR110	0.115	72	0.268	0.27	40	110	150	200	250
CR120	0.234	74	0.327	0.33	80	220	290	390	490
COX CREEK BASIN (CX)									
CX010	0.225	78	0.715	0.71	60	150	200	260	330
CX020	0.231	76	0.55	0.55	70	170	220	300	380
CX030	0.164	77	0.595	0.6	50	120	160	210	260
CX040	0.067	81	0.502	0.5	30	60	80	110	130
CX050	0.156	76	0.39	0.39	60	140	190	250	310
CX060	0.088	78	0.472	0.47	30	80	100	140	160
CX070	0.08	74	0.202	0.2	40	100	130	170	210
CX080	0.053	76	0.285	0.28	20	60	80	100	130
CX090	0.135	79	0.49	0.49	50	120	160	210	250
CX100	0.131	72	0.403	0.4	30	100	130	190	230
CX110	0.036	89	0.371	0.37	30	50	60	80	90
CX120	0.121	82	0.238	0.24	80	180	220	290	350
CX130	0.064	73	0.348	0.35	20	60	70	100	130
CX140	0.037	80	0.37	0.37	20	40	50	70	80
CX150	0.08	70	0.215	0.22	20	80	100	150	180
CX160	0.08	79	0.38	0.38	40	80	110	140	170
CX170	0.074	76	0.282	0.28	30	80	110	140	180
CX180	0.135	75	0.333	0.33	50	130	170	230	290
CX190	0.145	77	0.415	0.41	50	130	170	230	290
CX200	0.126	78	0.428	0.43	50	120	150	200	250
CX210	0.233	73	0.412	0.41	60	180	240	340	420

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
CX220	0.122	73	0.34	0.34	40	110	140	200	240
CX230	0.112	76	0.478	0.48	40	90	120	160	200
CX240	0.081	75	0.378	0.38	30	70	100	130	160
CX250	0.101	79	0.38	0.38	40	100	130	180	220
CX260	0.143	80	0.528	0.53	50	130	160	210	260
CX270	0.088	73	0.507	0.51	20	60	80	110	140
CX280	0.082	77	0.368	0.37	30	80	100	140	170
CX290	0.174	77	0.438	0.44	60	150	200	270	330
CX300	0.061	74	0.355	0.35	20	60	70	100	120
CX310	0.07	73	0.482	0.48	20	50	70	90	120
CX320	0.101	80	0.355	0.35	50	110	140	190	230
CX330	0.029	79	0.335	0.34	10	30	40	60	70
CX340	0.052	73	0.352	0.35	20	40	60	80	100
GRASSY CREEK BASIN (GC)									
GC010	0.085	78	0.542	0.54	30	70	90	120	150
GC020	0.164	86	0.673	0.67	70	150	190	240	290
GC030	0.171	77	0.553	0.55	50	130	170	230	290
GC040	0.176	82	0.215	0.22	130	270	340	440	530
GC050	0.133	90	0.712	0.71	70	130	160	200	240
GC060	0.215	83	0.294	0.29	140	300	370	480	580
GC070	0.236	74	0.326	0.33	80	220	290	400	490
GC080	0.156	77	0.568	0.57	50	120	150	210	260
GC090	0.18	75	0.562	0.56	50	130	170	230	280
GC100	0.13	79	0.527	0.53	50	110	140	190	230
GC110	0.085	75	0.728	0.73	20	50	70	90	110
GC120	0.141	82	0.657	0.66	50	120	150	190	230
GC130	0.172	69	0.225	0.22	50	160	210	300	380
GC140	0.114	80	0.274	0.27	60	150	190	250	300
GC150	0.125	81	0.76	0.76	40	90	120	150	180
GC160	0.207	66	0.915	0.92	20	70	100	140	180
GC170	0.136	74	0.7	0.7	30	80	100	140	180
GC180	0.176	72	0.732	0.73	30	90	120	170	220
GC190	0.244	68	0.301	0.3	50	180	250	360	460
GC200	0.165	71	0.558	0.56	30	100	130	180	240
GC210	0.12	73	0.858	0.86	20	60	80	110	140
GC220	0.101	74	0.283	0.28	40	100	130	180	230
GC230	0.129	81	0.628	0.63	50	100	130	180	220
GC240	0.277	79	0.942	0.94	70	160	210	280	340
GC250	0.289	74	1.035	1.03	50	130	170	240	300
GC260	0.223	79	0.813	0.81	60	140	180	250	300

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi²)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
GC270	0.142	79	0.713	0.71	40	100	130	170	210
GC280	0.169	71	0.847	0.85	20	80	100	140	180
GC290	0.075	81	0.58	0.58	30	60	80	110	130
GC300	0.216	78	0.613	0.61	70	160	210	280	350
GC310	0.12	78	0.647	0.65	40	90	110	150	180
GC320	0.176	77	0.642	0.64	50	120	160	220	270
GC330	0.082	78	0.505	0.5	30	70	90	120	150
GC340	0.046	76	0.438	0.44	20	40	50	70	90
GC350	0.135	80	0.612	0.61	50	110	140	180	230
GC360	0.12	81	0.813	0.81	40	80	100	140	170
GC370	0.111	80	0.568	0.57	40	90	120	160	190
GC380	0.143	81	1.192	1.19	30	80	100	130	160
GC390	0.154	81	0.527	0.53	60	140	180	240	290
GC400	0.062	87	0.612	0.61	30	60	80	100	120
GC410	0.174	81	0.437	0.44	80	180	230	300	360
GC430	0.124	78	1.078	1.08	20	60	80	110	140
GC440	0.112	80	0.6	0.6	40	90	120	160	190
GC450	0.134	92	0.617	0.62	80	150	180	230	270
HINES BRANCH BASIN (HB)									
HB010	0.203	79	0.38	0.38	90	210	270	360	440
HB020	0.136	79	0.313	0.31	70	160	200	270	330
HB030	0.129	81	0.392	0.39	60	140	180	240	290
HB040	0.114	74	0.478	0.48	30	80	110	160	190
HB050	0.154	85	0.44	0.44	90	180	220	290	340
HB060	0.115	70	0.263	0.26	30	100	140	190	240
HB070	0.131	80	0.269	0.27	80	170	220	290	350
HB080	0.081	87	0.353	0.35	60	110	140	180	210
HB090	0.184	75	0.455	0.46	60	150	190	260	330
HB100	0.116	80	0.415	0.41	50	120	150	200	240
HB110	0.125	79	0.443	0.44	50	120	150	200	250
HB120	0.074	84	0.367	0.37	40	90	120	150	180
HB130	0.072	80	0.36	0.36	40	80	100	140	160
HB140	0.069	79	0.268	0.27	40	90	110	150	180
HB150	0.138	82	0.31	0.31	80	180	220	290	350
HB160	0.216	82	0.39	0.39	110	240	310	410	490
HB170	0.125	81	0.548	0.55	50	110	140	190	230
HB180	0.088	76	0.467	0.47	30	70	90	130	160
HAW BRANCH BASIN (HW)									
HW010	0.196	84	0.462	0.46	100	210	270	350	420
HW020	0.251	81	0.433	0.43	120	260	330	440	530

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
HW030	0.106	83	0.65	0.65	40	90	110	150	180
HW040	0.181	80	0.327	0.33	90	210	270	360	430
HW050	0.107	79	0.392	0.39	50	110	140	190	230
HW060	0.211	79	0.512	0.51	80	180	240	320	390
HW070	0.209	90	0.361	0.36	170	310	380	480	560
HW080	0.225	74	0.387	0.39	70	190	250	340	430
HW090	0.189	86	0.438	0.44	110	220	280	360	430
KERNS BRANCH BASIN (KB)									
KB010	0.179	66	0.333	0.33	30	110	160	230	300
KB020	0.106	67	0.25	0.25	20	80	110	160	210
KB030	0.131	67	0.291	0.29	20	90	130	190	240
KB040	0.128	66	0.268	0.27	20	90	130	180	240
KB050	0.241	65	0.402	0.4	30	130	180	270	350
KB060	0.128	64	0.502	0.5	10	60	80	120	160
KB070	0.106	65	0.465	0.47	10	50	70	110	140
KB080	0.125	69	0.693	0.69	20	60	80	120	150
KB090	0.103	70	0.39	0.39	20	70	100	140	180
KB100	0.156	75	0.427	0.43	50	130	170	230	290
KB110	0.24	68	0.315	0.31	50	170	240	340	440
KB120	0.072	72	0.234	0.23	30	70	100	140	170
KB130	0.154	79	0.575	0.57	50	120	160	220	260
KB140	0.123	73	0.331	0.33	40	110	140	200	250
KB150	0.153	81	0.737	0.74	50	110	140	190	230
KB160	0.103	80	0.583	0.58	40	90	110	150	180
KB190	0.123	79	0.55	0.55	40	100	130	180	220
KB200	0.1	81	0.615	0.62	40	80	100	140	170
KB210	0.137	82	0.5	0.5	60	130	170	220	270
KB220	0.176	84	0.572	0.57	80	170	210	280	330
KB230	0.146	82	0.868	0.87	40	100	130	170	200
KNOB FORK BASIN (KF)									
KF010	0.255	81	0.415	0.41	120	270	340	450	550
KF020	0.137	85	0.253	0.25	110	220	270	340	410
KF030	0.081	70	0.492	0.49	20	50	70	100	120
KF040	0.092	84	0.252	0.25	70	140	180	230	270
KF050	0.128	70	0.667	0.67	20	60	90	120	160
KF060	0.14	66	0.643	0.64	20	60	80	120	160
KF070	0.247	84	0.68	0.68	100	210	260	340	420
KF080	0.098	66	0.707	0.71	10	40	50	80	100
KF090	0.176	84	0.592	0.59	80	160	210	270	320
KF100	0.111	80	0.61	0.61	40	90	110	150	190

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
KF110	0.054	81	0.508	0.51	20	50	60	80	100
KF120	0.031	62	0.388	0.39	0	10	20	30	40
KF130	0.244	69	0.638	0.64	40	120	160	240	300
KF140	0.047	75	0.318	0.32	20	50	60	80	100
KF150	0.1	72	0.326	0.33	30	80	110	160	200
KF160	0.037	70	0.348	0.35	10	30	40	50	70
KF170	0.14	85	0.788	0.79	50	110	140	180	220
KF180	0.062	82	0.688	0.69	20	50	60	80	100
KF190	0.188	81	0.216	0.22	130	280	350	460	560
KF200	0.095	87	0.547	0.55	50	100	130	160	190
KF210	0.14	81	0.236	0.24	90	200	250	330	400
KF220	0.095	89	0.513	0.51	60	110	140	180	210
KF230	0.202	71	0.433	0.43	50	140	190	270	340
KF240	0.134	70	0.429	0.43	30	90	120	170	220
KF250	0.103	88	0.648	0.65	50	100	120	160	190
KF260	0.106	74	0.399	0.4	30	90	120	160	200
KF270	0.107	85	0.421	0.42	60	130	160	200	240
KF280	0.223	90	0.386	0.39	170	320	380	490	570
KF290	0.169	89	0.448	0.45	110	220	260	340	390
KF300	0.154	83	0.642	0.64	60	130	170	220	260
KF310	0.247	82	0.623	0.62	100	210	270	350	420
KF320	0.072	78	0.718	0.72	20	50	60	80	100
MILL BRANCH BASIN (MB)									
MB020	0.161	67	0.53	0.53	20	80	110	160	210
MB030	0.172	66	0.567	0.57	20	80	110	160	210
MB040	0.162	68	0.285	0.28	40	120	170	240	310
MB050	0.138	68	0.315	0.31	30	100	140	200	250
MB070	0.209	68	0.54	0.54	30	110	150	220	280
MB080	0.077	68	0.405	0.41	10	50	70	100	120
MB090	0.136	66	0.402	0.4	20	80	110	160	200
MB100	0.179	68	0.53	0.53	30	90	130	190	240
MB110	0.088	71	0.36	0.36	20	70	90	130	160
MB120	0.298	67	0.428	0.43	50	170	240	340	440
MB130	0.053	66	0.279	0.28	10	40	50	70	100
MB140	0.21	66	0.361	0.36	30	130	180	260	340
MB150	0.12	64	0.375	0.38	10	60	90	130	180
MB160	0.143	67	0.517	0.52	20	70	100	150	190
MB180	0.132	72	0.414	0.41	30	100	130	180	230
MB190	0.149	78	0.384	0.38	60	150	190	260	320
MB200	0.161	76	0.521	0.52	50	120	160	220	270

