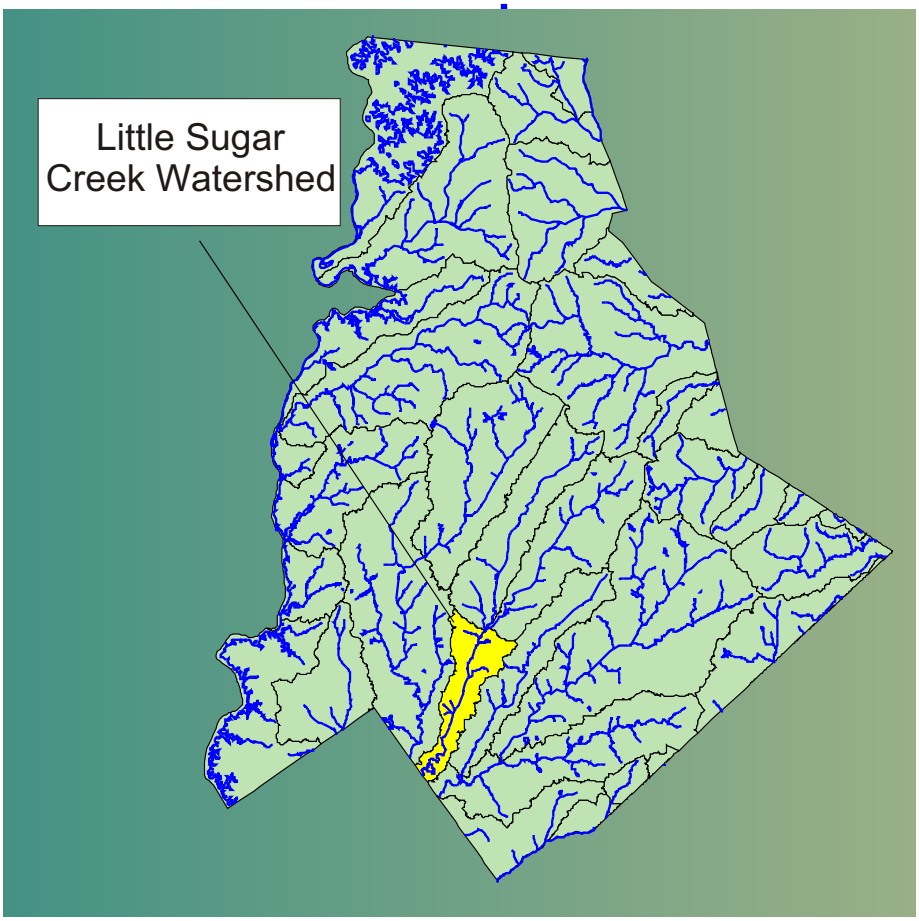
PRELIMINARY ENGINEERING REPORT

Watershed Study No. 1

Lower Little Sugar Creek Watershed



Prepared for

Mecklenburg
Storm Water Services

Prepared by

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August 2002

Charlotte-Mecklenburg STORM WATER Services

MCSWS Project No. 23014

MECKLENBURG COUNTY
STORM WATER SERVICES

PRELIMINARY ENGINEERING REPORT
FOR
WATERSHED STUDY NO. 1

LOWER LITTLE SUGAR CREEK WATERSHED

ACKNOWLEDGEMENT

The project staff of HDR Engineering, Inc. of the Carolinas (HDR) would like to express our sincere appreciation to Mecklenburg County Storm Water Services (MCSWS) for its assistance and support during this project. HDR would especially like to thank Mr. Dave Canaan and his staff.

DISCLAIMER

This watershed-wide study is for planning purposes only. These study results and recommendations are preliminary and should not be used for construction without additional detailed engineering design analysis.

CERTIFICATION

I hereby certify that this Preliminary Engineering Report for Watershed Study No. 1 for Mecklenburg County was prepared by me or under my direct supervision.

Signed, sealed, and dated this 30 day of August 2002.

By: _____
Seungho Song, PE, CFM
Project Manager

(SEAL)

MECKLENBURG COUNTY
STORM WATER SERVICES
PRELIMINARY ENGINEERING REPORT
FOR
WATERSHED STUDY NO. 1

LOWER LITTLE SUGAR CREEK WATERSHED

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GLOSSARY

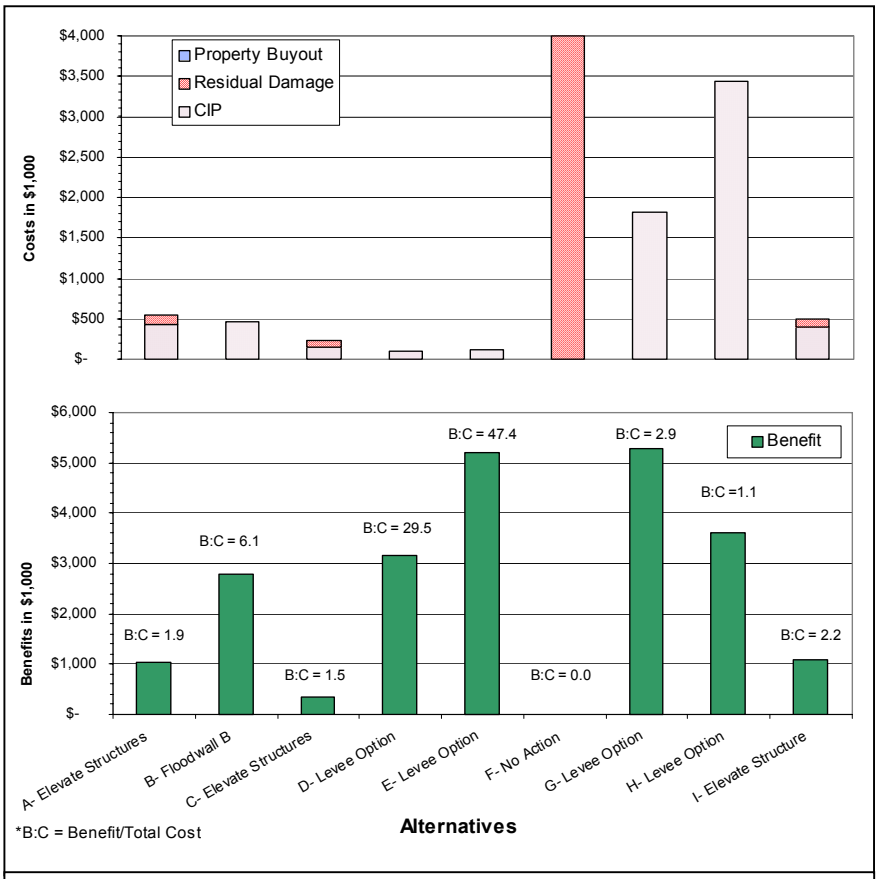
Future Condition Floodplain (FCF):	Floodplain delineated for the 1% chance of flood event in any given year using future built-out land use condition. It is currently defined as Floodplain Land Use Map (FLUM) in Mecklenburg County.
Existing Condition Floodplain:	Floodplain delineated for the 1% chance of flood event in any given year using current land use condition. It is defined the same as within the Flood Insurance Rate Map (FIRM).
1% Annual Chance Flood:	The 1% annual chance flood is the flood that has a 1% chance of being equaled or exceeded in any given year, which is referred to as the "100-year flood," in general.
Base Flood Elevation (BFE):	Water surface elevation based on the 1% annual chance flood (100-year flood).
Pre-FIRM:	Pertaining to structures constructed before 1973.
Post-FIRM:	Pertaining to structures constructed in 1973 or later.

EXECUTIVE SUMMARY

LOWER LITTLE SUGAR CREEK WATERSHED

This Preliminary Engineering Report (PER) summarizes a study focused on flood hazard mitigation and ecological restoration of the Lower Little Sugar Creek watershed. This watershed, with a drainage area of 10.1 square miles (excluding 41 sq.mi. of Upper Little Sugar Creek and Briar Creek watersheds), includes the main stem of Lower Little Sugar Creek from its confluence with Little Hope Creek to the South Carolina state line (9.3 miles). The stream flows through Charlotte, the town of Pineville, and then unincorporated areas of Mecklenburg County before crossing into South Carolina where it joins with Sugar Creek, just upstream of the Catawba River. Using field visits, available hydraulic information, aerial photographs, Geographic Information Systems (GIS), and a structural flooding damage analysis model, recommendations are proposed to meet the project goals.

The first project goal for this study was an economic analysis of flood hazard mitigation opportunities for a total of 248 structures located within the limits of the 1% annual chance **Future Condition Floodplain** (FCF) (Figure A-1). The second project goal of this study was to consider ecological restoration opportunities consistent with the flood hazard mitigation opportunities. Much of the ecological restoration would occur through off-line wetland construction and stream bank stabilization. One hundred and nine of the 248 structures have lowest finished floor elevations below the **Base Flood Elevation** (BFE: 1% annual chance FCF water surface elevation). Of these 248 structures, 19 were constructed before 1973 (Pre-FIRM). The total improvement construction costs, operation and maintenance costs, and buyout costs for the recommended improvements in the Lower Little Sugar Creek watershed are estimated at $6,898,900 (2001 dollars) and are summarized in Table E-1 and Graph E-1. Identified problem location "I," below Polk Street (Old U.S. 521) near the South Carolina state line, has recommended improvements that would provide both flood mitigation and water quality improvement benefits through stream restoration and construction of an off-line wetland. Figures E-1 through E-3 exhibit a representative cross section in this location for both existing conditions and mitigation options. Figures E-4 through E-7 illustrate the recommended improvement locations. Figure E-8 presents Mecklenburg County's Inter-Agency Capital Improvement Project (CIP) Map.



Graph E-1. Benefits and Costs for All Alternatives

The recommended combination of proposed flood mitigation options in the Lower Little Sugar Creek watershed includes the elevation of 31 structures and construction of levees and floodwalls to protect 48 additional structures. The recommendations also include taking no action for 30 structures, because cost-effective flood protective measures could not be identified for those structures. A more detailed description of improvements is included in Section 3.

Table E-1
Estimated Costs of Recommended Improvements (2001 Dollars)

Capital Costs	$5,883,500
Operating and Maintenance	$1,015,900
Buyout Costs	0
Total	**$6,898,900**

The Lower Little Sugar Creek watershed within Mecklenburg County is 94 percent developed, with 56 percent of development occurring before 1970. Development first occurred in the northern reaches of the watershed. These parcels are primarily of residential land use (81 percent). Urban development has changed the landscape of both the watershed and the creek channels. Overall, the Lower Little Sugar Creek watershed is known to be among the highest-developed watersheds within Mecklenburg County.

During field visits, little aquatic wildlife was observed in Lower Little Sugar Creek and its major tributaries. According to the Mecklenburg County Department of Environmental Protection (MCDEP) monitoring records, from 1994 to 1998 overall water quality has remained fairly consistent in the Lower Little Sugar Creek watershed. Review of ambient water quality data dating back to 1968 does not reveal significant trends in most of the data over time or by location along the creeks. Current Water Quality Index values indicate an average of "Fair-Good" water quality for Lower Little Sugar Creek. The aquatic fauna communities throughout the watershed have consistently ranked "Poor" and "Fair," while fish sampling ranked, on average, "Fair-Good," which results in a less than desirable diversity of species. This may indicate that aquatic habitat conditions limit these communities to some extent. While aquatic life is present in the creeks, the sand and silt benthic material (with little in-stream features such as boulders and woody debris) does not provide a protective habitat, and bottom dwelling communities (such as snails, shellfish, etc.) are not as abundant and diverse as may be desired. Bank stabilization projects may improve aquatic habitat; however, the stream bank stabilization project in the Huntingtowne Farms area did not significantly influence the aquatic communities (Roux, 1999). The best chance of improving aquatic conditions and water quality may lie in combining stream bank and bottom stabilization with the creation of diverse in-stream habitat (Roux, 1999, 2000).

Any streamside capital improvement projects will need to accommodate the existing utilities. Sanitary sewers are present along Lower Little Sugar Creek until near Carolina Place Parkway when the line crosses the watershed to the McAlpine Creek Wastewater Treatment Plant. Sugar Creek Wastewater Treatment Plant (WWTP) discharges into Lower Little Sugar Creek just below the confluence with Little Hope Creek; this also impacts water quality. Dual eight-inch force mains transmit sludge between the Sugar Creek WWTP and McAlpine WWTP. Duke Power maintains right-of-ways for major transmission lines along segments of the stream corridor. Additionally, a Piedmont Natural Gas (PNG) pipeline travels along the right bank, looking downstream, from Archdale Road to Ramblewood Lane. Just south of Ramblewood Lane, the 16-inch gas line crosses Little Sugar Creek and continues along the left bank until Sharon Road West. The City's Year 2000 Inter-Agency Coordination of CIP Map (Figure E-8) does not indicate that Charlotte-Mecklenburg Utilities (CMU) has proposed any CIP along the length of Lower Little Sugar Creek. Mecklenburg County Storm Water Services (MCSWS) should continue to coordinate with CMU and PNG to identify any potential projects or conflicts that arise in the future. If MCSWS is aware of CMU projects, it may influence the alignment of the relief sanitary sewer to coincide with the recommendations of this report.

The 1999 Mecklenburg County Greenway Master Plan recommends that the Greenway System be expanded as a floodplain management buffer and water quality program to include all creeks and streams throughout the County. Currently, two sections of greenway exist in the Upper Little Sugar Creek watershed, one near Freedom Park and the second connecting Alexander Street Park and Cordelia Park. Plans include expansion to connect these two segments and extend the greenway downstream to South Carolina, with the first priority being connecting the greenway from Freedom Park to Park Road Park in the Lower Little Sugar Watershed. Should this study watershed be included in future greenway development, property buyout expenses may be shared between MCSWS, Mecklenburg County Parks and Recreation Commission (MCPRC), or other County departments. HDR recommends that MCSWS coordinate with MCPRC as plans for the County Greenway System in this watershed continue to develop.

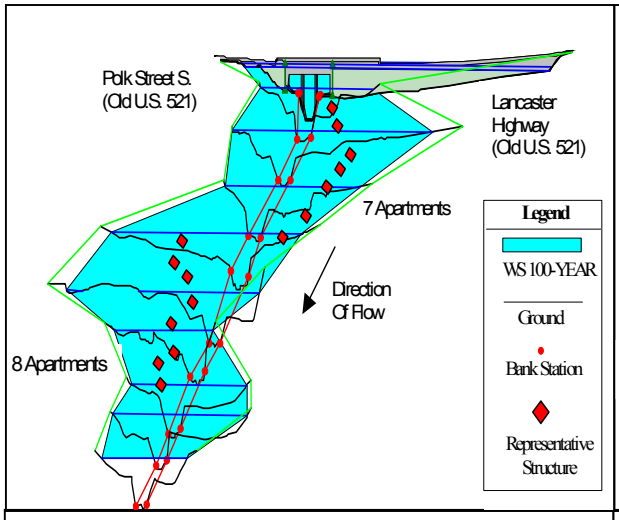


Figure E-1. Lower Little Sugar Creek, Area I Representative 1% Annual Chance FCF

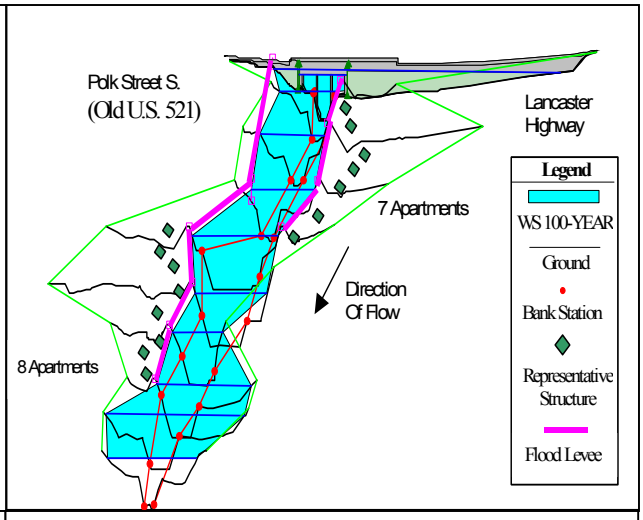


Figure E-2. Lower Little Sugar Creek, Area I Recommended Alternative 1% Annual Chance FCF

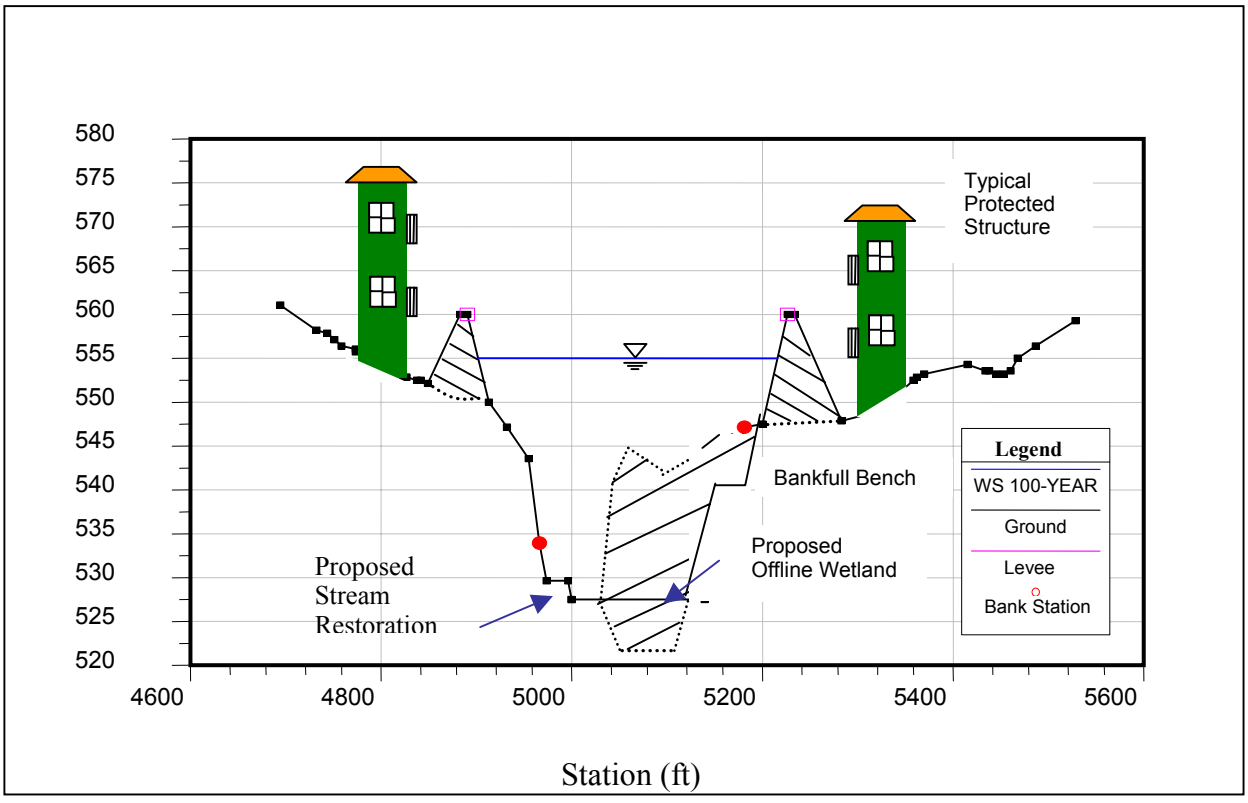
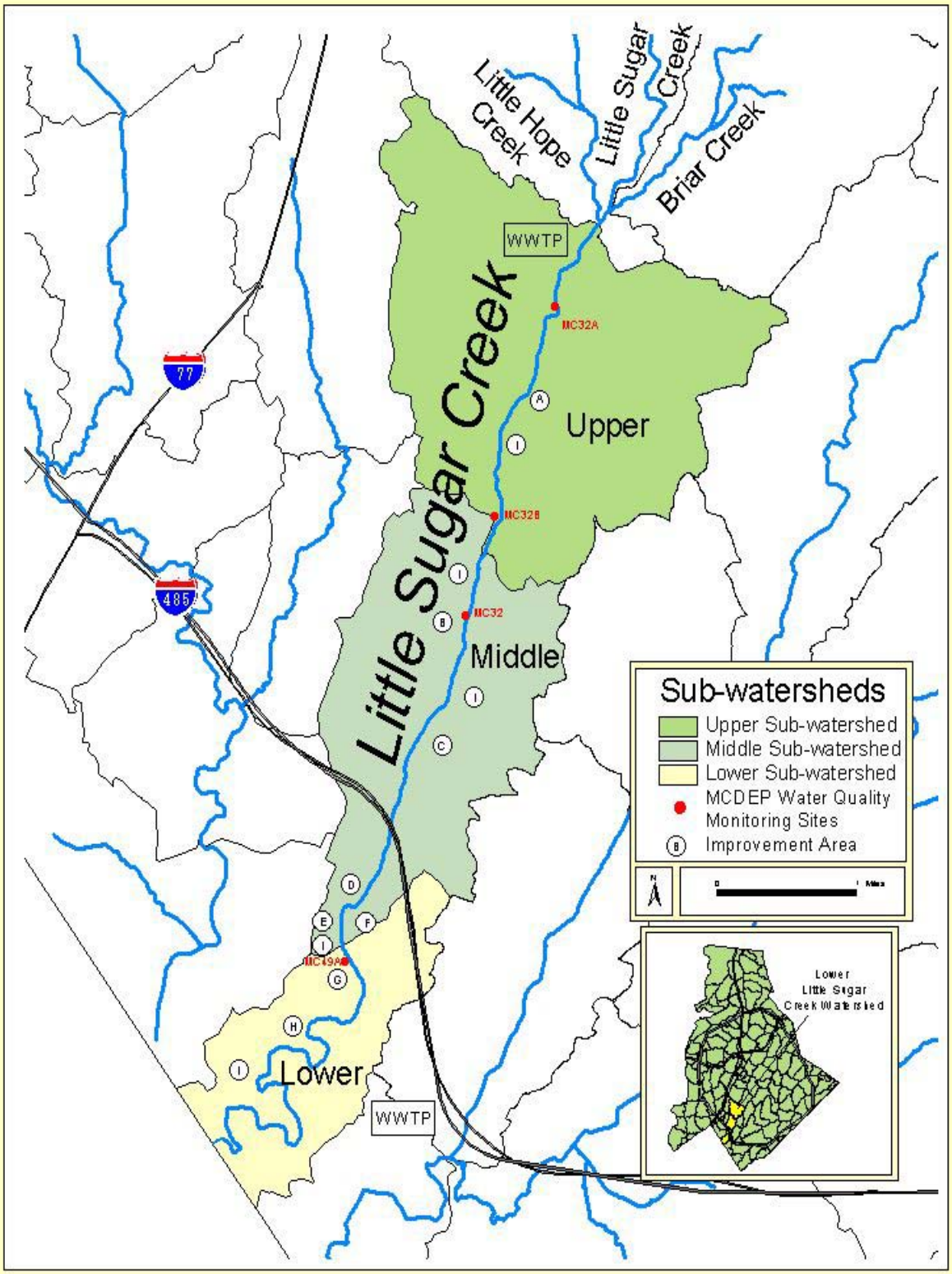