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
MB210	0.109	77	0.443	0.44	40	100	120	170	210
MB220	0.119	85	0.343	0.34	80	160	200	260	300
MEADOW CREEK BASIN (MC)									
MC010	0.199	70	0.78	0.78	30	90	120	170	220
MC020	0.082	80	0.582	0.58	30	70	90	120	140
MC030	0.22	76	0.683	0.68	50	140	190	250	320
MC040	0.122	77	0.607	0.61	40	90	110	160	190
MC050	0.188	78	1.098	1.1	40	100	120	160	200
MC060	0.038	80	0.568	0.57	10	30	40	50	70
MC070	0.199	79	0.668	0.67	60	150	190	250	310
MC080	0.093	83	0.593	0.59	40	80	110	140	170
MC090	0.221	74	1.275	1.27	30	80	110	150	200
MC100	0.144	83	0.655	0.65	60	120	160	200	240
MC110	0.133	79	0.477	0.48	50	120	150	210	250
MC120	0.208	71	0.331	0.33	60	170	230	320	400
MC130	0.105	80	0.867	0.87	30	70	80	110	140
MC140	0.133	78	0.558	0.56	40	100	140	180	220
MC150	0.149	84	0.495	0.5	70	160	190	250	300
MC160	0.118	79	0.81	0.81	30	80	100	130	160
MC170	0.139	79	0.613	0.61	40	110	140	190	230
MC180	0.176	80	0.963	0.96	40	100	130	180	220
MC190	0.161	79	1.245	1.25	30	80	100	130	160
MC200	0.07	81	0.88	0.88	20	50	60	80	90
MC210	0.147	81	0.512	0.51	60	140	170	230	280
MC220	0.196	83	0.435	0.44	100	210	270	350	420
MC230	0.075	82	0.675	0.68	30	60	80	100	120
MC240	0.121	90	0.475	0.47	80	150	190	240	280
MC250	0.157	85	0.612	0.61	70	150	180	240	290
MC260	0.083	78	0.58	0.58	30	60	80	110	140
NORTH FORK BASIN (NF)									
NF020	0.212	73	0.234	0.23	80	230	300	410	520
NF030	0.157	73	0.32	0.32	50	140	190	260	330
NF040	0.179	73	0.261	0.26	60	180	240	330	410
NF050	0.141	74	0.298	0.3	50	140	180	250	310
NF060	0.189	73	0.488	0.49	50	130	180	250	310
NF070	0.146	72	0.425	0.43	40	110	140	200	250
NF080	0.192	72	0.537	0.54	40	120	160	230	290
NF090	0.101	73	0.473	0.47	20	70	100	140	170
NF100	0.165	73	0.41	0.41	40	130	170	240	300
NF110	0.235	80	0.357	0.36	110	260	330	440	530

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
NF120	0.1	72	1.06	1.06	10	40	50	80	100
NF130	0.171	72	0.327	0.33	50	140	190	270	340
NF140	0.066	72	0.473	0.47	20	50	60	80	110
NF150	0.199	72	0.747	0.75	30	100	140	190	240
NF160	0.083	74	0.425	0.43	20	70	90	120	150
NF170	0.086	82	0.78	0.78	30	60	80	100	130
NF180	0.091	76	0.366	0.37	30	90	110	150	190
NF190	0.183	77	0.653	0.65	50	130	160	220	280
NF210	0.106	72	0.518	0.52	20	70	90	130	160
PLUMB CREEK BASIN (PC)									
PC010	0.075	93	0.213	0.21	90	160	190	230	270
PC020	0.205	93	0.4	0.4	180	310	370	460	530
PC030	0.096	92	0.37	0.37	80	150	180	220	260
PC040	0.09	90	0.263	0.26	90	160	190	240	280
PC050	0.156	90	0.185	0.19	180	320	390	490	560
PC060	0.201	82	0.569	0.57	80	180	230	300	360
PC070	0.143	77	0.292	0.29	60	160	210	280	340
PC080	0.152	79	0.468	0.47	60	140	180	240	290
PC090	0.1	84	0.455	0.46	50	110	140	180	210
PC100	0.14	83	0.553	0.55	60	130	170	220	260
PC110	0.257	81	0.662	0.66	90	200	260	340	420
PC120	0.123	82	0.65	0.65	50	100	130	170	210
PC130	0.163	72	0.777	0.78	30	80	110	150	190
PC140	0.087	72	0.265	0.26	30	80	110	160	200
PC150	0.144	74	0.351	0.35	50	130	170	230	290
PC160	0.26	73	0.777	0.78	50	140	180	250	320
PC170	0.195	76	0.853	0.85	40	110	140	190	240
PC180	0.176	78	0.968	0.97	40	100	120	170	210
PC190	0.197	84	1.125	1.13	60	120	150	190	240
PC200	0.064	83	0.433	0.43	30	70	90	120	140
PC210	0.135	83	0.862	0.86	40	100	120	160	190
PC220	0.092	79	0.495	0.5	30	80	100	140	170
PC230	0.11	78	0.62	0.62	30	80	100	140	180
SOUTH FORK BASIN (SF)									
SF010	0.183	75	0.602	0.6	50	120	160	220	280
SF020	0.088	79	0.577	0.58	30	70	90	120	150
SF030	0.098	76	0.575	0.57	30	70	90	130	160
SF040	0.1	77	0.5	0.5	30	80	110	140	180
SF050	0.071	81	0.508	0.51	30	70	80	110	140
SF060	0.134	76	0.457	0.46	40	110	140	200	240

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
SF070	0.118	74	0.362	0.36	40	100	140	190	240
SF080	0.112	68	0.297	0.3	20	80	110	160	210
SF090	0.075	73	0.403	0.4	20	60	80	110	140
SF100	0.123	77	0.493	0.49	40	100	130	180	220
SF110	0.12	77	0.512	0.51	40	100	130	170	210
SF120	0.051	79	0.358	0.36	20	60	70	90	110
SOLWAY ROAD BASIN (SR)									
SR010	0.095	89	0.198	0.2	100	180	220	280	330
SR020	0.142	91	0.178	0.18	170	300	370	460	530
SR030	0.109	92	0.231	0.23	120	210	260	320	370
SR040	0.086	90	0.292	0.29	80	140	170	220	260
SR050	0.208	86	0.261	0.26	170	330	410	520	620
SR060	0.196	89	0.28	0.28	180	320	400	500	590
SR080	0.19	89	0.296	0.3	160	300	370	470	550
SR090	0.131	89	0.318	0.32	110	200	250	310	370
TRAILER PARK BASIN (TP)									
TP010	0.111	79	0.42	0.42	50	110	140	190	230
TP020	0.092	82	0.39	0.39	50	100	130	170	210
TP030	0.08	94	0.535	0.54	60	100	120	150	180
TP040	0.06	92	0.618	0.62	40	70	80	100	120
THOMPSON SCHOOL BASIN (TS)									
TS010	0.134	65	0.647	0.65	10	50	80	110	150
TS020	0.092	73	0.387	0.39	30	70	100	140	170
TS030	0.151	77	0.595	0.6	40	110	140	190	240
TS040	0.11	77	0.537	0.54	30	90	110	150	190
TS050	0.172	81	0.728	0.73	60	130	160	220	260
TS060	0.119	80	0.697	0.7	40	90	110	150	180
TS070	0.125	83	0.378	0.38	70	150	190	240	290
TS080	0.071	82	0.402	0.4	40	80	100	130	160
TS090	0.104	82	0.38	0.38	60	120	150	200	240
TS100	0.114	84	0.515	0.51	60	120	150	190	230
TS110	0.041	83	0.46	0.46	20	40	60	70	90
TS120	0.077	82	0.555	0.56	30	70	90	120	140
WILLOW FORK BASIN (WF)									
WF010	0.218	66	0.373	0.37	30	130	180	260	340
WF020	0.145	66	0.364	0.36	20	90	120	180	230
WF030	0.11	67	0.515	0.51	20	60	80	110	150
WF040	0.164	66	0.342	0.34	30	100	140	210	270
WF050	0.086	63	0.5	0.5	10	40	50	80	100
WF060	0.19	67	0.468	0.47	30	100	140	210	270

Table B-2. Beaver Creek Future Condition Sub-basin Information (Contributing Areas Only)

Basin	Area (mi^2)	CN	Tc (hrs)	R Coeff	Peak Flow (cfs)				
					2-yr	10-yr	25-yr	100-yr	500-yr
WF080	0.079	67	0.312	0.31	20	50	80	110	140
WF090	0.156	66	0.331	0.33	20	100	140	200	260
WF100	0.121	71	0.35	0.35	30	100	130	180	230
WF130	0.135	78	0.545	0.55	40	110	140	190	230
WF170	0.115	82	0.933	0.93	30	80	90	120	150
WF180	0.112	72	0.38	0.38	30	90	120	160	210
WF190	0.159	80	0.655	0.65	50	120	160	210	260
WF200	0.123	84	0.513	0.51	60	130	160	210	250
WF210	0.142	84	0.805	0.81	50	110	140	180	210
WF220	0.102	86	0.663	0.66	50	100	120	150	180
WF230	0.13	84	0.742	0.74	50	100	130	170	210
WF240	0.143	82	0.697	0.7	50	110	140	190	230
WF250	0.117	83	0.962	0.96	40	80	100	130	150
WF260	0.09	81	0.37	0.37	40	100	130	170	200
WF270	0.088	80	0.74	0.74	30	60	80	110	130
WF280	0.081	83	0.592	0.59	30	70	90	120	150
WF290	0.071	83	0.407	0.41	40	80	100	130	160
WF300	0.06	88	0.393	0.39	40	80	100	130	150
WF310	0.07	84	0.532	0.53	30	70	90	120	140

APPENDIX C
FFE and Flood Depth Information for Habitable Structures in the Existing Floodplain

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
BEAVER CREEK													
1		3.443	829.86	-10.01	-7.20	-6.17	-4.67	-3.05	-9.32	-6.39	-5.32	-3.82	-2.20
2		3.422	834.86	-15.26	-12.47	-11.44	-9.94	-8.32	-14.58	-11.66	-10.60	-9.09	-7.48
3		5.843	861.49	-14.12	-10.05	-8.71	-6.80	-4.78	-12.98	-9.00	-7.62	-5.71	-3.67
4		5.808	869.49	-22.53	-18.45	-17.11	-15.19	-13.16	-21.38	-17.40	-16.02	-14.10	-12.03
5		12.325	943.96	-15.08	-10.24	-8.71	-6.63	-4.60	-13.68	-9.04	-7.47	-5.52	-3.63
12		16.122	958.70	-11.36	-5.99	-4.21	-1.77	0.93	-9.92	-4.59	-2.80	-0.25	2.47
13		16.122	966.10	-18.76	-13.39	-11.61	-9.17	-6.47	-17.32	-11.99	-10.20	-7.65	-4.93
14		16.122	958.80	-11.46	-6.09	-4.31	-1.87	0.83	-10.02	-4.69	-2.90	-0.35	2.37
18	6744 Greenbrook	19.295	977.70	-18.46	-14.10	-12.73	-10.79	-8.68	-17.23	-13.03	-11.61	-9.58	-7.37
19	6743 Greenbrook	19.295	971.60	-12.36	-8.00	-6.63	-4.69	-2.58	-11.13	-6.93	-5.51	-3.48	-1.27
20	6732 Greenbrook	19.295	979.41	-20.17	-15.81	-14.44	-12.50	-10.39	-18.94	-14.74	-13.32	-11.29	-9.08
21	6728 Greenbrook	19.295	974.07	-14.83	-10.47	-9.10	-7.16	-5.05	-13.60	-9.40	-7.98	-5.95	-3.74
22	6925 Greenbrook	20.133	975.16	-13.73	-9.03	-7.53	-5.44	-3.19	-12.43	-7.86	-6.33	-4.14	-1.78
23	Greenbrook	20.185	975.54	-14.00	-9.28	-7.78	-5.68	-3.43	-12.68	-8.11	-6.58	-4.38	-2.02
24	6913 Greenbrook	20.185	975.67	-14.13	-9.41	-7.91	-5.81	-3.56	-12.81	-8.24	-6.71	-4.51	-2.15
25	6909 Greenbrook	20.185	977.60	-16.06	-11.34	-9.84	-7.74	-5.49	-14.74	-10.17	-8.64	-6.44	-4.08
26	6901 Greenbrook	20.185	976.69	-15.15	-10.43	-8.93	-6.83	-4.58	-13.83	-9.26	-7.73	-5.53	-3.17
27	6765 Greenbrook	20.185	980.70	-19.16	-14.44	-12.94	-10.84	-8.59	-17.84	-13.27	-11.74	-9.54	-7.18
35	Clinton Hwy. @ W. Emory Rd.	24.915	987.86	-13.91	-8.77	-7.36	-5.44	-4.28	-12.36	-7.69	-6.24	-4.01	-2.41
36	Bridgefield Dr.	24.110	979.89	-9.18	-3.91	-2.44	-0.43	1.67	-7.64	-2.77	-1.28	0.80	3.02