Figure E-3. Typical Cross Section of Recommended Improvements for Area I (Facing Downstream)

Figure E-4, Study No. 1: Lower Little Sugar Creek Watershed



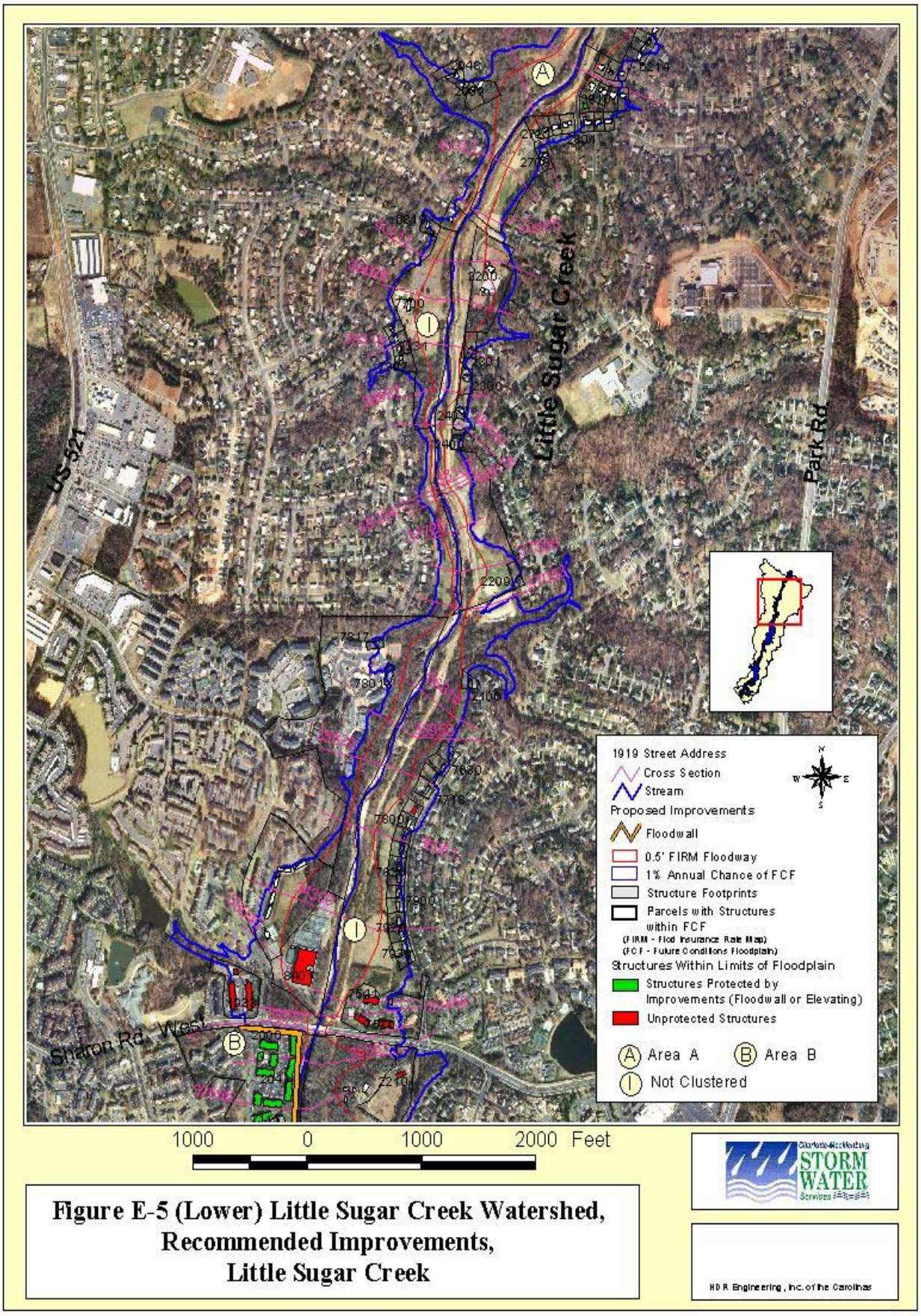


Figure E-5 (Lower) Little Sugar Creek Watershed, Recommended Improvements, Little Sugar Creek

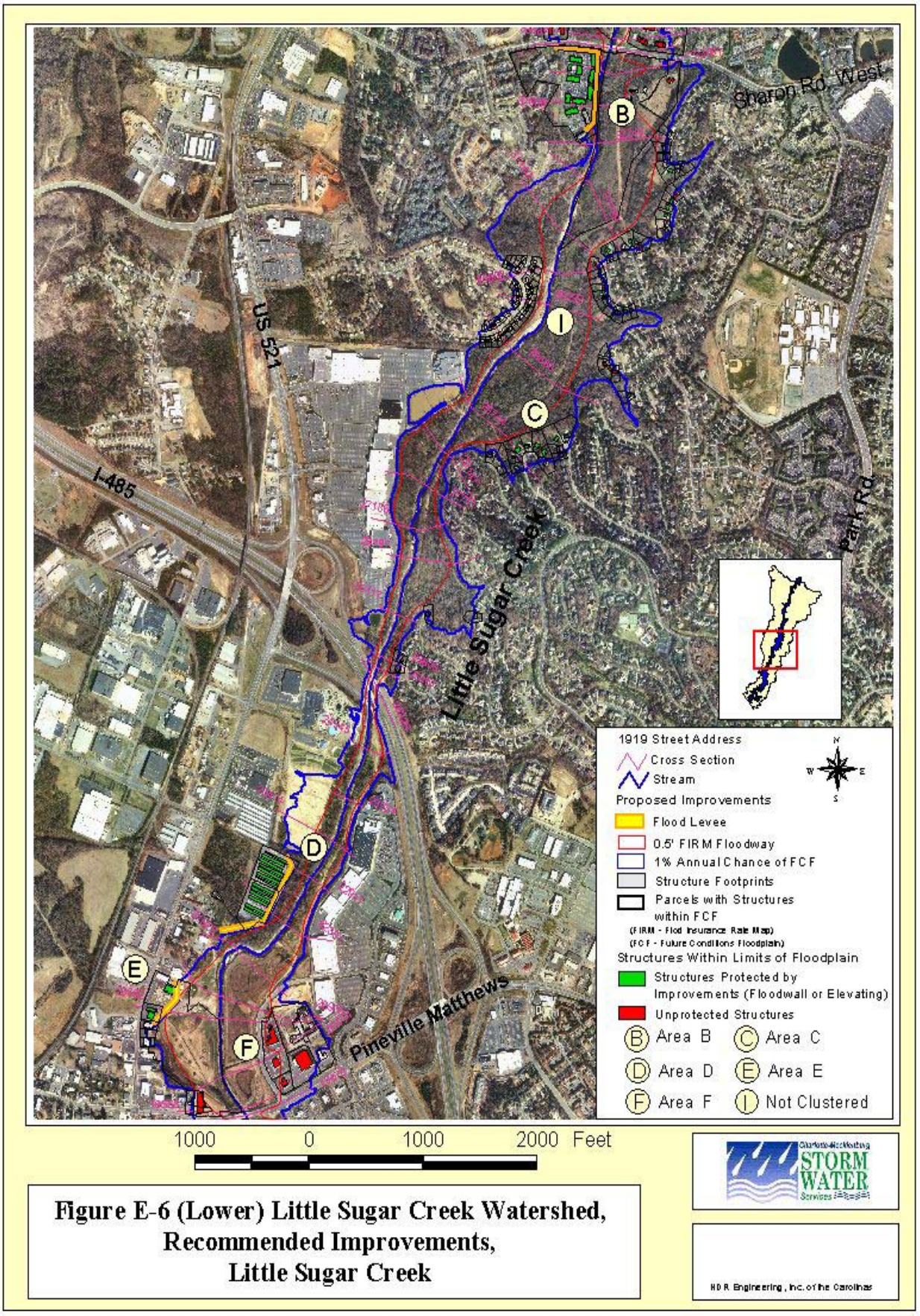


Figure E-6 (Lower) Little Sugar Creek Watershed, Recommended Improvements, Little Sugar Creek