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
37	Bridgefield Dr.	24.091	979.42	-8.78	-3.51	-2.05	-0.05	2.05	-7.25	-2.38	-0.89	1.18	3.39
38	Bridgefield Dr.	24.063	978.81	-8.28	-3.00	-1.54	0.44	2.52	-6.74	-1.87	-0.39	1.66	3.86
39	Clinton Hwy.	25.178	986.99	-12.45	-7.20	-5.64	-3.45	-1.75	-10.93	-6.01	-4.38	-1.88	0.20
40	Clinton Hwy.	25.009	987.25	-12.98	-7.61	-6.04	-3.85	-2.17	-11.40	-6.41	-4.78	-2.28	-0.20
41	Dry Gap Pk.	32.525	1001.79	-8.67	-4.58	-2.69	0.12	2.95	-7.64	-3.15	-1.24	2.27	4.04
42	Josepi Dr.	31.749	1010.52	-19.39	-15.26	-13.51	-11.27	-8.66	-18.35	-13.94	-12.28	-9.59	-6.80
43	Josepi Dr.	31.764	1008.88	-17.71	-13.58	-11.84	-9.60	-6.99	-16.67	-12.27	-10.61	-7.92	-5.13
44	Ambassador Pl.	35.189	1012.49	-8.41	-4.36	-3.07	-1.38	0.43	-7.35	-3.35	-2.19	-0.21	1.53
45		34.990	1021.47	-18.56	-15.26	-14.32	-13.16	-12.00	-17.67	-14.52	-13.70	-12.41	-11.44
46		37.169	1022.96	-9.43	-6.30	-5.22	-3.55	-1.72	-8.66	-5.45	-4.32	-2.33	-0.57
47		37.188	1021.33	-7.70	-4.54	-3.45	-1.77	0.06	-6.92	-3.68	-2.54	-0.55	1.21
50	6936 Greenbrook	19.574	972.94	-13.03	-8.47	-7.00	-4.97	-2.77	-11.75	-7.32	-5.84	-3.70	-1.41
51	Greenbrook	19.545	977.44	-17.61	-13.06	-11.59	-9.56	-7.36	-16.33	-11.91	-10.43	-8.30	-6.01
52	Greenbrook	19.527	969.79	-10.01	-5.46	-4.00	-1.97	0.23	-8.73	-4.32	-2.83	-0.71	1.58
53	6926 Greenbrook	19.508	969.98	-10.25	-5.71	-4.25	-2.22	-0.03	-8.98	-4.57	-3.08	-0.96	1.33
54	6920 Greenbrook	19.470	973.22	-13.59	-9.06	-7.60	-5.58	-3.39	-12.32	-7.92	-6.44	-4.32	-2.04
55	6920 Greenbrook	19.464	979.55	-19.94	-15.41	-13.95	-11.93	-9.74	-18.67	-14.27	-12.79	-10.67	-8.39
56	6916 Greenbrook	19.441	983.23	-23.67	-19.16	-17.72	-15.71	-13.53	-22.41	-18.03	-16.56	-14.45	-12.18
57	6908 Greenbrook	19.432	977.93	-18.39	-13.89	-12.45	-10.44	-8.27	-17.13	-12.76	-11.30	-9.19	-6.93
58	6900 Greenbrook	19.384	979.63	-20.19	-15.75	-14.33	-12.35	-10.19	-18.94	-14.64	-13.19	-11.11	-8.86
59		19.356	980.66	-21.28	-16.87	-15.46	-13.49	-11.35	-20.04	-15.77	-14.33	-12.27	-10.03
60	6756 Greenbrook	19.328	980.53	-21.21	-16.83	-15.43	-13.48	-11.35	-19.98	-15.74	-14.31	-12.26	-10.04
61	6763 Bonneville	20.435	973.80	-11.72	-6.90	-5.40	-3.30	-1.04	-10.35	-5.73	-4.20	-2.00	0.39
62	6759 Bonneville	20.521	978.66	-16.41	-11.63	-10.14	-8.05	-5.80	-15.04	-10.47	-8.94	-6.75	-4.37

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
63	7008 Regency	18.983	977.25	-18.77	-14.76	-13.50	-11.70	-9.68	-17.64	-13.77	-12.46	-10.56	-8.43
64	7012/7014 Regency	19.129	970.87	-12.01	-7.84	-6.53	-4.67	-2.62	-10.83	-6.81	-5.46	-3.51	-1.35
65	7024 Regency	19.394	977.37	-17.91	-13.46	-12.03	-10.04	-7.89	-16.66	-12.34	-10.89	-8.81	-6.55
66	7028 Regency	19.413	979.84	-20.34	-15.86	-14.43	-12.43	-10.27	-19.08	-14.74	-13.28	-11.19	-8.93
67	7032 Regency	19.470	980.58	-20.95	-16.42	-14.96	-12.94	-10.75	-19.68	-15.28	-13.80	-11.68	-9.40
68	7036 Regency	19.489	982.05	-22.37	-17.83	-16.37	-14.35	-12.16	-21.10	-16.69	-15.21	-13.09	-10.81
69	7040 Regency	19.498	977.74	-18.04	-13.50	-12.04	-10.01	-7.82	-16.76	-12.36	-10.87	-8.75	-6.47
70	7044 Regency	19.555	983.99	-24.13	-19.58	-18.11	-16.08	-13.88	-22.86	-18.43	-16.95	-14.81	-12.52
71		25.415	996.40	-21.48	-16.40	-14.85	-12.65	-10.94	-20.05	-15.21	-13.58	-11.09	-9.01
72		25.415	985.17	-10.25	-5.17	-3.62	-1.42	0.29	-8.82	-3.98	-2.35	0.14	2.22
73		25.415	986.16	-11.24	-6.16	-4.61	-2.41	-0.70	-9.81	-4.97	-3.34	-0.85	1.23
74		25.415	985.69	-10.77	-5.69	-4.14	-1.94	-0.23	-9.34	-4.50	-2.87	-0.38	1.70
75		25.415	985.96	-11.04	-5.96	-4.41	-2.21	-0.50	-9.61	-4.77	-3.14	-0.65	1.43
76		25.415	986.88	-11.96	-6.88	-5.33	-3.13	-1.42	-10.53	-5.69	-4.06	-1.57	0.51
77		25.415	986.80	-11.88	-6.80	-5.25	-3.05	-1.34	-10.45	-5.61	-3.98	-1.49	0.59
78		25.415	990.50	-15.58	-10.50	-8.95	-6.75	-5.04	-14.15	-9.31	-7.68	-5.19	-3.11
79		25.658	993.88	-18.62	-13.67	-12.12	-9.90	-8.15	-17.25	-12.48	-10.83	-8.36	-6.30
80		25.658	993.49	-18.23	-13.28	-11.73	-9.51	-7.76	-16.86	-12.09	-10.44	-7.97	-5.91
81		25.701	993.93	-18.61	-13.68	-12.13	-9.91	-8.16	-17.25	-12.49	-10.84	-8.37	-6.31
82		25.701	994.43	-19.11	-14.18	-12.63	-10.41	-8.66	-17.75	-12.99	-11.34	-8.87	-6.81
83		25.701	994.57	-19.25	-14.32	-12.77	-10.55	-8.80	-17.89	-13.13	-11.48	-9.01	-6.95
84		25.734	993.53	-18.16	-13.25	-11.70	-9.48	-7.72	-16.81	-12.06	-10.41	-7.94	-5.89
85		25.734	993.31	-17.94	-13.03	-11.48	-9.26	-7.50	-16.59	-11.84	-10.19	-7.72	-5.67
86		25.734	994.16	-18.79	-13.88	-12.33	-10.11	-8.35	-17.44	-12.69	-11.04	-8.57	-6.52

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
87		25.748	992.88	-17.49	-12.59	-11.04	-8.82	-7.05	-16.15	-11.40	-9.75	-7.28	-5.23
88		25.767	993.10	-17.68	-12.79	-11.24	-9.02	-7.25	-16.35	-11.60	-9.95	-7.48	-5.43
89		25.767	993.49	-18.07	-13.18	-11.63	-9.41	-7.64	-16.74	-11.99	-10.34	-7.87	-5.82
90		25.800	994.84	-19.38	-14.50	-12.95	-10.73	-8.96	-18.05	-13.31	-11.66	-9.19	-7.15
91		25.826	991.49	-15.99	-11.13	-9.58	-7.35	-5.58	-14.67	-9.94	-8.28	-5.82	-3.78
92		25.850	990.54	-15.01	-10.16	-8.61	-6.38	-4.60	-13.69	-8.97	-7.31	-4.85	-2.81
95	W. Beaver Cr. Dr.	24.148	988.58	-17.72	-12.47	-10.99	-8.96	-6.84	-16.19	-11.32	-9.82	-7.71	-5.48
96	W. Beaver Cr. Dr.	24.119	984.01	-13.26	-8.00	-6.53	-4.52	-2.41	-11.73	-6.86	-5.36	-3.28	-1.06
97	W. Beaver Cr. Dr.	24.119	985.05	-14.30	-9.04	-7.57	-5.56	-3.45	-12.77	-7.90	-6.40	-4.32	-2.10
98	W. Beaver Cr. Dr.	24.119	986.20	-15.45	-10.19	-8.72	-6.71	-4.60	-13.92	-9.05	-7.55	-5.47	-3.25
99	W. Emory Rd.	26.913	990.43	-12.44	-8.18	-6.66	-4.47	-2.50	-11.35	-7.01	-5.40	-3.02	-0.80
100		26.809	991.33	-13.75	-9.41	-7.88	-5.69	-3.74	-12.64	-8.24	-6.62	-4.22	-2.03
101		26.770	989.56	-12.10	-7.73	-6.19	-4.00	-2.05	-10.98	-6.55	-4.93	-2.52	-0.33
102		26.770	992.31	-14.85	-10.48	-8.94	-6.75	-4.80	-13.73	-9.30	-7.68	-5.27	-3.08
103		27.064	986.65	-8.00	-3.28	-1.23	0.49	1.98	-6.88	-1.71	0.36	1.46	3.51
104		27.074	993.48	-14.80	-10.07	-8.04	-6.31	-4.83	-13.68	-8.52	-6.45	-5.34	-3.30
105	Brickyard Rd.	27.178	995.96	-17.08	-12.34	-10.41	-8.67	-7.16	-15.94	-10.89	-8.84	-7.69	-5.63
106	W. Emory Rd.	27.216	992.51	-13.59	-8.86	-6.94	-5.20	-3.68	-12.46	-7.42	-5.37	-4.21	-2.15
107	W. Emory Rd.	27.263	986.81	-7.84	-3.13	-1.21	0.53	2.06	-6.72	-1.69	0.35	1.52	3.58
108	W. Emory Rd.	27.281	986.62	-7.63	-2.93	-1.01	0.73	2.26	-6.51	-1.49	0.55	1.72	3.78
109	W. Emory Rd.	27.281	985.15	-6.16	-1.46	0.46	2.20	3.73	-5.04	-0.02	2.02	3.19	5.25
110	W. Emory Rd.	27.462	985.09	-5.75	-1.23	0.66	2.40	3.94	-4.68	0.19	2.19	3.39	5.44
111	W. Emory Rd.	27.491	989.20	-9.76	-5.29	-3.40	-1.66	-0.13	-8.71	-3.87	-1.88	-0.68	1.37
112	W. Emory Rd.	27.554	986.36	-6.72	-2.34	-0.46	1.27	2.81	-5.70	-0.92	1.04	2.26	4.29