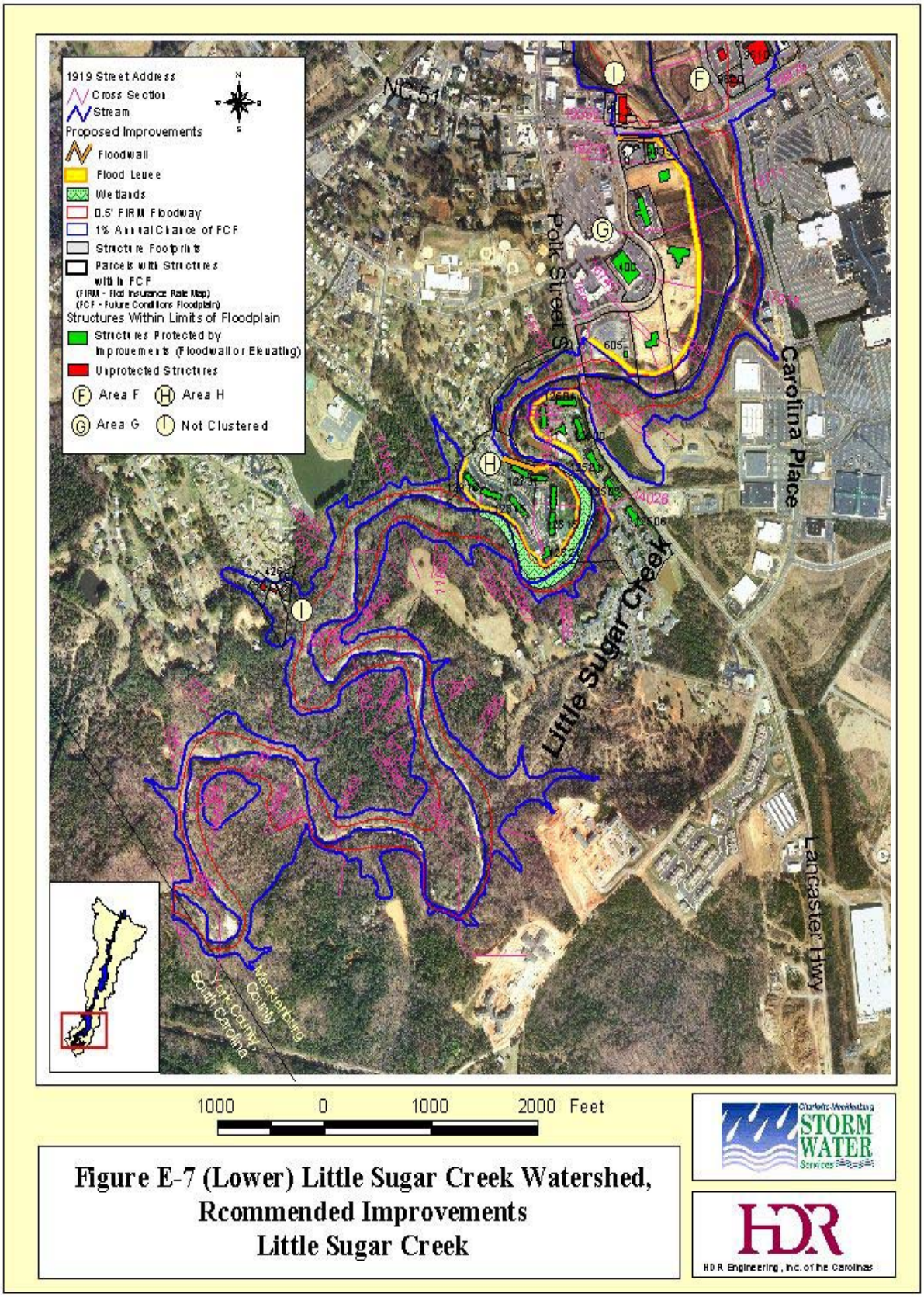
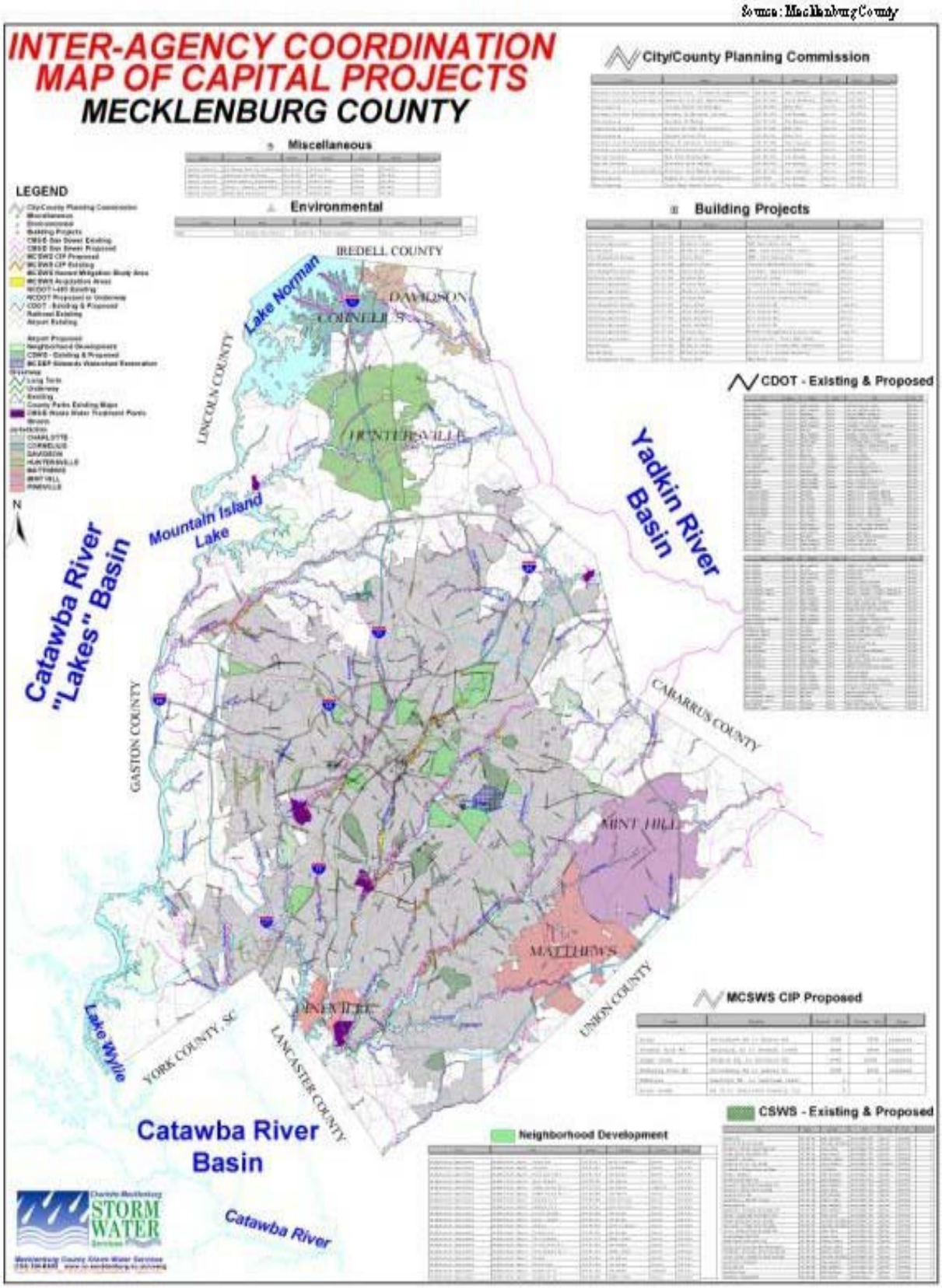


Figure E-7 (Lower) Little Sugar Creek Watershed, Rcommended Improvements Little Sugar Creek

Figure E-8 capital Improvement Project Map



1. GENERAL CONDITIONS

1.1 Watershed Characteristics

This 10.1 mi^2 study watershed includes 9.3 miles of Lower Little Sugar Creek from the Mecklenburg County border with South Carolina to its confluence with Little Hope Creek. As shown in Figure E-1, the Little Sugar Creek watershed is a fairly long and thin watershed with few major tributary streams. The headwaters of Lower Little Sugar Creek also include Upper Little Sugar Creek and Briar Creek (Figure E-4). Field observations of the channel and watershed characteristics were conducted at all road crossings in March 2001. Throughout the watershed, sloping banks appear stable with vegetation. Observed bank erosion problems are discussed in Section 1.5, Bank Stability Problem Identification. Land use and development patterns in the watershed are discussed in Section 1.2.

Lower Little Sugar Creek

Lower Little Sugar Creek flows through a highly residential portion of Mecklenburg County, beginning where it joins Little Hope Creek just south of Tyvola Road. The Sugar Creek Wastewater Treatment Plant (WWTP) discharges into Lower Little Sugar Creek at this point. During the low flow summer months, the WWTP discharges can constitute over one-half of the total base flow in the creek. On the bridge leading to the WWTP, debris accumulation and scour at the center bent were observed. Bottom material in this area is a sandy-silty mix.

Figure 1. Confluence of Briar Creek and Upper Little Sugar Creek (Roll #4, Photo #9)

This wide channel typically has shallow water levels as it flows southward. At the Archdale Road bridge crossing, the bottom material upstream is very sandy. Downstream of the bridge, stone has manually been placed along the banks to stabilize the stream and rocks in the stream to create riffles. The sandy bottom material throughout most of the stream length creates a series of runs with only a few scattered riffles. A United States Geological Survey (USGS) stream flow gage is present at the Archdale Road crossing.

Further downstream at the Sharon Road West crossing, a stream bank and channel stabilization project was completed in 2000 (Figure 2). This stream reach is attempting to find equilibrium by meandering within its limitations, creating a Rosgen C type channel within an E channel. Point bar deposition is visible in Figure 2, presenting further evidence of channel processes.

Figure 2. Little Sugar Creek Stream Bank Stabilization Project, Sharon Road West (Photo Courtesy of MCSWS)

Sand and silt bottom material and vegetated, sloping banks characterize this section of

Lower Little Sugar Creek. Trees are present on the overbanks. Similar stream characteristics were also observed near the I-485 crossing (Figure 3), where three bridges cross Lower Little Sugar Creek. The Polk Road (Old US 521) Bridge is the final road crossing before Lower Little Sugar Creek leaves Mecklenburg County. Rocks in the channel near the bridge create riffle habitat (Figure 4). Banks in this area of Lower Little Sugar Creek are generally stable with vegetation; however, one area of erosion was visible on the left bank (looking downstream).

Figure 3. Typical Channel, Lower Little Sugar Creek at I-485, Looking Downstream (Roll #4, Photo #15)

Figure 4. Typical Channel, Lower Little Sugar Creek at Polk Road (Roll #4, Photo #23)

Figure 5 shows a constructed wetland by North Carolina Dept. of Transportation (NCDOT) at immediately upstream of Pineville-Matthews Road (NC 51). Downstream of NC 51, Lower Little Sugar Creek begins to meander. Observations from this vantage point were similar to other parts of the watershed; the stream has a sandy bottom with some rocks present under and near the bridge. The banks are grassy with some brush and appear stable. A USGS gage is also present at this location.

Figure 5.NCDOT Constructed Wetland at upstream of NC 51 (Photo Courtesy of MCSWS)

1.2 Watershed Development

For the purpose of discussion in this study, the Lower Little Sugar Creek watershed was divided into three sub-watersheds: (1) the upper, (2) middle, and (3) lower sub-watersheds of Lower Little Sugar Creek (Figure E-4). These divisions were based on the delineated sub-watersheds of Little Sugar Creek.

The watershed is one of the most developed suburban and commercial watersheds in Mecklenburg County (Figure 6). Flowing south, the Little Sugar Creek watershed is bounded on the west by South Boulevard and on the east by Park Road. The upper study limit, the confluence with Little Hope Creek, is between the Sugar Creek WWTP and Tyvola Road. I-485 crosses the southern portion of the watershed. Transportation

Figure 6. Development, Lower Little Sugar Creek at NC 51, Looking Upstream (Roll #4, Photo #20)

patterns have influenced development in this watershed.

Table 1 summarizes development in the watershed as a whole. Tables 2 through 4 summarize development within each of the sub-watersheds of Lower Little Sugar Creek. The majority of parcels in the Lower Little Sugar Creek watershed are developed (93.9 percent). Just over half of this development occurred before 1970 (56.3 percent). Development first occurred in the northern reaches of the watershed. These parcels are of primarily (80.9 percent) single-family residential land use. Non-residential land uses constitute a very small portion, 8.7 percent, of development. Although the land use and land cover in the entire watershed influence conditions in the stream, development in the riparian corridor can be particularly damaging to water quality and aquatic communities.

The upper sub-watershed of Lower Little Sugar Creek is very close to build-out conditions (Table 2). Only 3.1 percent of the parcels remain vacant or unclassified. A majority of development, 81.2 percent, occurred before 1970. This portion of the watershed has the highest concentration of residential land use (93.3 perent). Infill development may still occur on the few remaining vacant parcels.

The middle sub-watershed developed later than the upper sub-watershed (Table 3). Development peaked in the 1980s (56.7 percent), while currently 9.8 percent of the parcels are vacant or unclassified. This development, as with the watershed as a whole, is primarily residential (85.4 percent). Multi-family residential land use is highest in this watershed, with 23.3 percent of parcels in this category and 62.1 percent of parcels as single-family land use.

Development in the lower sub-watershed also peaked in the 1980s (41 percent) (Table 4). Overall, this small watershed is the least developed of the three, with 17.3 percent of the parcels vacant or unclassified. Similar to the middle sub-watershed, multi-family residential land use is 20.3 percent and single-family residential is 50.3 percent. This sub-watershed also has the highest percentage of non-residential land use (12.1 percent). Overall, development occurred first in the northern portion of the watershed and has spread south over time. The majority of vacant land now remains in the lower sub-watershed.

Figure 7. Sanitary Sewer Crossing, Lower Little Sugar Creek upstream of Sharon Road West (Roll #4 Photo #14)

Any streamside capital improvement projects will need to accommodate the existing utilities. Sanitary sewers are present along Lower Little Sugar Creek until near Carolina Place Parkway when the line crosses the watershed to the McAlpine Creek Wastewater Treatment Plant. Sugar Creek Wastewater Treatment Plant (WWTP) discharges into Lower Little Sugar Creek just below the confluence with Little Hope Creek; this also impacts water quality. Dual eight-inch force mains transmit sludge between the Sugar Creek WWTP and McAlpine WWTP. Duke Power maintains right-of-ways for major transmission lines along segments of the stream corridor. Additionally, a Piedmont Natural Gas (PNG) pipeline travels along the right bank, looking downstream, from Archdale Road to Ramblewood Lane. Just south of Ramblewood Lane, the 16-inch gas line crosses Little Sugar Creek and continues along the left bank until Sharon Road West. The City's Year 2000 Inter-Agency Coordination of CIP Map (Figure E-8) does not indicate that Charlotte-Mecklenburg Utilities (CMU) has proposed any CIP along the length of Lower Little Sugar Creek. Mecklenburg County Storm Water Services (MCSWS) should continue to coordinate with CMU and PNG to identify any potential projects or conflicts that arise in the future. If MCSWS is aware of CMU projects, it may influence the alignment of the relief sanitary sewer to coincide with the recommendations of this report.

The 1999 Mecklenburg County Greenway Master Plan recommends that the Greenway System be expanded as a floodplain management buffer and water quality program to include all creeks and streams throughout the County. Currently, two sections of greenway exist in the watershed of Upper Little Sugar

Creek, one near Freedom Park and the second connecting Alexander Park and Cordelia Park. Plans include expansion to connect these two segments and extend the greenway downstream to Lancaster, South Carolina, with the first priority being connecting the greenway to Park Road Park in the Lower Little Sugar Watershed. Currently, the County owns half of the needed land for the greenway. Should this study watershed be included in future greenway development, property buyout expenses may be shared between MCSWS, MCPRC, or other County departments. HDR recommends that MCSWS coordinate with MCPRC as plans for the Mecklenburg County Greenway System in this watershed continue to develop. A typical greenway with a creek identification sign within the County is shown in Figure 8.

Figure 8. MCSWS Creek Identification Sign

Table 1
Development in the Lower Little Sugar Creek Watershed*

	Year Developed					Vacant/ Unclassified	Total
	Before 1961	1961-1970	1971-1980	1981-1990	1991-2000		
Parcels	1,211	2,747	731	1,691	220	424	7,024
Percentage	17.2%	39.1%	10.4%	24.1%	3.1%	6.0%	100%

	Land Use as of 2000				
	Single Family	Other Residential	Non-Residential	Vacant/ Unclassified	Total
Parcels	5,682	610	308	424	7,024
Percentage	80.9%	8.7%	4.4%	6.0%	100%

*Lower Little Sugar Creek watershed within Mecklenburg County (10.1 mi^2).

Table 2
Development in the Upper Sub-Watershed

	Year Developed					Vacant/ Unclassified	Total
	Before 1961	1961-1970	1971-1980	1981-1990	1991-2000		
Parcels	1,093	2,556	298	328	75	141	4,491
Percentage	24.3%	56.9%	6.6%	7.3%	1.7%	3.1%	100%

	Land Use as of 2000				
	Single Family	Other Residential	Non-Residential	Vacant/ Unclassified	Total
Parcels	4,164	33	153	141	4,491
Percentage	92.7%	0.7%	3.4%	3.1%	100%

* Upper sub-watershed of Lower Little Sugar Creek watershed (5.0 mi^2).

Table 3
Development in the Middle Sub-Watershed*

	Year Developed					Vacant/ Unclassified	Total
	Before 1961	1961-1970	1971-1980	1981-1990	1991-2000		
Parcels	45	131	411	1,173	107	203	2,070
Percentage	2.1%	6.3%	19.9%	56.7%	5.2%	9.8%	100%

	Land Use as of 2000				
	Single Family	Other Residential	Non-Residential	Vacant/ Unclassified	Total
Parcels	1,285	483	99	203	2,070
Percentage	62.1%	23.3%	4.8%	9.8%	100%

* Middle sub-watershed of Lower Little Sugar Creek watershed (3.3 mi^2).

Table 4
Development in the Lower Sub-Watershed*

	Year Developed					Vacant/ Unclassified	Total
	Before 1961	1961-1970	1971-1980	1981-1990	1991-2000		
Parcels	73	60	22	190	38	80	463
Percentage	15.8%	13.0%	4.8%	41.0%	8.2%	17.3%	100%

	Land Use as of 2000				
	Single Family	Other Residential	Non-Residential	Vacant/ Unclassified	Total
Parcels	233	94	56	80	463
Percentage	50.3%	20.3%	12.1%	17.3%	100%

*Lower sub-watershed of Lower Little Sugar Creek watershed (1.8 mi^2).

1.3 Aquatic Habitats and Environmental Monitoring

Throughout this study watershed, bank conditions appear stable, with the majority of both banks heavily vegetated with brush and trees. Typical current conditions are illustrated throughout this PER (field photos are included in the Appendix and referenced in Figure A-1). The abundant vegetation protects most of the channel banks from severe erosion and provides intermittent shade and some habitat for wildlife. The stream channel is wide, so often the center of the channel receives little shade. In-stream aquatic habitat includes mostly sand bottom substrate and intermittent areas of cobble and rock creating riffles. Very little aquatic wildlife was observed in Lower Little Sugar Creek. However, note that field surveys for this study were conducted within close proximity to road crossings, and did not include walking along the entire stream channel. Bank stabilization problems are discussed in Section 1.5 and included in the Flood Mitigation Improvement Analysis in Section 3.

MCDEP maintains three ambient water quality sampling and bio-monitoring locations along Lower Little Sugar Creek (Figure E-4). An effort was made to look for trends and impacts of individual sub-watersheds (Table 5). Macroinvertebrate and fish community health indices provide valuable information because they reflect both water quality and habitat conditions.