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
113	W. Emory Rd.	27.611	993.78	-13.96	-9.66	-7.78	-6.06	-4.52	-12.97	-8.24	-6.31	-5.08	-3.05
114	W. Emory Rd.	27.630	1003.06	-23.18	-18.91	-17.03	-15.31	-13.77	-22.20	-17.49	-15.57	-14.33	-12.31
115	Emory Rd.	27.680	985.86	-5.83	-1.64	0.22	1.94	3.48	-4.88	-0.23	1.67	2.92	4.94
116	Emory Rd.	27.813	991.23	-10.81	-6.83	-5.00	-3.29	-1.74	-9.92	-5.45	-3.58	-2.31	-0.30
118	Brickey Ln.	33.615	1005.11	-8.45	-5.76	-4.38	-2.07	0.52	-7.84	-4.73	-3.22	-0.17	1.70
119	Brickey Ln.	33.615	1001.44	-4.78	-2.09	-0.71	1.60	4.19	-4.17	-1.06	0.45	3.50	5.37
120	Brickey Ln.	33.615	1001.68	-5.02	-2.33	-0.95	1.36	3.95	-4.41	-1.30	0.21	3.26	5.13
121	Brickey Ln.	34.100	1009.03	-9.81	-7.19	-6.25	-4.60	-2.47	-9.03	-6.48	-5.45	-3.12	-1.32
122		35.843	1013.27	-7.18	-2.68	-1.25	0.66	2.71	-5.99	-1.57	-0.26	1.99	3.98
123		35.871	1016.46	-10.29	-5.80	-4.36	-2.45	-0.40	-9.10	-4.67	-3.36	-1.11	0.87
124		36.274	1022.28	-13.84	-10.22	-8.87	-7.01	-4.95	-13.01	-9.17	-7.90	-5.65	-3.68
125		36.326	1014.12	-5.32	-1.88	-0.54	1.31	3.36	-4.55	-0.84	0.42	2.66	4.63
126		36.335	1017.42	-8.55	-5.14	-3.81	-1.97	0.09	-7.80	-4.11	-2.86	-0.61	1.36
127		36.364	1014.96	-5.89	-2.58	-1.26	0.58	2.63	-5.17	-1.55	-0.31	1.93	3.90
128		36.373	1022.91	-13.78	-10.50	-9.19	-7.34	-5.29	-13.07	-9.48	-8.23	-5.99	-4.02
129		36.787	1014.37	-3.05	-0.21	0.92	2.60	4.51	-2.39	0.66	1.78	3.87	5.71
130		36.787	1015.04	-3.72	-0.88	0.25	1.93	3.84	-3.06	-0.01	1.11	3.20	5.04
131		36.805	1017.20	-5.77	-2.93	-1.81	-0.14	1.76	-5.10	-2.07	-0.95	1.12	2.96
132		36.805	1015.39	-3.96	-1.12	-0.00	1.67	3.57	-3.29	-0.26	0.86	2.93	4.77
133		36.805	1015.57	-4.14	-1.30	-0.18	1.49	3.39	-3.47	-0.44	0.68	2.75	4.59
134		36.808	1017.57	-6.12	-3.28	-2.17	-0.50	1.40	-5.45	-2.42	-1.31	0.77	2.60
135		36.932	1020.79	-8.56	-5.76	-4.71	-3.10	-1.27	-7.87	-4.95	-3.88	-1.88	-0.11
136	Sam Lee Rd.	4.692	Not Surveyed										
137	Hardin Valley Dr.	12.638	Not										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
			Surveyed										
138	Crossland Rd.	12.982	Not Surveyed										
139	Crossland Rd.	12.982	Not Surveyed										
140	Byington-Solway Rd.	13.277	Not Surveyed										
141	Byington-Solway Rd.	13.391	Not Surveyed										
142	8021 Oak Ridge Hwy	15.914	954.97	-8.74	-3.27	-1.49	0.98	3.75	-7.23	-1.88	-0.05	2.49	5.35
146	8008 Oak Ridge Hwy	15.989	956.03	-9.43	-4.01	-2.23	0.25	3.04	-7.95	-2.62	-0.79	1.79	4.64
148	7946 Oak Ridge Hwy	16.766	956.80	-6.52	-1.26	0.49	2.87	5.29	-5.04	0.11	1.87	4.26	6.74
149	7941 Oak Ridge Hwy	16.766	954.13	-3.85	1.41	3.16	5.54	7.96	-2.37	2.78	4.54	6.93	9.41
150	7941 Oak Ridge Hwy	16.084	959.24	-12.18	-6.81	-5.04	-2.54	0.28	-10.73	-5.43	-3.60	-0.96	1.86
152	7942 Oak Ridge Hwy	16.084	959.34	-12.28	-6.91	-5.14	-2.64	0.18	-10.83	-5.53	-3.70	-1.06	1.76
154	7940 Oak Ridge Hwy	16.084	958.86	-11.80	-6.43	-4.66	-2.16	0.66	-10.35	-5.05	-3.22	-0.58	2.24
156		20.397	Not Surveyed										
157	Wright Rd.	20.850	Not Surveyed										
158	Wright Rd.	20.888	Not Surveyed										
159	Harrell Rd.	21.071	Not Surveyed										
160		21.692	Not Surveyed										
161		25.548	Not Surveyed										
162		25.548	Not Surveyed										
163		25.548	Not Surveyed										
164	W. Emory Rd.	27.668	Not Surveyed										
165	W. Emory Rd.	27.668	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
166	Collier Rd.	27.857	Not Surveyed										
167	Beaver Creek Dr.	28.122	Not Surveyed										
168	Beaver Creek Dr.	28.122	Not Surveyed										
169	Betenia Rd.	28.190	Not Surveyed										
170	Betenia Rd.	28.190	Not Surveyed										
171		28.227	Not Surveyed										
172	Betenia Rd.	28.227	Not Surveyed										
173	Betenia Rd.	28.227	Not Surveyed										
174	Betenia Rd.	28.227	Not Surveyed										
175		28.227	Not Surveyed										
176		28.265	Not Surveyed										
177	Belinda Rd.	28.303	Not Surveyed										
178	Belinda Rd.	28.303	Not Surveyed										
179		28.552	Not Surveyed										
180	Central Avenue Pk.	29.687	Not Surveyed										
181	Central Avenue Pk.	29.716	Not Surveyed										
182	East Emory Rd.	29.773	Not Surveyed										
183	East Emory Rd.	29.865	Not Surveyed										
184	East Emory Rd.	30.017	Not Surveyed										
185	East Emory Rd.	30.055	Not Surveyed										
186	East Emory Rd.	30.373	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
187	Dry Gap Pk.	32.448	Not Surveyed										
188	Spurlin Rd.	32.969	Not Surveyed										
189	Spurlin Rd.	32.969	Not Surveyed										
190	Spurlin Rd.	32.969	Not Surveyed										
191	Spurlin Rd.	32.969	Not Surveyed										
192	Dixon Spring Ln.	34.367	Not Surveyed										
193	Cunningham Dr.	34.673	Not Surveyed										
194	Cunningham Dr.	34.838	Not Surveyed										
195		34.876	Not Surveyed										
196		34.876	Not Surveyed										
197		34.914	Not Surveyed										
198		35.616	Not Surveyed										
199	Rollins Rd.	36.742	Not Surveyed										
200	Rollins Rd.	36.742	Not Surveyed										
201	Rollins Rd.	36.742	Not Surveyed										
202	Rollins Rd.	36.742	Not Surveyed										
203	Rollins Rd.	36.742	Not Surveyed										
204	Rollins Rd.	36.787	Not Surveyed										
205	Rollins Rd.	36.787	Not Surveyed										
206	Seeber Dr.	36.808	Not Surveyed										
207	Seeber Dr.	36.808	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
208	7034 Maynardville Pk	37.970	1027.00	-8.57	-4.30	-2.53	0.01	1.73	-7.51	-2.76	-0.91	1.26	3.02
209	7052 Maynardville Pk	37.665	1027.25	-10.21	-5.71	-4.06	-0.92	0.80	-9.10	-4.25	-2.07	0.33	2.12
210	7110 Maynardville Pk	37.665	1025.94	-8.90	-4.40	-2.75	0.39	2.11	-7.79	-2.94	-0.76	1.64	3.43
211	4522 Doris Circle	38.030	1025.44	-6.72	-2.64	-0.90	1.62	3.34	-5.72	-1.12	0.70	2.87	4.65
212	7106 Maynardville Pk	37.665	1026.98	-9.94	-5.44	-3.79	-0.65	1.07	-8.83	-3.98	-1.80	0.60	2.39
213	7108 Maynardville Pk	37.665	1027.55	-10.51	-6.01	-4.36	-1.22	0.50	-9.40	-4.55	-2.37	0.03	1.82
214	7224 Maynardville Pk	37.711	1025.69	-8.56	-4.10	-2.47	0.66	2.39	-7.46	-2.63	-0.49	1.92	3.73
215	7212 Maynardville Pk	37.711	1021.89	-4.76	-0.30	1.33	4.46	6.19	-3.66	1.17	3.31	5.72	7.53
216	6950 Maynardville Pk	37.946	1024.04	-5.69	-1.37	0.41	2.94	4.66	-4.61	0.18	2.02	4.19	5.96
217	7120-7154 Maynardville Pk	37.984	1025.16	-6.69	-2.44	-0.67	1.86	3.58	-5.63	-0.90	0.94	3.11	4.88
218	7139 Commercial Pk	38.030	1025.83	-7.11	-3.03	-1.29	1.23	2.95	-6.11	-1.51	0.31	2.48	4.26
219	Commercial Pk	38.030	1026.78	-8.06	-3.98	-2.24	0.28	2.00	-7.06	-2.46	-0.64	1.53	3.31
220	Commercial Pk	38.030	1026.98	-8.26	-4.18	-2.44	0.08	1.80	-7.26	-2.66	-0.84	1.33	3.11
221	7113 Commercial Pk	38.030	1027.65	-8.93	-4.85	-3.11	-0.59	1.13	-7.93	-3.33	-1.51	0.66	2.44
222	7140 Commercial Pk	38.041	1026.78	-8.00	-3.97	-2.22	0.29	2.02	-7.02	-2.45	-0.62	1.55	3.32
223	7132 Commercial Pk	38.041	1028.99	-10.21	-6.18	-4.43	-1.92	-0.19	-9.23	-4.66	-2.83	-0.66	1.11
224	4505 Marshall Dr	38.260	1024.54	-4.62	-1.33	0.29	2.74	4.48	-3.86	0.09	1.84	4.01	5.79
225	Marshall Dr	38.260	1026.00	-6.08	-2.79	-1.17	1.28	3.02	-5.32	-1.37	0.38	2.55	4.33
226	4500 Marshall Dr	38.331	1022.46	-1.92	1.05	2.58	4.96	6.71	-1.22	2.39	4.09	6.24	8.01
227	4508 Marshall Dr	38.402	1025.23	-4.07	-1.42	0.01	2.34	4.09	-3.43	-0.16	1.48	3.62	5.39
228	4512 Marshall Dr	38.459	1026.58	-5.06	-2.42	-1.06	1.20	2.94	-4.39	-1.21	0.36	2.48	4.23
229	4600 Marshall Dr	38.478	1027.19	-5.54	-2.91	-1.57	0.66	2.40	-4.87	-1.72	-0.17	1.93	3.68
230	Marshall Dr	38.523	1027.44	-5.51	-2.88	-1.60	0.57	2.31	-4.81	-1.74	-0.24	1.85	3.58
231	4606 Marshall Dr	38.561	1026.25	-4.08	-1.46	-0.22	1.90	3.63	-3.36	-0.35	1.11	3.18	4.90

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
232	4620 Marshall Dr	38.609	1029.34	-6.86	-4.25	-3.07	-1.01	0.71	-6.12	-3.19	-1.78	0.26	1.97
233	4622 Marshall Dr	38.637	1029.17	-6.51	-3.91	-2.76	-0.74	0.98	-5.76	-2.87	-1.50	0.53	2.23
234	4624 Marshall Dr	38.665	1029.22	-6.37	-3.77	-2.64	-0.65	1.08	-5.62	-2.75	-1.40	0.63	2.33
235	4723 Zirkle Dr	38.790	1030.53	-6.86	-4.33	-3.28	-1.40	0.33	-6.12	-3.37	-2.11	-0.11	1.58
236	7313 Homestead Dr	38.877	1029.84	-5.65	-3.34	-2.33	-0.50	1.21	-5.01	-2.42	-1.20	0.78	2.46
237	7311 Homestead Dr	38.887	1030.31	-6.06	-3.77	-2.77	-0.95	0.76	-5.43	-2.86	-1.64	0.33	2.01
238	7309 Homestead Dr	38.892	1030.55	-6.28	-3.99	-3.00	-1.18	0.53	-5.65	-3.08	-1.87	0.10	1.78
239	7102 Periwinkle Rd	39.288	1034.25	-7.26	-3.22	-2.09	-0.74	1.34	-6.24	-2.14	-1.21	0.19	1.26
240	7104 Periwinkle Rd	39.288	1037.99	-11.00	-6.96	-5.83	-4.48	-2.40	-9.98	-5.88	-4.95	-3.55	-2.48
241	5202 Millet Lane	39.710	1036.28	-6.15	-2.96	-2.02	-0.37	1.60	-5.20	-2.07	-0.96	0.93	2.39
242	Stormer Rd.	41.564	Not Surveyed										
243	Tazewell Pk.	44.286	Not Surveyed										
244	Tazewell Pk.	44.295	Not Surveyed										
245	Tazewell Pk.	44.313	Not Surveyed										
246	Tazewell Pk.	44.323	Not Surveyed										
249	8028 Oak Ridge Hwy	15.815	956.20	-10.43	-4.89	-3.09	-0.62	2.14	-8.89	-3.48	-1.64	0.88	3.77
250	8030 Oak Ridge Hwy	15.796	958.75	-13.05	-7.48	-5.67	-3.19	-0.40	-11.51	-6.07	-4.21	-1.67	1.23
253	Oak Ridge Hwy.	16.334	Not Surveyed										
254	Oak Ridge Hwy.	16.521	Not Surveyed										
255	Emory Rd.	16.758	Not Surveyed										
256	Brickey Ln.	33.615	Not Surveyed										
257	Fairview Ln.	34.625	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
258	Cunningham Dr.	34.673	Not Surveyed										
259	Cunningham Dr.	34.701	Not Surveyed										
260	Cunningham Dr.	34.853	Not Surveyed										
261	Imperial Dr.	35.028	Not Surveyed										
262	Imperial Dr.	35.028	Not Surveyed										
263	Imperial Dr.	35.028	Not Surveyed										
264	Imperial Dr.	35.028	Not Surveyed										
265	Imperial Dr.	35.028	Not Surveyed										
266	Ambassador Ln.	35.234	Not Surveyed										
267	Ambassador Ln.	35.234	Not Surveyed										
268	Cynruss Dr.	36.041	Not Surveyed										
269	Cynruss Dr.	36.060	Not Surveyed										
270	N. Fountaincrest Dr.	36.284	Not Surveyed										
271	Fountaincrest Dr.	36.284	Not Surveyed										
272	Madeira Rd.	36.362	Not Surveyed										
273	Fountaincrest Dr.	36.362	Not Surveyed										
274	Fountaincrest Dr.	36.362	Not Surveyed										
275	N. Fountaincrest Dr.	36.409	Not Surveyed										
276	N. Fountaincrest Dr.	36.428	Not Surveyed										
277	N. Fountaincrest Dr.	36.457	Not Surveyed										
278	N. Fountaincrest Dr.	36.476	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
279	N. Fountaincrest Dr.	36.504	Not Surveyed										
280	N. Fountaincrest Dr.	36.523	Not Surveyed										
281	N. Fountaincrest Dr.	36.561	Not Surveyed										
282	Rollins Rd.	36.742	Not Surveyed										
283	Rollins Rd.	36.742	Not Surveyed										
284	Rollins Rd.	36.742	Not Surveyed										
285	Rollins Rd.	36.742	Not Surveyed										
286	Rollins Rd.	36.742	Not Surveyed										
287	Rollins Rd.	36.742	Not Surveyed										
288	Rollins Rd.	36.742	Not Surveyed										
289	Rollins Rd.	36.742	Not Surveyed										
290	Afton Dr.	36.815	Not Surveyed										
291	Afton Dr.	36.857	Not Surveyed										
292	Afton Dr.	36.885	Not Surveyed										
293	Afton Dr.	36.913	Not Surveyed										
294	Afton Dr.	37.036	Not Surveyed										
295	Afton Dr.	37.093	Not Surveyed										
296	Afton Dr.	37.121	Not Surveyed										
297	Shalimar Pointe Way	37.064	Not Surveyed										
298	Shalimar Pointe Way	37.093	Not Surveyed										
299	Shalimar Pointe Way	37.121	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
300	Afton Dr.	37.216	Not Surveyed										
301	Afton Dr.	37.235	Not Surveyed										
302	Afton Dr.	37.544	Not Surveyed										
303	Afton Dr.	37.585	Not Surveyed										
304	7050 Maynardville Pk	37.984	1030.77	-12.30	-8.05	-6.28	-3.75	-2.03	-11.24	-6.51	-4.67	-2.50	-0.73
305	7048 Maynardville Pk	37.984	1032.34	-13.87	-9.62	-7.85	-5.32	-3.60	-12.81	-8.08	-6.24	-4.07	-2.30
306	7032 Maynardville Pk	37.984	1028.25	-9.78	-5.53	-3.76	-1.23	0.49	-8.72	-3.99	-2.15	0.02	1.79
307	4521 Doris Circle	37.984	1027.46	-8.99	-4.74	-2.97	-0.44	1.28	-7.93	-3.20	-1.36	0.81	2.58
308	Maynardville Pk	37.984	1029.27	-10.80	-6.55	-4.78	-2.25	-0.53	-9.74	-5.01	-3.17	-1.00	0.77
309	6934 Maynardville Pk	37.984	1031.31	-12.84	-8.59	-6.82	-4.29	-2.57	-11.78	-7.05	-5.21	-3.04	-1.27
310	7108-7110 Commercial Pk	38.076	1028.88	-9.91	-6.01	-4.28	-1.78	-0.05	-8.97	-4.50	-2.69	-0.52	1.25
311	Commercial Pk	38.076	1028.98	-10.01	-6.11	-4.38	-1.88	-0.15	-9.07	-4.60	-2.79	-0.62	1.15
312	4500 Doris Circle	38.076	1032.91	-13.94	-10.04	-8.31	-5.81	-4.08	-13.00	-8.53	-6.72	-4.55	-2.78
313	4500 Doris Circle	38.076	1032.89	-13.92	-10.02	-8.29	-5.79	-4.06	-12.98	-8.51	-6.70	-4.53	-2.76
314	7313 Arlie Dr	38.152	1027.62	-8.24	-4.62	-2.93	-0.45	1.28	-7.40	-3.15	-1.36	0.81	2.59
315	7309Arlie Dr	38.152	1028.13	-8.75	-5.13	-3.44	-0.96	0.77	-7.91	-3.66	-1.87	0.30	2.08
316	7305 Arlie Dr	38.152	1027.15	-7.77	-4.15	-2.46	0.02	1.75	-6.93	-2.68	-0.89	1.28	3.06
317	7301 Arlie Dr	38.171	1029.77	-10.29	-6.74	-5.06	-2.59	-0.85	-9.48	-5.27	-3.49	-1.32	0.46
318	7225 Arlie Dr	38.171	1027.93	-8.45	-4.90	-3.22	-0.75	0.99	-7.64	-3.43	-1.65	0.52	2.30
319	7201 Arlie Dr	38.459	1026.83	-5.31	-2.67	-1.31	0.95	2.69	-4.64	-1.46	0.11	2.23	3.98
320	4626 Marshall Dr	38.713	1028.03	-4.86	-2.26	-1.16	0.79	2.52	-4.10	-1.26	0.05	2.07	3.77
321	4724 Zirkle Dr	38.762	1027.83	-4.33	-1.73	-0.67	1.24	2.97	-3.56	-0.76	0.52	2.53	4.22
322	4715 Zirkle Dr	38.830	1032.45	-8.54	-6.11	-5.08	-3.22	-1.50	-7.85	-5.17	-3.93	-1.94	-0.25

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
323	7319 Homestead Dr	38.868	1030.06	-5.92	-3.59	-2.58	-0.74	0.97	-5.27	-2.67	-1.44	0.54	2.22
324	7320 Homestead Dr	38.868	1031.21	-7.07	-4.74	-3.73	-1.89	-0.18	-6.42	-3.82	-2.59	-0.61	1.07
325	7316 Homestead Dr	38.875	1031.10	-6.92	-4.60	-3.60	-1.77	-0.06	-6.28	-3.69	-2.46	-0.49	1.19
326	7314 Homestead Dr	38.877	1034.16	-9.97	-7.66	-6.65	-4.82	-3.11	-9.33	-6.74	-5.52	-3.54	-1.86
327	7307 Homestead Dr	38.910	1032.12	-7.76	-5.50	-4.51	-2.71	-1.00	-7.14	-4.60	-3.39	-1.43	0.24
328	7325 Palmyra Dr	38.935	1027.57	-3.08	-0.86	0.11	1.90	3.61	-2.48	0.02	1.22	3.18	4.84
329	7328 Palmyra Dr	38.935	1032.91	-8.42	-6.20	-5.23	-3.44	-1.73	-7.82	-5.32	-4.12	-2.16	-0.50
330	7341 Parkman Dr	38.940	1032.15	-7.64	-5.42	-4.46	-2.67	-0.96	-7.04	-4.54	-3.35	-1.39	0.27
331	7317 Palmyra Dr	38.940	1030.60	-6.09	-3.87	-2.91	-1.12	0.59	-5.49	-2.99	-1.80	0.16	1.82
332	7305 Palmyra Dr	39.007	1030.36	-5.25	-3.07	-2.17	-0.51	1.15	-4.64	-2.24	-1.14	0.73	2.35
333	7301 Palmyra Dr	39.039	1037.52	-12.10	-9.93	-9.07	-7.47	-5.84	-11.47	-9.14	-8.08	-6.25	-4.65
334	4927 Crippen Rd	39.258	1034.20	-7.48	-4.97	-4.18	-2.79	-1.28	-6.70	-4.23	-3.32	-1.64	-0.18
335	4918 Crippen Rd	39.296	1038.74	-11.71	-7.44	-6.56	-5.20	-3.11	-10.63	-6.60	-5.67	-4.26	-3.17
336	5021 Crippen Rd	39.258	1036.31	-9.59	-7.08	-6.29	-4.90	-3.39	-8.81	-6.34	-5.43	-3.75	-2.29
337	3012 Crippen Rd	39.287	1033.88	-6.90	-2.89	-1.72	-0.38	1.71	-5.88	-1.77	-0.84	0.55	1.62
338	7153 Periwinkle Rd	39.287	1036.80	-9.82	-5.81	-4.64	-3.30	-1.21	-8.80	-4.69	-3.76	-2.37	-1.30
339	7151 Periwinkle Rd	39.296	1039.09	-12.06	-7.79	-6.91	-5.55	-3.46	-10.98	-6.95	-6.02	-4.61	-3.52
340	7149 Periwinkle Rd	39.306	1033.94	-6.85	-2.61	-1.72	-0.35	1.74	-5.78	-1.76	-0.83	0.60	1.70
341	7145 Periwinkle Rd	39.326	1038.15	-10.94	-6.75	-5.85	-4.46	-2.37	-9.88	-5.90	-4.95	-3.49	-2.36
342	7141 Periwinkle Rd	39.343	1037.40	-10.09	-5.94	-5.04	-3.63	-1.54	-9.04	-5.08	-4.12	-2.64	-1.49
343	7137 Periwinkle Rd	39.362	1033.62	-6.20	-2.10	-1.19	0.24	2.33	-5.15	-1.23	-0.25	1.26	2.43
344	7133 Periwinkle Rd	39.372	1041.76	-14.28	-10.20	-9.29	-7.85	-5.76	-13.24	-9.33	-8.35	-6.82	-5.64
345	7129 Periwinkle Rd	39.391	1038.87	-11.28	-7.25	-6.32	-4.86	-2.78	-10.25	-6.37	-5.37	-3.82	-2.61
346	7117 Periwinkle Rd	39.445	1037.73	-9.82	-5.93	-4.98	-3.46	-1.37	-8.82	-5.02	-3.99	-2.35	-1.08

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
347	7113 Periwinkle Rd	39.464	1039.20	-11.18	-7.33	-6.37	-4.83	-2.75	-10.18	-6.42	-5.38	-3.70	-2.41
348	7109 Periwinkle Rd	39.483	1038.43	-10.30	-6.50	-5.53	-3.97	-1.89	-9.31	-5.58	-4.52	-2.82	-1.50
349	7107 Periwinkle Rd	39.502	1039.18	-10.92	-7.20	-6.23	-4.66	-2.58	-9.95	-6.28	-5.21	-3.50	-2.17
350	7105 Periwinkle Rd	39.521	1038.65	-10.25	-6.63	-5.65	-4.07	-1.99	-9.32	-5.70	-4.62	-2.90	-1.56
351	7103 Periwinkle Rd	39.540	1038.81	-10.28	-6.74	-5.76	-4.16	-2.10	-9.37	-5.81	-4.73	-2.98	-1.64
352	7101 Periwinkle Rd	39.578	1038.10	-9.30	-5.93	-4.94	-3.33	-1.27	-8.45	-4.99	-3.90	-2.13	-0.77
353	7100 Periwinkle Rd	39.620	1037.80	-8.70	-5.53	-4.53	-2.89	-0.84	-7.91	-4.58	-3.47	-1.67	-0.29
354	5204 Bittersweet Rd	39.679	1038.10	-8.20	-4.97	-4.03	-2.38	-0.40	-7.25	-4.08	-2.97	-1.10	0.35
355	5208 Bittersweet Rd	39.689	1042.80	-12.76	-9.53	-8.59	-6.94	-4.97	-11.79	-8.64	-7.53	-5.65	-4.19
356	5212 Bittersweet Rd	39.689	1043.45	-13.41	-10.18	-9.24	-7.59	-5.62	-12.44	-9.29	-8.18	-6.30	-4.84
357	5220 Bittersweet Rd	39.689	1041.62	-11.58	-8.35	-7.41	-5.76	-3.79	-10.61	-7.46	-6.35	-4.47	-3.01
358	5224 Bittersweet Rd	39.689	1040.13	-10.09	-6.86	-5.92	-4.27	-2.30	-9.12	-5.97	-4.86	-2.98	-1.52
359	5228 Bittersweet Rd	39.689	1039.81	-9.77	-6.54	-5.60	-3.95	-1.98	-8.80	-5.65	-4.54	-2.66	-1.20
360	5203 Millet Lane	39.699	1038.89	-8.81	-5.60	-4.65	-3.00	-1.04	-7.84	-4.70	-3.59	-1.71	-0.25
361	5201 Millet Lane	39.699	1036.80	-6.72	-3.51	-2.56	-0.91	1.05	-5.75	-2.61	-1.50	0.38	1.84
362	5200 Millet Lane	39.699	1038.23	-8.15	-4.94	-3.99	-2.34	-0.38	-7.18	-4.04	-2.93	-1.05	0.41
363	5204 Millet Lane	39.724	1037.48	-7.29	-4.12	-3.18	-1.53	0.44	-6.35	-3.23	-2.12	-0.23	1.23
364	6909 Maize Dr	39.743	1038.20	-7.93	-4.80	-3.85	-2.20	-0.24	-7.00	-3.90	-2.79	-0.90	0.56
365	Fairview Rd.	43.851	Not Surveyed										
366	Fairview Rd.	43.967	Not Surveyed										
367	4520 Doris Circle	38.022	1023.41	-4.74	-0.63	1.12	3.64	5.37	-3.73	0.90	2.73	4.90	6.67
368	7100 Commercial Pk	38.022	1029.52	-10.85	-6.74	-4.99	-2.47	-0.74	-9.84	-5.21	-3.38	-1.21	0.56
369	4717 Zirkle Dr	38.830	1038.51	-14.60	-12.17	-11.14	-9.28	-7.56	-13.91	-11.23	-9.99	-8.00	-6.31