Table 5

MCDEP Water Quality Monitoring Summary

NC Piedmont Macroinvertebrate Taxa Richness		June-94		June-95		June-96		June-97		June-98	
Site	Location	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating	S_{EPT}	WQ Rating
MC32A	Little Sugar Creek-Archdale Drive	4	Poor	-	-	4	Poor	5	Poor	6	Poor
MC32B	Little Sugar Creek-Ramblewood Road	-	-	-	-	4	Poor	6	Poor	7	Fair
MC49A	Little Sugar Creek-NC Highway 51	-	-	-	-	8	Fair	4	Poor	-	-

Fish Bioassessment		June-94		June-95		June-96		June-97		June-98	
Site	Location	NCIBI	WQ Rating	NCIBI	WQ Rating	NCIBI	WQ Rating	NCIBI	WQ Rating	NCIBI	WQ Rating
MC32A	Little Sugar Creek-Archdale Drive	-	-	-	-	46	Fair-Good	46	Fair-Good	48	Fair-Good
MC32B	Little Sugar Creek-Ramblewood Road	-	-	-	-	48	Good	46	Fair-Good	44	Fair-Good
MC49A	Little Sugar Creek-NC Highway 51	-	-	-	-	46	Fair-Good	46	Fair-Good	42	Fair

Water Quality Index		June-94		June-95		June-96		June-97		June-98	
Site	Location	WQI	WQI Rating	WQI	WQ Rating	WQI	WQI Rating	WQI	WQI Rating	WQI	WQI Rating
MC32A	Little Sugar Creek-Archdale Drive	55	Average	-	-	56	Fair-Good	55	Fair-Good	57	Fair-Good
MC32B	Little Sugar Creek-Ramblewood Road	-	-	-	-	55	Fair	61	Fair-Good	38	Poor-Fair
MC49A	Little Sugar Creek-NC Highway 51	-	-	-	-	56	Fair-Good	54	Fair	59	Fair-Good

Macroinvertebrate Taxa Richness sampling produced consistently "Poor" and "Fair" rankings throughout the watershed. Site MC32A, Little Sugar Creek at Archdale Drive, is in "Poor" condition according to results from 1994 to 1998. Site MC32B, Little Sugar Creek at Ramblewood Road, is located at the bottom of the Huntingtowne Farms stream stabilization project site, while site MC49A, Little Sugar Creek at NC Highway 51, is 3 miles downstream. The Huntingtowne stablization project from Burnt Mill Lane to Ramblewood Lane was completed in 1997. Recent data indicate the macroinvertebrate community did not seem to be impacted, either adversely or positively, after the completion of this project. Rankings at these two downstream sites remain "Poor." Overall, these rankings indicate the watershed does not support a large diversity of aquatic fauna at the macroinvertebrate level—the lower levels of the aquatic system food chain.

Fish bioassessment of Lower Little Sugar Creek produced recent "Fair" to "Good" ratings using the North Carolina Index of Biological Integrity (NCIBI). MCDEP reports large quantities of fish; however, diversity is low and most species are pollution-tolerant. Site MC32A has produced "Fair-Good" ratings consistently from 1996 to 1998. Sites MC32B and MC49A, both downstream of the stream stabilization project, do not indicate fish community health changes after project completion. Ranks remain consistent over time.

Ambient water quality sampling of Lower Little Sugar Creek shows slightly decreasing water quality. At Site MC32A, Little Sugar Creek at Archdale Drive, "Average" 1996 Water Quality Index (WQI) rankings decreased to "Fair-Good" in 1996, 1997, and 1998. Site MC32B, Little Sugar Creek at Ramblewood Road, decreased from "Fair" in 1996 to a "Poor-Fair" WQI in 1998. The most downstream site, MC49A, Little Sugar Creek at NC 51, remained relatively consistent from 1996 to its 1998 "Fair-Good" WQI rating.

Overall, water quality has remained fairly consistent in the Lower Little Sugar Creek watershed since 1994. The WQI indicates water quality conditions better than the macroinvertebrate communities reflect. The NCIBI indicates fish communities reflect ambient water quality data. This may indicate that aquatic habitat conditions limit these communities to some extent. Other influences include point source pollution such as spills that go undetected by ambient water quality sampling efforts. These incidents influence the health of the aquatic system and are reflected only in biological sampling. In the case of Lower Little Sugar Creek, influences include stream channelization, a lack of shade and pool-riffle sequences, and poor diversity of bottom substrate (primarily sand). Much of this material is probably transported downstream from upstream bank erosion, channel entrenchment, and watershed surface runoff. While there are aquatic life forms present in the creek, the sand benthic material (with few instream features such as boulders and woody debris) does not provide a protective habitat, and bottom dwelling communities are not as abundant and diverse as may be desired.

Review of ambient water quality data dating back to 1968 does not reveal significant trends in most of the data over time or by location. However, fecal coliform levels have dropped and pH has increased since the 1968-1970 data. This may be due to improvements to the sanitary sewer infrastructure that eliminated clogged and broken sewer pipes.

Problems throughout the watershed include channel entrenchment and channelization, sediment transport, and urban debris (trash, shopping carts). The vegetated riparian zones also may not be providing their full filtering functions because of channel entrenchment throughout the watershed. Entrenchment of a stream channel lowers the water table, with the effect being a loss of water quality improvement for infiltrated water. Because the channel is very wide, riparian zones do not provide adequate shade for the stream channel. These problems are characteristic of urban streams.

1.4 Rosgen Stream Morphology Assessment

River form and fluvial processes evolve simultaneously and operate through mutual adjustments toward self-stabilization (Rosgen 1994). The stream tries to balance the combination of sediment load and sediment size with the stream slope and discharge (Lane 1955). If any one of these components is altered (e.g., smaller sediment load), the opposing side of the balance must adjust proportionally (e.g., decrease in

bed slope). If bed slope on a main channel changes, often tributaries will change to meet the main channel. Sediment contributions from this headcutting and degrading also occur. Due to intense development and increased peak flows, fluvial processes in streams may change more rapidly in an urban environment than if the watershed was undisturbed.

Figure 9. Realignment, Lower Little Sugar Creek at Sharon Road West (Roll #4, Photo #14)

When humans interfere with fluvial processes by increasing watershed imperviousness and change stream channels by realignment and armoring the banks, the stream counteracts by gradually lowering the bed slope (the flow remains fairly constant once the watershed is developed) in the upstream direction from a control point, such as the confluence with a larger stream or at a culvert. Review of historical aerial photos shows changes in stream channel alignment. For instance, Lower Little Sugar Creek has been realigned along Sharon Road West (Figure 9). The realignment and straightening of the creek has caused increased entrenchment (and related bank erosion) as the stream attempts to re-establish equilibrium between the stream gradient, its reduced sinuosity, and the sediment load that it carries. Figure 2 illustrates one example of the stream trying to reach equilibrium and meandering within its constraints.

Rosgen Level 1 analysis is intended for obtaining a course geomorphic characterization that results from the integration of basin relief, landform, and valley morphology (Rosgen 1996). Aerial photos, elevations from HEC-RAS input, 2-foot interval topographic contours, soil survey reports, and field observations were used to conduct Level 1 analysis.

For this Level 1 analysis, sinuosity and channel slope were calculated for the length of Lower Little Sugar Creek in each of the three sub-watersheds. Rosgen analysis should be done using unique conditions to define each reach, not arbitrary segments chosen from a map. Sinuosity, or the measure of a channel's meanders, varies in the different streams. Typical Piedmont streams are expected to be more sinuous in their natural condition; however, realignment to accommodate urban development often restricts the channel's path. If the channel is the same length as the valley, the sinuosity is 1.0, indicating that the channel has been straightened. Naturally, streams with higher sinuosities generally have lower slopes, and streams with steeper slopes have lower sinuosities. Sinuosity dissipates the erosive sheer stresses and velocities of storm events. This relationship was observed in the Lower Little Sugar Creek watershed, as seen in Table 6. The lower segment of Lower Little Sugar Creek has the greatest sinuosity (2.50) and the lowest slope (0.10 percent). This low slope is typical for the lower portion of a watershed. The middle and upper segments of Lower Little Sugar Creek have similar sinuosities (1.05 and 1.09, respectively). These small values are influenced by channel realignment. The upper segment has the highest channel slope, 0.18 percent, which is typical of the upstream reaches of a stream. Note that sinuosity is typically underestimated when calculated from topographic maps due to course contour refinement.

Table 6
Rosgen Level 1 Assessment: Geomorphic Characterization

Lower Little Sugar Creek Segments	Channel Length (mi)	Valley Length (mi)	Channel Sinuosity	Channel Slope (percent)
Upper	2.5	2.3	1.09	0.18
Middle	2.9	2.8	1.05	0.10
Lower	3.8	1.5	2.50	0.10

The urban development of Charlotte has significantly altered the natural stream system; therefore, the influence of the valley type is diminished. The typical channel types were not classified because they vary greatly, and observations were only taken from road crossings. However, the Rosgen stream type E is typical of the highly altered Charlotte area urban streams. Lower Little Sugar Creek at Archdale Road was surveyed for Rosgen analysis and was assigned an E stream type (Doll et. al. 2000). A Type E stream in an urban setting can have moderate entrenchment ratios and lower sinuosities than other Type E streams, as was observed in the Lower Little Sugar Creek watershed. When straightening, channelization, or changes in the watershed disturb streams, they begin adapting themselves to the new conditions. Lower Little Sugar Creek seems to be evolving from its current Type E condition (with suppressed sinuosity) towards a more sinuous Type C condition. In the process, the creek is rebuilding its connection with a lowered floodplain (Figure 2).

During this study, channel bottom materials were visually characterized; however, detailed grain size distribution analysis (or representative pebble counts) and shear stress calculations should be conducted to assess the sediment transport capacity of the stream before modifications, including stream restoration efforts, are made to the channel.

Soils in the Lower Little Sugar Creek watershed influence how water moves to the streams; however, impervious surfaces can prevent infiltration. These soil types are predominantly well-drained upland soils with clayey subsoil. In the northern reaches of the watershed, soils are Cecil-Urban. These soils, formed from acid igneous and metamorphic rock, are typical of the heavily developed Charlotte urban area and are nearly level to strongly sloping well-drained soils with clayey subsoil. The soils in the southern portion of the watershed have similar characteristics but are of different origins, formed from rock high in ferromagnesian minerals. These are Iredell-Mecklenburg soils. Along the Lower Little Sugar Creek channels lies another soil type, Monacan. These somewhat poorly drained floodplain soils are loamy because they are formed from fluvial deposits of sediment. At the southern edge of the watershed as Little Sugar Creek flows into South Carolina, soils are Cecil. Cecil soils are similar in characteristics to the other upland soils and are formed in residuum from acid igneous and metamorphic rock (USDA SCS 1980). Some of this soil material has been cut, filled, and graded as development and stream channelization have occurred. These activities have altered the physical characteristics and functions of the soils.

1.5 Bank Stability Problem Identification

Channel instability problems typically fall into two general categories: isolated areas of bank erosion and long-term equilibrium adjustments to changes in the watershed and stream system. The former may be caused by rapid inflow from tributaries, unstable banks, or encroachment of development. The latter is related to larger scale changes in the land use of the watershed and flows in the stream, which manifest in the form of changes to the channel bottom level. Both of these are present in the Lower Little Sugar Creek watershed. The short tributaries to Little Sugar Creek show significant evidence of head-cutting. This phenomenon is common throughout Charlotte streams and is generally halted only when the stream encounters a man-made obstruction such as a pipe, culvert, or other structure that serves as an effective grade control. The continuing stream entrenchment, and subsequent bank erosion, alters the physical and habitat characteristics of the stream and produces large amounts of sediment to downstream reaches.