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
370	4719 Zirkle Dr	38.830	1032.15	-8.24	-5.81	-4.78	-2.92	-1.20	-7.55	-4.87	-3.63	-1.64	0.05
371	4721 Zirkle Dr	38.830	1031.53	-7.62	-5.19	-4.16	-2.30	-0.58	-6.93	-4.25	-3.01	-1.02	0.67
372	7312 Homestead Dr	38.887	1032.63	-8.38	-6.09	-5.09	-3.27	-1.56	-7.75	-5.18	-3.96	-1.99	-0.31
373	7320 Palmyra Dr	38.940	1030.15	-5.64	-3.42	-2.46	-0.67	1.04	-5.04	-2.54	-1.35	0.61	2.27
374	Parkman Dr	38.935	1030.84	-6.35	-4.13	-3.16	-1.37	0.34	-5.75	-3.25	-2.05	-0.09	1.57
375	Maize Dr	39.733	Not Surveyed										
376			Not Surveyed										
377			Not Surveyed										
378			Not Surveyed										
379			Not Surveyed										
380			Not Surveyed										
381			Not Surveyed										
382			Not Surveyed										
383			Not Surveyed										
384			Not Surveyed										
385			Not Surveyed										
386			Not Surveyed										
387			Not Surveyed										
388			Not Surveyed										
389			Not Surveyed										
390			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
391			Not Surveyed										
392			Not Surveyed										
393			Not Surveyed										
394			Not Surveyed										
395			Not Surveyed										
396			Not Surveyed										
397			Not Surveyed										
398			Not Surveyed										
399			Not Surveyed										
400			Not Surveyed										
401			Not Surveyed										
402			Not Surveyed										
403			Not Surveyed										
404			Not Surveyed										
405			Not Surveyed										
406			Not Surveyed										
407			Not Surveyed										
408			Not Surveyed										
409			Not Surveyed										
410			Not Surveyed										
411			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
412			Not Surveyed										
413			Not Surveyed										
414			Not Surveyed										
415			Not Surveyed										
416			Not Surveyed										
417			Not Surveyed										
418			Not Surveyed										
419			Not Surveyed										
420			Not Surveyed										
421			Not Surveyed										
422			Not Surveyed										
423			Not Surveyed										
424			Not Surveyed										
425			Not Surveyed										
426			Not Surveyed										
427			Not Surveyed										
428			Not Surveyed										
429			Not Surveyed										
430			Not Surveyed										
431			Not Surveyed										
432			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
433			Not Surveyed										
434			Not Surveyed										
435			Not Surveyed										
436			Not Surveyed										
437			Not Surveyed										
438			Not Surveyed										
439			Not Surveyed										
440			Not Surveyed										
441			Not Surveyed										
442			Not Surveyed										
443			Not Surveyed										
444			Not Surveyed										
445			Not Surveyed										
446			Not Surveyed										
447			Not Surveyed										
448			Not Surveyed										
449			Not Surveyed										
450			Not Surveyed										
451			Not Surveyed										
452			Not Surveyed										
453			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
454			Not Surveyed										
455			Not Surveyed										
456			Not Surveyed										
457			Not Surveyed										
458			Not Surveyed										
459			Not Surveyed										
460			Not Surveyed										
461			Not Surveyed										
462			Not Surveyed										
463			Not Surveyed										
464			Not Surveyed										
465			Not Surveyed										
466			Not Surveyed										
467			Not Surveyed										
468			Not Surveyed										
469			Not Surveyed										
470			Not Surveyed										
471			Not Surveyed										
472			Not Surveyed										
473			Not Surveyed										
474			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
475			Not Surveyed										
476			Not Surveyed										
477			Not Surveyed										
478			Not Surveyed										
479			Not Surveyed										
480			Not Surveyed										
481			Not Surveyed										
482			Not Surveyed										
483			Not Surveyed										
TRIBUTARY TO COX CREEK													
CT1	Brown Gap Rd.	0.008	Not Surveyed										
CT2	6427 Cedar Breeze Ln.	0.670	1072.46	-4.63	-2.24	-0.95	0.31	0.82	-4.32	-1.80	-0.38	0.53	0.97
CT3	Bay Circle Dr.	0.467	1063.13	-4.73	-3.79	-3.48	-2.97	-2.59	-4.58	-3.68	-3.42	-2.80	-2.48
CT4	Bay Circle Dr.	0.521	1066.96	-5.23	-4.00	-3.69	-3.38	-2.94	-4.97	-3.87	-3.55	-3.22	-2.82
CT5	Bay Circle Dr.	0.540	1070.38	-7.89	-6.76	-6.46	-6.13	-5.71	-7.64	-6.64	-6.33	-5.98	-5.60
CT6	Bay Circle Dr.	0.500	1067.08	-6.64	-5.53	-5.22	-4.83	-4.41	-6.43	-5.41	-5.11	-4.67	-4.30
CT7	Bay Circle Dr.	0.480	1062.41	-3.21	-2.20	-1.89	-1.43	-1.03	-3.03	-2.08	-1.81	-1.26	-0.92
CT8	Bay Circle Dr.	0.450	1063.47	-5.89	-4.87	-4.55	-4.06	-3.68	-5.72	-4.75	-4.48	-3.90	-3.57
CT9	Bay Circle Dr.	0.430	1066.48	-9.87	-8.75	-8.42	-7.96	-7.57	-9.67	-8.63	-8.34	-7.80	-7.45
CT10	Bay Circle Dr.	0.646	1076.1	-9.51	-8.76	-8.51	-8.18	-7.86	-9.24	-8.66	-8.41	-8.06	-7.77
COX CREEK													
CX1	Brown Gap Rd.	0.270	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
CX2	Brown Gap Rd.	0.302	Not Surveyed										
CX3			Not Surveyed										
CX4			Not Surveyed										

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing 2-yr	Existing 10-yr	Existing 25-yr	Existing 100-yr	Existing 500-yr	Future 2-yr	Future 10-yr	Future 25-yr	Future 100-yr	Future 500-yr
GRASSY CREEK													
GC1	Ball Dr.	2.118	991	-5.63	-2.09	-0.79	1.65	2.89	-4.55	-0.96	0.52	2.63	3.86
GC2	Ball Dr.	2.118	989.21	-3.84	-0.30	1.00	3.44	4.68	-2.76	0.83	2.31	4.42	5.65
GC3	Ball Dr.	2.118	988.9	-3.53	0.01	1.31	3.75	4.99	-2.45	1.14	2.62	4.73	5.96
GC4		1.266	979.4	-6.48	-5.11	-4.71	-4.21	-3.72	-6.02	-4.76	-4.38	-3.83	-3.26
GC5	W. Beaver Cr. Dr.	0.530	974.24	-8.78	-4.81	-3.26	-1.50	0.36	-7.89	-3.66	-1.99	-0.44	1.70
GC6	W. Beaver Cr. Dr.	0.607	973.19	-7.07	-3.72	-2.21	-0.45	1.41	-6.42	-2.61	-0.94	0.61	2.75
GC7	W. Beaver Cr. Dr.	0.494	985.57	-20.38	-16.14	-14.59	-12.83	-10.97	-19.28	-14.99	-13.32	-11.77	-9.63
GC8	W. Beaver Cr. Dr.	0.569	Not Surveyed										
GC9	W. Beaver Cr. Dr.	0.854	Not Surveyed										
GC10	Hackberry Rd.	2.166	Not Surveyed										
GC11	Hackberry Rd.	2.166	Not Surveyed										
GC12	Hackberry Rd.	2.166	Not Surveyed										
GC13	Oak Ridge Hwy.	N/A	Not Surveyed										
GC14	Johnson Rd.	N/A	Not Surveyed										
GC15	Johnson Rd.	N/A	Not Surveyed										
GC16			Not Surveyed										
GC17			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
GC18			Not Surveyed										
GC19			Not Surveyed										
GC20			Not Surveyed										
GC21			Not Surveyed										
GC22			Not Surveyed										
GC23			Not Surveyed										
GC24			Not Surveyed										
GC25			Not Surveyed										
HINES BRANCH													
HB1	7121 W. Chermont Circle	0.106	1016.32	-9.44	-6.03	-4.60	-2.70	-0.65	-8.77	-4.91	-3.61	-1.37	0.61
HB2	7113 W. Chermont Circle	0.161	1017.33	-9.58	-7.04	-5.61	-3.71	-1.66	-9.33	-5.92	-4.62	-2.38	-0.40
HB3	7105 W. Chermont Circle	0.172	1014.63	-6.70	-4.34	-2.91	-1.01	1.04	-6.54	-3.22	-1.92	0.32	2.30
HB4	Cunningham Rd.	0.189	1016.36	-7.88	-6.07	-4.64	-2.74	-0.69	-7.75	-4.95	-3.65	-1.41	0.57
HB5	3312 Cunningham Rd.	0.236	1018.79	-7.79	-6.59	-6.20	-5.17	-3.12	-7.56	-6.48	-6.07	-3.84	-1.86
HB6	3308 Cunningham Rd.	0.236	1015.81	-4.81	-3.61	-3.22	-2.19	-0.14	-4.58	-3.50	-3.09	-0.86	1.12
HB7		1.080	1043.38	-10.27	-8.00	-7.14	-6.06	-5.18	-10.10	-7.80	-6.95	-5.89	-5.04
HB8		1.157	1040.92	-5.56	-3.36	-2.42	-1.18	-0.15	-5.38	-3.13	-2.22	-0.99	0.04
HB9		1.174	1038.01	-2.15	0.10	1.04	2.28	3.32	-1.97	0.32	1.24	2.47	3.51
HB10	3631 Rothmoor Dr.	1.863	1064.12	-2.74	-0.83	-0.25	0.53	1.15	-2.56	-0.71	-0.16	0.61	1.23
HB11	3715 Mynatt Rd.	1.863	1062.38	-1.00	0.91	1.49	2.27	2.89	-0.82	1.03	1.58	2.35	2.97
HB12	6619 Maynardville Hwy.	1.477	1060.41	-6.11	0.78	1.18	1.75	2.19	-5.58	0.92	1.26	1.82	2.27
HB16	7133 Chermont Circle	0.040	1016.3	-10.46	-6.01	-4.58	-2.68	-0.63	-9.29	-4.89	-3.59	-1.35	0.63
HB17	Chermont Circle	0.176	Not										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
			Surveyed										
HB18	Fraker Rd.	0.678	Not Surveyed										
HB19	Fountain Valley Dr	1.155	1043.4	-8.10	-5.90	-4.96	-3.73	-2.70	-7.92	-5.67	-4.76	-3.54	-2.51
HB21	6621 Maynardville Hwy.	1.441	1061.15	-8.38	-2.40	-1.83	-1.03	-0.43	-7.91	-2.24	-1.70	-0.93	-0.32
HB23	Maynardville Hwy.	1.494	1062.1	-7.64	-0.87	-0.45	0.15	0.61	-7.12	-0.72	-0.37	0.22	0.69
HB24	Maynardville Hwy.	1.555	Not Surveyed										
HB25	6533 Maynardville Hwy.	1.598	1062.31	-1.63	-0.07	0.32	0.87	1.36	-1.49	0.02	0.37	0.93	1.43
HB26	6525 Maynardville Hwy.	1.634	1062.31	-1.60	0.05	0.47	1.07	1.60	-1.44	0.15	0.54	1.15	1.67
HB27	Northridge Estates MHP lot 53	1.967	1068.54	-3.24	-1.27	-0.59	0.32	1.06	-3.07	-1.14	-0.48	0.42	1.15
HB28	Northridge Estates MHP lot 69	1.967	Not Surveyed										
HB29	Northridge Estates MHP lot 51	1.982	1067.69	-0.98	0.59	1.19	2.04	2.69	-0.81	0.70	1.29	2.11	2.81
HB30	Northridge Estates MHP lot 70	1.997	1068.81	-1.77	-0.06	0.63	1.61	2.41	-1.61	0.07	0.74	1.70	2.53
HB31	Northridge Estates MHP lot 39	2.062	1070.25	-1.41	0.37	0.98	1.84	2.57	-1.25	0.49	1.09	1.94	2.65
HB32	Northridge Estates MHP	2.084	Not Surveyed										
HB33	Northridge Estates MHP	2.165	Not Surveyed										
HB34	Northridge Estates MHP lot 28	2.176	Not Surveyed										
HB35	Fountain City MHP lot 34	1.830	1061.42	-0.18	1.63	2.17	2.91	3.52	-0.01	1.75	2.25	3.00	3.60
HB36	Fountain City MHP	1.760	Not Surveyed										
HB37	Fountain City MHP	1.800	Not Surveyed										
HB38	Fountain City MHP	1.800	Not Surveyed										
HB39	Fountain City MHP lot 34B	1.780	1061.87	-0.69	1.09	1.60	2.31	2.88	-0.53	1.19	1.68	2.39	2.96
HB40	Fountain City MHP	1.740	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
HB41	Rothmoor Dr	1.850	Not Surveyed										
HB42	Maynardville Hwy.	1.676	1061.5	-0.69	1.02	1.47	2.12	2.67	-0.53	1.12	1.54	2.20	2.74
HB43	Maynardville Hwy.	1.676	1061.6	-0.79	0.92	1.37	2.02	2.57	-0.63	1.02	1.44	2.10	2.64
KERNS BRANCH													
KB1	Beeler Rd.	0.293	Not Surveyed										
KB2	Majors Rd.	1.434	Not Surveyed										
KB3			Not Surveyed										
KB4			Not Surveyed										
KB5			Not Surveyed										
KNOB FORK													
KF1	Central Ave. @ Beaver Cr. Dr.	0.336	999.04	-13.19	-9.06	-7.46	-5.36	-3.13	-12.13	-7.84	-6.26	-4.05	-1.53
KF2	Central Ave. @ Beaver Cr. Dr.	0.350	995.27	-9.42	-5.29	-3.69	-1.59	0.64	-8.36	-4.07	-2.49	-0.28	2.24
KF3	Central Ave. @ Beaver Cr. Dr.	0.366	992.03	-6.18	-2.05	-0.45	1.65	3.88	-5.12	-0.83	0.75	2.96	5.48
KF4	Greer St.	2.228	1023.12	-6.00	-2.09	-0.62	1.74	3.03	-4.72	-0.88	0.72	2.84	6.70
KF5	Jim Sterchi Rd.	2.987	1034.75	0.64	3.83	4.11	4.70	5.06	1.76	4.13	4.58	5.04	5.30
KF6	Jim Sterchi Rd.	2.994	1035.4	0.15	3.20	3.49	4.09	4.46	1.24	3.50	3.96	4.44	4.70
KF7	Greer St.	2.249	1026.99	-9.31	-5.83	-4.39	-2.06	-0.77	-8.34	-4.65	-3.07	-0.96	2.87
KF8	Central Ave.	1.286	1004.01	-4.86	-2.43	-1.45	0.10	1.84	-4.05	-1.46	-0.34	1.48	3.62
KF9	Central Ave.	1.295	1000.3	-0.91	1.34	2.29	3.83	5.56	-0.16	2.28	3.39	5.20	7.34
KF10	Central Ave.	1.295	999.76	-0.37	1.88	2.83	4.37	6.10	0.38	2.82	3.93	5.74	7.88
KF11	Central Avenue Pk.	1.801	Not Surveyed										
KF12	Greer St.	2.236	Not Surveyed										
KF13	Kern St.	2.395	Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
KF14	Kern St.	2.423	Not Surveyed										
KF15	Whitesburg Dr.	2.743	Not Surveyed										
KF16			Not Surveyed										
KF17			Not Surveyed										
KF18			Not Surveyed										
KF19			Not Surveyed										
KF20			Not Surveyed										
KF21			Not Surveyed										
KF22			Not Surveyed										
KF23			Not Surveyed										
KF24			Not Surveyed										
KF25			Not Surveyed										
KF26			Not Surveyed										
KF27			Not Surveyed										
KF28			Not Surveyed										
KF29			Not Surveyed										
KF30			Not Surveyed										
KF31			Not Surveyed										
MILL BRANCH													
MB1			Not Surveyed										
MB2			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
MB3			Not Surveyed										
MB4			Not Surveyed										
MB5			Not Surveyed										
MB6			Not Surveyed										
MB7			Not Surveyed										
MB8			Not Surveyed										
NORTH FORK													
NF1	4400 Ventura Dr.	1.204	1048.48	-7.79	-5.79	-5.18	-4.48	-3.82	-6.50	-4.73	-4.12	-3.35	-2.79
NF2	4404 Ventura Dr.	1.222	1045.54	-4.44	-2.35	-1.73	-1.02	-0.33	-3.08	-1.28	-0.65	0.16	0.74
NF3	4508 Ventura Dr.	1.403	1055.67	-4.67	-2.53	-1.62	-0.53	0.26	-3.34	-0.88	-0.06	0.75	1.30
NF4	4428 McCloud Rd.	1.861	1084.91	-5.16	-2.04	-1.55	-0.97	-0.54	-2.28	-0.94	-0.55	-0.04	0.33
NF5	7508 Cathy Dr.	0.301	1018.21	-5.07	-2.54	-1.77	-0.19	1.62	-4.06	-1.83	-0.77	1.02	2.77
NF6	7512 Cathy Dr.	0.285	1018.5	-5.54	-2.91	-2.06	-0.48	1.33	-4.48	-2.18	-1.13	0.73	2.48
NF7	7501 Halls View Dr.	0.339	1019.75	-6.21	-3.88	-3.31	-1.73	0.08	-5.31	-3.22	-2.14	-0.52	1.23
NF8	7504 Cathy Dr.	0.314	1018	-4.72	-2.26	-1.56	0.02	1.83	-3.75	-1.57	-0.50	1.23	2.98
NF9	7409 Lena Ln.	0.270	1019.43	-6.63	-3.92	-2.99	-1.41	0.40	-5.53	-3.18	-2.12	-0.20	1.55
NF10	7415 Lena Ln.	0.339	1016.2	-2.66	-0.33	0.24	1.82	3.63	-1.76	0.33	1.41	3.03	4.78
NF11	7408 Lena Ln.	0.339	1018	-4.46	-2.13	-1.56	0.02	1.83	-3.56	-1.47	-0.39	1.23	2.98
NF12	7404 Lena Ln.	0.339	1018.21	-4.67	-2.34	-1.77	-0.19	1.62	-3.77	-1.68	-0.60	1.02	2.77
NF13	7401 Lena Ln.	0.246	1016.82	-4.19	-1.40	-0.38	1.20	3.01	-3.19	-0.62	0.43	2.41	4.16
NF14	4300 North Gate Dr.	0.742	1030.23	-5.69	-2.20	-1.56	-1.12	-0.86	-4.35	-1.28	-0.99	-0.62	-0.26
NF15	4304 North Gate Dr.	0.748	1030.54	-5.90	-2.40	-1.85	-1.40	-1.12	-4.53	-1.57	-1.27	-0.88	-0.51
NF16	4308 North Gate Dr.	0.758	1030.44	-5.52	-2.22	-1.69	-1.22	-0.90	-4.13	-1.40	-1.07	-0.62	-0.21

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
NF17	4312 North Gate Dr.	0.770	1031.26	-6.00	-2.99	-2.45	-1.94	-1.57	-4.61	-2.14	-1.78	-1.26	-0.77
NF18	4316 North Gate Dr.	0.777	1031.34	-5.87	-3.04	-2.49	-1.96	-1.56	-4.47	-2.17	-1.79	-1.22	-0.70
NF19	4320 North Gate Dr.	0.788	1031.98	-6.17	-3.63	-3.07	-2.50	-2.05	-4.76	-2.73	-2.31	-1.68	-1.09
NF20	4324 North Gate Dr.	0.800	1031.85	-5.56	-3.28	-2.72	-2.09	-1.59	-4.19	-2.35	-1.88	-1.18	-0.53
NF21	4328 North Gate Dr.	0.808	1030.77	-4.07	-1.91	-1.33	-0.67	-0.13	-2.78	-0.94	-0.44	0.30	0.98
NF22	4328 North Gate Dr.	0.812	1032.88	-5.92	-3.83	-3.26	-2.56	-2.01	-4.69	-2.85	-2.33	-1.56	-0.87
NF23	4332 North Gate Dr.	0.820	1031.62	-4.21	-2.25	-1.66	-0.92	-0.33	-3.07	-1.23	-0.67	0.14	0.85
NF24	4332 North Gate Dr.	0.825	1033.12	-5.46	-3.56	-2.97	-2.21	-1.59	-4.36	-2.53	-1.94	-1.11	-0.38
NF25	4336 North Gate Dr.	0.849	1032.76	-3.86	-2.29	-1.69	-0.82	-0.12	-3.00	-1.19	-0.52	0.40	1.18
NF26	4400 North Gate Dr.	0.862	1034.4	-4.98	-3.53	-2.92	-2.07	-1.38	-4.20	-2.43	-1.77	-0.86	-0.08
NF27	4404 North Gate Dr.	0.874	1033.94	-4.03	-2.68	-2.08	-1.23	-0.55	-3.33	-1.60	-0.95	-0.04	0.74
NF28	4408 North Gate Dr.	0.888	1034.32	-3.84	-2.62	-2.02	-1.18	-0.51	-3.24	-1.54	-0.90	-0.00	0.78
NF29	4412 North Gate Dr.	0.899	1034.56	-3.63	-2.33	-1.72	-0.91	-0.24	-2.99	-1.25	-0.62	0.26	1.01
NF30	4416 North Gate Dr.	0.910	1035.71	-4.32	-2.92	-2.30	-1.50	-0.84	-3.63	-1.82	-1.20	-0.36	0.37
NF31	4420 North Gate Dr.	0.923	1036.82	-4.88	-3.36	-2.72	-1.93	-1.29	-4.12	-2.24	-1.63	-0.82	-0.13
NF32	4424 North Gate Dr.	0.936	1039.41	-6.93	-5.29	-4.64	-3.87	-3.23	-6.11	-4.16	-3.55	-2.78	-2.12
NF33	7404 Oaken Rd.	0.988	1037.87	-3.30	-1.36	-0.69	0.04	0.68	-2.25	-0.20	0.39	1.11	1.69
NF34	7408 Oaken Rd.	1.010	1037.04	-1.64	0.29	0.94	1.67	2.33	-0.53	1.41	2.03	2.78	3.38
NF35	7412 Oaken Rd.	1.032	1037.63	-1.39	0.53	1.16	1.88	2.57	-0.21	1.61	2.26	3.05	3.67
NF36	7416 Oaken Rd.	1.066	1038.5	-1.11	0.73	1.33	2.03	2.71	0.07	1.76	2.40	3.18	3.78
NF37	7420 Oaken Rd.	1.096	1040.68	-2.55	-0.85	-0.28	0.38	0.99	-1.50	0.14	0.72	1.38	1.91
NF38	7424 Oaken Rd.	1.127	1042.86	-3.97	-2.33	-1.77	-1.13	-0.57	-2.98	-1.36	-0.82	-0.22	0.26
NF39	7804 Stillbrook Ln.	1.582	1064.62	-3.20	-1.08	-0.77	-0.12	0.41	-1.63	-0.25	0.26	0.90	1.38
NF40	7806 Stillbrook Ln.	1.596	1064.58	-2.29	-0.47	-0.08	0.50	0.94	-1.03	0.42	0.86	1.43	1.85

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
NF41	7808 Stillbrook Ln.	1.617	1065.87	-2.32	-0.54	-0.06	0.54	0.98	-1.02	0.45	0.90	1.46	1.89
NF42	7812 Stillbrook Ln.	1.654	1069.96	-4.48	-2.44	-1.95	-1.32	-0.84	-2.92	-1.42	-0.94	-0.33	0.13
NF43	7816 Stillbrook Ln.	1.694	1071.81	-3.66	-0.88	-0.53	-0.14	0.11	-1.22	-0.20	0.05	0.87	1.19
NF44	7818 Stillbrook Ln.	1.713	1073.23	-4.57	-2.15	-1.73	-1.13	-0.70	-2.51	-1.22	-0.78	-0.20	0.18
NF45	7328 Melanie Lane	0.131	1020.15	-7.55	-4.75	-3.71	-2.13	-0.32	-6.86	-3.95	-2.90	-0.92	0.83
NF46	7332 Melanie Lane	0.149	1019.72	-7.12	-4.32	-3.28	-1.70	0.11	-6.43	-3.52	-2.47	-0.49	1.26
NF47	7336 Melanie Lane	0.169	1018.58	-5.98	-3.18	-2.14	-0.56	1.25	-5.29	-2.38	-1.33	0.65	2.40
NF48	7517 Cathy Rd	0.298	1019.52	-6.41	-3.86	-3.08	-1.50	0.31	-5.40	-3.15	-2.09	-0.29	1.46
NF49	7524 Cathy Rd	0.314	1019.97	-6.69	-4.23	-3.53	-1.95	-0.14	-5.72	-3.54	-2.47	-0.74	1.01
NF50	7320 Melanie Lane	0.083	1019.84	-7.24	-4.44	-3.40	-1.82	-0.01	-6.55	-3.64	-2.59	-0.61	1.14
NF51	7324 Melanie Lane	0.107	1021.84	-9.24	-6.44	-5.40	-3.82	-2.01	-8.55	-5.64	-4.59	-2.61	-0.86
NF52	7340 Melanie Lane	0.189	1017.46	-4.86	-2.06	-1.02	0.56	2.37	-4.17	-1.26	-0.21	1.77	3.52
NF53	7509 Cathy Rd	0.298	1017.22	-4.11	-1.56	-0.78	0.80	2.61	-3.10	-0.85	0.21	2.01	3.76
NF54	7404 Jesilee Rd	0.298	1019.53	-6.42	-3.87	-3.09	-1.51	0.30	-5.41	-3.16	-2.10	-0.30	1.45
NF55	7521 Cathy Rd	0.314	1019.69	-6.41	-3.95	-3.25	-1.67	0.14	-5.44	-3.26	-2.19	-0.46	1.29
NF56	3908 Edina Dr	0.314	1024.74	-11.46	-9.00	-8.30	-6.72	-4.91	-10.49	-8.31	-7.24	-5.51	-3.76
NF57	7509 Halls View Dr	0.332	1021.84	-8.37	-6.01	-5.40	-3.82	-2.01	-7.45	-5.33	-4.26	-2.61	-0.86
NF58	7407 Andersonville Pk	0.718	1028.04	-4.35	-2.88	-2.43	-1.92	-1.48	-3.50	-2.10	-1.72	-1.07	-0.51
NF59	4301 Northgate Dr	0.750	1031.72	-7.05	-3.54	-3.02	-2.57	-2.29	-5.67	-2.74	-2.44	-2.04	-1.67
NF60	Ledgerwood Rd.	1.072	Not Surveyed										
NF62	W. Sesame Ln.	1.701	Not Surveyed										
NF63	Stillbrook Ln.	1.732	Not Surveyed										
NF65	7520 Cathy Rd	0.314	1020.14	-6.86	-4.40	-3.70	-2.12	-0.31	-5.89	-3.71	-2.64	-0.91	0.84