Figure 10. Erosion, Lower Little Sugar Creek at Polk Road, Looking Downstream (Roll #4, Photo #21)

Bank stability problem areas were identified near road crossings and are described with photos below. Other problems not visible from these vantage points may exist and should be researched before any bank stabilization projects are planned. Further quantitative studies of bank erosion rates and aquatic habitats throughout the study reach should precede further restoration efforts.

The left bank of Lower Little Sugar Creek is eroding at the Polk Road (Old US 521) bridge (Figure 10). Sheer stress on the bank is causing erosion. Vegetation on the bank has not been sufficient to prevent erosion. The bank toe is unprotected. Roots are exposed and vegetation is falling into the channel.

Figure 11. Little Sugar Creek Stream Bank Stabilization Project, Huntingtowne Farms (Photo Courtesy of MCSWS)

The area of Huntingtowne Farms Park from Burnt Mill Lane to Ramblewood Lane was suffering from bank erosion and stream channel instability. MCSWS addressed this problem with a soil bioengineering and channel stabilization project in 1997 (Figure 11). The goals of this project include providing aquatic habitat, improving water quality, and improving bank stability. MCDEP monitored the aquatic community impacts of this site for two years after construction. When compared to preconstruction data, fish and macroinvertebrate communities were not significantly different. This indicates the project had little impact to date, neither positive nor negative, on these communities. MCDEP suggests this may be influenced by the water quality impacts of the Sugar Creek WWTP upstream. The bank stability improvements have been successful, with establishment of a willow forest buffer. Park maintenance and mowing habits have also been altered to promote bank stability; mowing is only to the top of bank.

2. BENEFIT:COST ECONOMIC ANALYSIS

2.1 Riverine and Coastal A-Zone Flood Model Overview

The Riverine and Coastal A-Zone Flood model (RCAZF) (Version 1.0, January 1995), a spreadsheet-based model developed by FEMA, was used for estimating damages in this study to be consistent with previous Mecklenburg County flood damage analyses. The estimated damages represent a foundation building block in the benefit:cost (B:C) analysis in this project. This B:C analysis compares benefits, or damages removed by the proposed project, with costs of the proposed flood hazard mitigation project.

Damages induced by flooding were estimated for structures with first finished floor elevations lower than the BFE and located within the 1% annual chance of Future Condition Floodplain (FCF). RCAZF requires four storm events: 10%, 2%, 1%, and 0.2% annual chance flood events, which are typically defined as 10-, 50-, 100-, and 500-year storm events, respectively. The WSEs were modeled using the US Army Corps of Engineers HEC-RAS model (Version 3.0, March 2001) for build-out conditions estimated to occur in year 2020.

RCAZF performs flood damage analysis at two levels. Level One analysis relies heavily on default values built into the model and requires minimum data input from users, while Level Two analysis allows the user to enter structure-specific information. The basic structure information required includes: structure type, size, replacement value, contents value, and various economic data about the use and function of the structure. Estimates of the flood damage vulnerability of the structure and its contents both before and after mitigation are particularly important. In addition to data about the structure under evaluation, B:C analysis of flood hazard mitigation projects requires a quantitative assessment of the degree of flood risk at the site. This assessment is performed automatically by the B:C program using flood data input from a Flood Insurance Study and a FIRM, along with data on the Zero Flood Depth (first finished floor) elevation of the building (RCAZF 1995). To utilize the model capability and site-specific and structure-specific data available to perform the best possible economic analysis, the Level Two analysis was performed for this study.

2.2 Economic Data

The numerous economic attributes were assigned to all flooding structures including the parcel identification number. Each structure was assigned a structure category, such as one-story building without basement, two-story building with basement, etc. The structure category determines which of the unique depth/damage curves the model uses. Each depth/damage curve describes the relationship between the flooding depth and the damage to the structure expressed in percent of the structure value. The flooding depth was calculated as the difference between various WSEs and the first finished floor elevation. A set of depth/damage curves was developed by Watershed Concepts using available data from local damage claims. These curves reflect specific conditions in Mecklenburg County.

The structures were also divided into commercial and residential occupancy types. In the model, these occupancy types were described by the total area occupied by the owner. The residential structures were considered to be 100% occupied by the owner, and commercial structures 0% occupied by owner. The damages to residential structures consisted of both building and content damages. The model estimates damages to commercial buildings that include a portion of the business income losses and displacement costs. Thus, commercial damage estimates are slightly higher than those of residential structures of the same size and structure category.

The structure characteristic data was extracted from a database (1999 tax data) provided by Mecklenburg County. Structure values were increased by 25% to reflect the value in 2001 dollars. A content value of 25% of the structure value was used to be consistent with previous Mecklenburg flood damage analyses. Using the heating area of each structure, the building replacement value was calculated.

The first finished floor elevations for all structures were taken from various sources, such as MCSWS GPS Elevation Certificates, Flood-Proofing Certificates, Dewberry and Davis surveys, and information provided by Watershed Concepts. Each structure was assigned a station value that is a stream distance in feet measured from the confluence of the stream in an upstream direction. The structure station equals the station of the stream cross-section on which the structure is located. Using the station data, the WSE for four frequency storms at each structure location was interpolated and assigned to each structure.

2.3 Hydraulic Data

A HEC-RAS model developed for the Lower Little Sugar Creek watershed by Watershed Concepts was used to process the hydraulic data for future build-out conditions in the watershed. The modeling output provided the WSEs for four frequency storms, 10%, 2%, 1%, and 0.2% annual chance of flood events, for each stream cross-section throughout the watershed. The WSEs were interpolated to retrieve data for the cross-sections attributed to each structure. Part of the model input includes these WSEs for each structure at each storm frequency. The hydraulic data pertaining to the each flooded structure is presented in Appendix Table A-2.

2.4 Modeling Process

RCAZF processes the economic and hydraulic data to estimate the damages to each structure during the four frequency storms. The damages for each storm are then statistically processed to account for the probability of the damage occurrence during any given year. The estimated damage output data is in the form of annual damages.

2.5 Economic Analysis

After assessing the damages to all flooded structures in the watershed, several improvements were evaluated for hydraulic and economic feasibility. Each proposed improvement was analyzed for the hydraulic feasibility of not increasing the 1% annual chance flood WSE to satisfy the County's no-rise criteria. The economical feasibility of improvement is measured by a B:C ratio. The B:C ratio is a ratio of benefits obtained by the proposed improvement and cost of the improvement. A B:C ratio greater than 1.0 determines economic feasibility for structural improvements. For property buy-out consideration, FEMA considers a B:C ratio greater than 1.0 economically feasible. In other words, if the estimated damages are greater than 100 percent of the property value, the buyout option is considered feasible.

The potential flood damages to the structure are estimated using the model. The structure attributes are then amended to reflect the improvement, such as elevated finished floor elevation, decreased WSEs, etc. The potential damages to the structure after the improvement is implemented are then calculated. These represent the residual damages after the improvement is implemented. The benefit is calculated as the difference between damages prior to improvement and damages after the improvement is in place. All benefits are calculated on an annual basis. In order to compare them with the cost of improvement and to clearly present them, these were brought to present value by using a 50-year life of the project and the Federal Discount Rate of 5.5 percent (as of January 29, 2001).

Each proposed improvement capital cost, depending on its character, can be represented by a construction cost, and can also include an operation and maintenance (O&M) cost as well as a buyout cost. These construction and buyout costs are estimated in the form of present values. The O&M cost, which includes debris and sediment removal as well as vegetation maintenance, is given on an annual basis. In order to sum all costs associated with improvement, the annual costs were brought to present value by using a 50-year project life and a 5.5 percent discount rate.

The total cost used in B:C analysis includes, in addition to the above-mentioned costs, the residual damages, or the damages that will remain even after the proposed improvement is implemented. Floods with greater than a 1% annual chance generate these damages and are included in the analysis, but the improvement is designed for a 1% annual chance of flood.

2.6 Improvements

A number of flood damage mitigation improvement alternatives were carefully considered. Improvements selected due to their hydraulic feasibility include floodwalls, structure elevation, and property buyout. In the case of a floodwall, the benefit was a sum of all damages to be removed by the proposed floodwall. In the Lower Little Sugar Creek Watershed, floodwalls were found to provide cost-effective flood protection that offers, in some cases, creek habitat enhancement as well. Section 3 summarizes the improvements and the economic analysis results for the alternatives. Detailed economic information is provided in Appendix in Table A-1.

3. FLOOD HAZARD MITIGATION

3.1 Storm Water Services Requests

According to information provided by MCSWS, no reports of FEMA regulated stream service requests are within the Lower Little Sugar Creek watershed.

3.2 Repetitive Loss Structures

The list of repetitive loss structures within the study area was obtained from MCSWS and is presented in Appendix Table A-3.

3.3 Permanent Storm Water Easements

There are 20 recorded permanent drainage easements within the limits of the Lower Little Sugar Creek watershed; however, only 10 of these provide access to Lower Little Sugar Creek. These addresses are:

- 2300 Archdale Drive
- 6100 Birmingham Drive
- 6120 Birmingham Drive
- 2709 Burnt Mill Road
- 6701 Woodstock Drive
- 6705 Woodstock Drive
- 6711 Woodstock Drive
- 6717 Woodstock Drive
- 6723 Woodstock Drive
- 7700 Woodstream Drive

These easements were granted in 1996 and 1997 for the soil bioengineering and stream bank stabilization project in the Huntingtowne Farms neighborhood. This project was discussed in Section 1.3. These easements provide over 8,500 linear feet of access to Lower Little Sugar Creek along both banks.

3.4 Roadway Overtopping Problem Locations

From HEC-RAS modeling results of Sugar Creek watershed, roadway overtopping locations were investigated based on the FCF (as defined on page iii). Table 7 summarizes the roadway overtopping problem location for the study streams.

Because motor vehicles can be swept away in as little as 24 inches of flood flow depth over the road, any roadway overtopping locations need to be identified for emergency response preparations for public safety purposes. The following items are listed for future action:

- Signage of roadway overtopping warning for avoiding road crossing during flood event.
- Coordination with Police Dept. and Fire Dept. for special attention during flood event.
- Routine inspection for bridge/culvert scour and safety conditions, such as a lack of guardrail (or handrail). Guardrail post would give indication of the edge of the structure when inundated during flood flows.