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
PLUMB CREEK													
PC1	50 Hardin Valley Dr.	0.469	948.21	-4.34	-1.53	-0.42	1.30	3.04	-2.91	-0.12	1.12	3.21	4.97
PC2	Hardin Valley Dr.	0.553	952.76	-4.90	-2.51	-1.65	-0.68	0.24	-3.69	-1.44	-0.76	0.34	1.62
PC3	2334 Lovell Rd.	0.691	954.78	-1.76	0.57	1.34	2.41	3.26	-0.47	1.55	2.31	3.32	4.11
PC4	10086 Highgate Circle	0.028	945.11	-12.33	-9.46	-7.71	-5.19	-2.51	-10.99	-8.15	-6.32	-3.80	-1.19
PC5	10082 Highgate Circle	0.028	945.14	-12.36	-9.49	-7.74	-5.22	-2.54	-11.02	-8.18	-6.35	-3.83	-1.22
PC6	10078 Highgate Circle	0.057	944.78	-12.00	-9.13	-7.38	-4.86	-2.18	-10.66	-7.82	-5.99	-3.47	-0.86
PC7	10074 Highgate Circle	0.076	944.61	-11.83	-8.96	-7.21	-4.69	-2.01	-10.49	-7.65	-5.82	-3.30	-0.69
PC8	10070 Highgate Circle	0.146	945.31	-12.53	-9.66	-7.91	-5.39	-2.71	-11.19	-8.35	-6.52	-4.00	-1.39
PC9	10066 Highgate Circle	0.165	944.77	-11.53	-8.71	-7.03	-4.63	-2.08	-10.20	-7.43	-5.68	-3.28	-0.80
PC10	10062 Highgate Circle	0.189	945.04	-10.68	-7.98	-6.49	-4.36	-2.14	-9.38	-6.79	-5.24	-3.12	-0.96
PC11	10058 Highgate Circle	0.205	945.71	-10.61	-7.99	-6.62	-4.67	-2.67	-9.33	-6.86	-5.44	-3.50	-1.55
PC12	10054 Highgate Circle	0.216	944.93	-9.32	-6.76	-5.47	-3.64	-1.79	-8.05	-5.66	-4.34	-2.52	-0.72
PC13	10050 Highgate Circle	0.231	945.95	-9.64	-7.16	-5.98	-4.33	-2.68	-8.39	-6.11	-4.91	-3.27	-1.67
PC14	10044 Highgate Circle	0.246	946.67	-9.66	-7.26	-6.19	-4.71	-3.27	-8.44	-6.26	-5.19	-3.72	-2.32
PC15	10038 Highgate Circle	0.259	951	-13.39	-11.05	-10.08	-8.75	-7.48	-12.18	-10.10	-9.13	-7.82	-6.59
PC16	10032 Highgate Circle	0.275	953.57	-15.22	-12.96	-12.11	-10.96	-9.91	-14.03	-12.06	-11.23	-10.10	-9.08
PC17	2333 Lovell Rd.	0.665	Not Surveyed										
PC18	9754 Middlebrook Pk.	0.799	Not Surveyed										
PC19	9704 Middlebrook Pk.	0.858	Not Surveyed										
PC20			Not Surveyed										
PC21			Not Surveyed										
PC22			Not Surveyed										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
PC23			Not Surveyed										
PC24			Not Surveyed										
PC25			Not Surveyed										
PC26			Not Surveyed										
PC27			Not Surveyed										
PC28			Not Surveyed										
PC29			Not Surveyed										
SOUTH FORK													
SF1	Fairview Rd.	0.053	Not Surveyed										
SF2	Fairview Rd.	0.072	Not Surveyed										
SF3	Fairview Rd.	0.098	Not Surveyed										
SF4	Fairview Rd.	0.126	Not Surveyed										
SF5	Fairview Rd.	0.152	Not Surveyed										
SF6	Fairview Rd.	0.18	Not Surveyed										
SF7	Maloneyville Rd.	0.918	Not Surveyed										
SF8	Maloneyville Rd.	0.939	Not Surveyed										
SF9	Fairview Rd.	0.194	Not Surveyed										
SF10	Fairview Rd.	0.216	Not Surveyed										
SF11			Not Surveyed										
WILLOW FORK													
WF1	Old Maynardville Pk.	0.955	Not										

Table C-1. Reference Table for Structures located in or near Existing Condition Floodplains

Structure Number	Address	River Mile	FFE (ft, NAVD)	Existing Condition Depth of Flooding (ft)					Future Condition Depth of Flooding (ft)				
				2-yr	10-yr	25-yr	100-yr	500-yr	2-yr	10-yr	25-yr	100-yr	500-yr
			Surveyed										
WF2			Not Surveyed										
WF3			Not Surveyed										
WF4			Not Surveyed										
WF5			Not Surveyed										
WF6			Not Surveyed										
WF7			Not Surveyed										
WF8			Not Surveyed										
WF9			Not Surveyed										
WF10			Not Surveyed										
WF11			Not Surveyed										
WF12			Not Surveyed										
WF13			Not Surveyed										

APPENDIX D

Stream Cross-Sections where the 100-Year Future Condition Elevation exceeds the 500-Year Existing Condition Elevation

Table D-1. Stream Cross-Sections where the 100-Year Future Condition Elevation Exceeds the 500-Year Existing Condition Elevation

HEC-RAS Cross-Section(s)	500-Year Existing Elevation (ft NAVD)	100-Year Future Elevation (ft NAVD)	Difference (ft)
BEAVER CREEK			
24.904	983.47	983.77	0.3
24.915	983.58	983.85	0.27
KERNS BRANCH			
0.222	1062.03	1062.26	0.23
0.224	1062.32	1064.04	1.72
0.226	1062.74	1064.27	1.53
0.260	1064.01	1064.41	0.4
0.370	1065.72	1066.08	0.36
0.443	1066.85	1067.20	0.35
0.516	1068.26	1068.58	0.32
0.588	1071.06	1071.32	0.26
0.661	1073.53	1073.79	0.26
0.744	1076.54	1076.80	0.26
0.797	1079.37	1079.67	0.3
0.840	1081.13	1081.42	0.29
0.852	1083.75	1084.04	0.29
0.882	1083.87	1084.16	0.29
0.932	1084.10	1084.40	0.3
0.983	1084.43	1084.71	0.28
1.051	1085.51	1085.72	0.21
1.120	1087.83	1087.94	0.11
1.188	1090.74	1090.90	0.16
1.256	1093.28	1093.44	0.16
1.359	1096.42	1096.60	0.18
1.462	1099.36	1099.52	0.16
1.539	1102.01	1102.19	0.18
1.616	1104.15	1104.36	0.21
1.634	1105.75	1105.96	0.21

Table D-1. Stream Cross-Sections where the 100-Year Future Condition Elevation Exceeds the 500-Year Existing Condition Elevation

HEC-RAS Cross-Section(s)	500-Year Existing Elevation (ft NAVD)	100-Year Future Elevation (ft NAVD)	Difference (ft)
1.640	1108.08	1108.24	0.16
1.655	1108.16	1108.33	0.17
1.720	1108.73	1108.95	0.22
1.765	1109.82	1110.03	0.21
1.809	1110.61	1110.80	0.19
1.815	1113.29	1113.46	0.17
1.855	1113.41	1113.59	0.18
1.896	1113.82	1114.05	0.23
1.938	1114.83	1115.09	0.26
2.007	1117.95	1118.15	0.2
2.075	1120.85	1121.05	0.2
2.144	1123.63	1123.78	0.15
2.157	1124.75	1124.89	0.14
2.163	1127.20	1127.37	0.17
2.185	1127.37	1127.58	0.21
2.251	1128.07	1128.36	0.29
2.318	1130.31	1130.58	0.27
MILL BRANCH			
1.887	1088.26	1088.34	0.08
WILLOW FORK			
1.340	1028.88	1028.89	0.01
1.421	1029.73	1029.74	0.01
1.498	1030.35	1030.36	0.01
1.576	1031.81	1031.83	0.02
1.653	1032.67	1032.69	0.02
1.740	1033.14	1033.17	0.03
1.800	1034.91	1034.95	0.04
1.852	1035.36	1035.38	0.02
1.861	1039.44	1039.54	0.1
1.873	1039.72	1039.82	0.1
1.962	1040.01	1040.13	0.12
2.051	1040.37	1040.51	0.14
2.120	1041.32	1041.46	0.14

Table D-1. Stream Cross-Sections where the 100-Year Future Condition Elevation Exceeds the 500-Year Existing Condition Elevation

HEC-RAS Cross-Section(s)	500-Year Existing Elevation (ft NAVD)	100-Year Future Elevation (ft NAVD)	Difference (ft)
2.188	1042.12	1042.27	0.15
2.257	1042.75	1042.91	0.16
2.330	1043.51	1043.67	0.16
2.403	1044.58	1044.75	0.17
2.476	1045.59	1045.76	0.17
2.549	1046.98	1047.14	0.16
2.694	1051.74	1051.90	0.16
2.767	1053.62	1053.77	0.15
2.776	1053.81	1053.96	0.15
2.786	1055.76	1055.85	0.09
2.795	1056.18	1056.32	0.14
2.821	1056.97	1057.14	0.17
2.846	1058.21	1058.37	0.16
2.872	1058.90	1059.07	0.17
2.889	1059.02	1059.18	0.16
2.905	1059.65	1060.20	0.55
2.922	1061.91	1062.21	0.3
2.939	1062.37	1062.69	0.32
3.006	1064.43	1064.78	0.35
3.073	1066.44	1066.78	0.34
3.198	1071.21	1071.46	0.25
3.324	1077.35	1077.72	0.37
3.449	1081.32	1081.57	0.25
3.574	1085.34	1085.56	0.22
3.642	1087.69	1087.89	0.2
3.684	1089.61	1089.80	0.19
3.728	1091.00	1091.21	0.21
3.739	1091.94	1092.09	0.15
3.756	1092.35	1092.56	0.21
3.851	1093.71	1093.98	0.27
NORTH FORK			
0.411	1020.71	1020.85	0.14
0.442	1020.76	1020.91	0.15

Table D-1. Stream Cross-Sections where the 100-Year Future Condition Elevation Exceeds the 500-Year Existing Condition Elevation

HEC-RAS Cross-Section(s)	500-Year Existing Elevation (ft NAVD)	100-Year Future Elevation (ft NAVD)	Difference (ft)
0.499	1020.88	1021.05	0.17
0.556	1021.19	1021.41	0.22
0.703	1025.59	1026.00	0.41
0.730	1027.33	1027.74	0.41
0.741	1029.36	1029.60	0.24
0.750	1029.43	1029.68	0.25
0.796	1030.03	1030.43	0.4
0.843	1032.46	1032.99	0.53
0.889	1033.84	1034.35	0.51
0.971	1037.89	1038.30	0.41
1.053	1041.01	1041.51	0.5
1.117	1042.00	1042.34	0.34
1.227	1045.36	1045.86	0.5
1.234	1046.08	1046.57	0.49
1.245	1047.28	1047.56	0.28
1.261	1047.93	1048.39	0.46
1.354	1053.75	1054.29	0.54
1.445	1057.82	1058.28	0.46
1.518	1061.13	1061.44	0.31
1.575	1064.77	1065.27	0.5
1.603	1065.78	1066.26	0.48
1.631	1067.98	1068.45	0.47
1.679	1070.39	1070.93	0.54
1.692	1071.85	1072.68	0.83
1.706	1072.25	1072.65	0.4
1.732	1073.23	1073.99	0.76
1.757	1074.43	1075.16	0.73
1.783	1076.63	1076.85	0.22
1.841	1080.87	1081.39	0.52
1.871	1086.07	1086.57	0.5
1.890	1086.46	1087.19	0.73
1.904	1086.44	1087.17	0.73
1.915	1087.32	1086.90	x

Table D-1. Stream Cross-Sections where the 100-Year Future Condition Elevation Exceeds the 500-Year Existing Condition Elevation

HEC-RAS Cross-Section(s)	500-Year Existing Elevation (ft NAVD)	100-Year Future Elevation (ft NAVD)	Difference (ft)
1.929	1087.94	1089.00	1.06
1.943	1088.70	1090.05	1.35
1.949	1090.37	1090.43	0.06
1.957	1091.08	1092.10	1.02
1.965	1090.83	1091.72	0.89
1.971	1093.62	1093.32	x
1.981	1094.31	1095.04	0.73
1.995	1094.35	1095.09	0.74
2.008	1096.14	1096.55	0.41
2.020	1096.03	1096.38	0.35
KNOB FORK			
2.941	1036.95	1037.02	0.07
3.311	1048.44	1048.45	0.01
3.349	1050.76	1050.80	0.04
3.360	1051.11	1051.14	0.03
3.369	1052.69	1052.70	0.01
3.373	1052.68	1052.69	0.01
3.375	1052.68	1052.69	0.01
3.389	1052.90	1052.92	0.02
3.408	1053.08	1053.09	0.01
3.529	1055.59	1055.63	0.04
3.663	1060.95	1060.98	0.03
3.840	1066.75	1066.77	0.02
3.984	1072.39	1072.43	0.04
4.076	1074.04	1074.09	0.05
4.119	1076.40	1076.42	0.02
4.150	1077.21	1077.27	0.06
4.167	1078.32	1078.37	0.05
4.178	1079.96	1080.01	0.05
4.205	1080.18	1080.23	0.05
PLUMB CREEK			
0.301	943.89	943.94	0.05
0.335	945.71	945.76	0.05

Table D-1. Stream Cross-Sections where the 100-Year Future Condition Elevation Exceeds the 500-Year Existing Condition Elevation

HEC-RAS Cross-Section(s)	500-Year Existing Elevation (ft NAVD)	100-Year Future Elevation (ft NAVD)	Difference (ft)
0.410	950.36	950.56	0.2
0.447	950.79	950.98	0.19
0.576	953.48	953.56	0.08
0.590	953.82	953.89	0.07
0.638	956.08	956.11	0.03
0.667	957.49	957.54	0.05
0.677	958.00	958.06	0.06
0.702	958.07	958.13	0.06
0.780	958.54	958.60	0.06
0.858	958.84	958.91	0.07
0.933	959.45	959.57	0.12
1.008	961.32	961.47	0.15
1.162	964.28	964.44	0.16
1.326	971.65	971.87	0.22
1.425	975.39	975.74	0.35
1.430	975.42	975.76	0.34
1.438	976.11	976.25	0.14
1.459	976.71	976.91	0.2
1.501	977.02	977.25	0.23

Figure 2-3b. Existing Condition Land Uses Beaver Creek Watershed (Lower Half)

Figure 5-1b. Future Condition Land Uses Beaver Creek Watershed (Lower Half)

Figure 2-3a. Existing Condition Land Uses Beaver Creek Watershed (Upper Half)