Table 7
Roadway Overtopping Problem Locations

Lower Little Sugar Creek	Crossing Structure Type	Culvert Size	Top of Road El (FT. NAVD)	WSE of 1% FCF (FT. NAVD)	Overtopping Depth (FT)
Wastewater Treatment Plant	Bridge	-	584.0	591.4	7.4
Rockledge Drive	Bridge	-	565.1	572.8	7.7
Sharon Road West	Bridge	-	566.0	569.0	3.0
Highway 51	Bridge	-	552.6	560.6	8.0
South Polk Street	Bridge	-	558.5	559.1	0.6

3.5 Flood Mitigation Improvement Analysis

Because 248 structures are within the limits of the FCF of the Lower Little Sugar Creek Watershed, flood protection alternatives were investigated as the first priority for this study. The flood damage structures along Lower Little Sugar Creek are shown in Figure A-1. Of the 248 structures within the limits of the FCF along Lower Little Sugar Creek, 109 structures flood. Of these structures, 67 are residential land use and 42 are commercial structures. There are 40 single-family residential structures, with values ranging from $54,800 to $334,900. 27 multi-family residential structures values range from $173,500 to $977,800. The 42 commercial structure values range from $48,300 to $5,548,700.

Of the 248 structures within the limits of the FCF along Lower Little Sugar Creek, 86 structures are Pre-FIRM and 162 are Post-FIRM. The improvements recommended in this report are based strictly on the economic and water quality benefits that they are expected to produce. While the economic analyses included in this report do not distinguish between damages to Pre- and Post-FIRM structures, it is Mecklenburg County policy to not use public funds on mitigation of Post-FIRM structures damages[1]. Further analysis will be required to determine if consideration of damages to only Pre-Firm structures would significantly alter the recommendations.

The improvement alternative analyses use the FCF. Figure 12 illustrates these recommended improvement alternatives. Table A-1 in the Appendix provides more detailed information about the flood mitigation improvement alternative B:C evaluation. A summary of the economic information is presented in Table 8.

[1] Mecklenburg County

Table 8 Flooding Structures Summary	
	Lower Little Sugar Creek
Within FCF Floodplain	248
Pre-FIRM	86
Post-FIRM	162
Finished Floor Inundated in FCF	109
Pre-FIRM	19
Post-FIRM	90
Protected by Floodwalls	48
Pre-FIRM	-
Post-FIRM	48
Elevate Structures	31
Pre-FIRM	16
Post-FIRM	15
Recommended Buyout	-
Pre-FIRM	-
Post-FIRM	-
No Action	30
Pre-FIRM	3
Post-FIRM	27

Alternative Evaluation

The improvement alternative analyses use the FCF. Figure 12 illustrates these recommended improvement alternatives.

There are 109 structures in Lower Little Sugar Creek watershed that have their lowest floor below the BFE of FCF. These include structures with a basement that is possibly flooding or structures with their first finished floor below the BFE of FCF. The structures were clustered into study areas based on their proximity and possible proposed improvements, such as a floodwall or levee. Each study area was separately analyzed for several improvement alternatives, such as purchase structures, culvert improvements, elevating structures, levees, channel widening, and upstream detention. The economic effect of the improvement was compared to the "No Action" alternative to determine economic feasibility of the improvement.

Alternative 1 – No Action

Potential flood damages were estimated as part of the damage assessment and improvement option analysis. These figures are based on the damages accrued by flooding structures within the limits of the FCF due to the 10%, 2%, 1%, and 0.2% annual chance of flood frequency storms. The total damages from flooding in Lower Little Sugar Creek watershed if "No Action" was taken are estimated to be $28,493,200 over the 50-year life of the project (2001 dollars). Each proposed improvement alternative benefit is compared to the damages before the improvement to analyze its economic feasibility.

Alternative 2 – Purchasing Structures

The structures were analyzed as possible buyouts. FEMA justifies property buyout if the B:C ratio is greater than 1.0, or if the estimated structure damages due to flooding exceed 100% of the value of the property (land value and structure value in 2001 dollars). These same structures were also analyzed for possible elevation above the BFE of FCF, or protection by levee. In all cases, structural improvement had a far greater B:C ratio than the buyout option, so buyout is not recommended.

Alternative 3 – Culvert Improvements

The culvert improvements for the Lower Little Sugar watershed were not found to be hydraulically feasible, because their implementation resulted in elevating the downstream FCF, or did not improve flooding conditions by lowering the upstream FCF. Therefore detailed hydraulic analysis and cost estimates for Alternative 3 were not prepared for this study.

Alternative 4 – Elevating Structures

The structures were analyzed for the economic feasibility to avoid flood damages by raising the structures. In the case of elevation, a structure is raised so the first finished floor is 1 foot above the BFE of the FCF. For the purposes of analysis, $30,000 was used as the present value of the cost of elevating a structure with a heated area smaller than 2,000 square foot. For structures with a larger footprint, floor elevation costs were estimated at $20 per square foot. Some large structures were considered not suitable for floor elevation.

Alternative 5 – Earthen Berm and Floodwall Alternatives

A combination of berms and floodwalls, coupled with floodplain restoration and off-line wetland construction, were considered as alternatives. These alternatives preserved peak flow storage by setting levees back from the edges of the existing banks and excavating a portion of the area between the berms to substitute for lost conveyance. The excavated area would be constructed as an off-line wetland that would provide enhancements to stream water quality and improved aquatic habitat. The recommended floodwall improvements do not result in any net increase in the Base Flood Elevation or flow velocity.

Alternative 6 – Channel Widening

Channel widening, in the absence of stream and floodplain restoration, is contradictory to the Mecklenburg County Creek Use Policy Statement and is environmentally detrimental. Therefore this option was not investigated.

Alternative 7– Upstream Detention

Upstream detention was not considered as a flood mitigation option since it appears to lack available detention areas to detain the 100-year storm water to reduce the peak flow.

Problem Area A

In Problem Area A, there are 14 single-residential houses flooding in BFE of FCF. Average depth of FCF flooding is 2.0 feet (with flood depths ranging from 0.1 to 4.9 feet). Within the FIRM floodplain limits, six houses are flooding with an average depth of 2.0 feet (flooding depths ranged from 0.3 to 3.4 feet).

The analysis in Problem Area A showed the three feasible alternatives: purchasing structures, elevating structures, and protecting structures with levees on both banks of Little Sugar Creek. The levee on the left bank includes a 1,800-LF earthen berm with one pump station to protect 12 flooding residential houses with lowest finished floors below the FCF flood elevation (see Figure E-5). The levee on the right bank includes a 550-LF earthen berm with one pump station protecting two flooding residential houses with lowest finished floors below the FCF flood elevation. The benefits, costs, and B:C ratios for each alternative in Area A are shown in Table 9.

The recommended improvement option for Problem Area A is structure elevation, the alternative with the highest B:C ratio.

Table 9
Problem Area A

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1	No Action	$1,136,400	-	-	-
2	Purchasing Structures	-	$1,136,400	$2,315,800	0.5
4*	Elevating Structures	$105,300	$1,031,100	$434,300	1.9
5	Levee Options	-	$1,136,400	$703,300	1.6

* Recommended Alternative

Problem Area B

In area B, there are 10 multi-residential houses located at Sharon Oaks Lane that are flooding in BFE of FCF. Average depth of FCF flooding is 2.8 feet (with flood depths ranging from 0.3 to 4.0 feet). Within the FIRM floodplain limits, eight houses are flooded with an average depth of 1.5 feet (flood depths ranged from 0.5 to 2.1 feet).

The analysis in Problem Area B showed two feasible alternatives: purchasing structures and protecting structures with floodwall B. The benefits, costs, and B:C ratios for each alternative in Area B are shown in Table 10. The recommended alternative, Floodwall B, a floodwall equipped with one pump station, extends 1,400 LF and protects 10 buildings in the apartment complex with lowest finished floor elevations below the BFE of FCF flood elevation. Note that the recommended improvement alternative is still subject to change due to unforeseen hardships such as utility or construction conflicts.

Table 10
Problem Area B

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1	No Action	$2,787,600	-	-	-
2	Purchasing Structures	-	$2,787,600	$6,476,300	0.4
5*	Floodwall Options	-	$2,787,600	$455,700	6.1

* Recommended Alternative

The recommended improvement alternative was also examined for any adverse impact on the 1% annual chance flood WSE to satisfy the County's no-rise criteria. Table 11 shows comparison of the WSE of the existing and improved conditions. Since there might be unforeseen constraints, such as utility crossings, the proposed improvement was designed with a slightly lower WSE than the existing condition.

Table 11
1% Annual Flood Stages at Area B

	Existing Condition	Improved Condition	Δ h (FT)
X-32,240	567.8	567.8	0.0
X-32,666	567.8	567.8	0.0
X-33,061	568.2	568.2	0.0
X-33,330	568.4	568.3	-0.1

Problem Area C

In area C, there are five single-residential houses located at Avondale Avenue and Hanover Trail that are flooding in BFE of FCF. Average depth of FCF flooding is 1.8 feet (with flood depths ranging from 0.3 to 3.3 feet). Within the FIRM floodplain limits, two houses are flooded with an average depth of 1.1 feet (with flood depths at 0.9 feet and 1.2 feet).

The analysis in Problem Area C showed three feasible alternatives: purchasing structures, elevating structures, and protecting structures with levee. The benefits, costs, and B:C ratios for alternatives considered in Area C are shown in Table 12. Even though Alternatives 4 and 5 have very close B:C ratios (1.51 and 1.53, respectively), Alternative 4, elevating structures, is recommended. It is an economically feasible alternative that will protect the residential structures with lowest finished floor elevations below the FCF flood elevation; also, this alternative is not likely to encounter more expenses from possible utility conflicts.

Table 12
Problem Area C

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1	No Action	$430,400	-	-	-
2	Purchasing Structures	-	$430,400	$1,839,100	0.2
4*	Elevating Structures	$81,400	$349,000	$150,000	1.5
5	Levee Options	-	$430,400	$281,700	1.5

* Recommended Alternative

Problem Area D

In area D, there are 13 commercial storage buildings located at Pineville Road that are flooding in BFE of FCF and FIRM. This area includes the NCDOT wetland (Figure 5). Average depth of FCF flooding is 4.6 feet (with flood depths ranging from 3.0 to 7.5 feet). Within the FIRM floodplain limits, the average depth of flooding is 2.3 feet (with flood depths ranging from 0.7 to 5.2 feet).

The analysis in Problem Area D showed three feasible alternatives: purchasing structures, elevating structures, and protecting structures with levee. The benefits, costs, and B:C ratios for the alternatives in Area D are shown in Table 13. Alternative 5, levee construction, is recommended because its B:C ratio is much greater than those of other investigated alternatives and is also greater than 1.0. Note that the recommended improvement alternative is still subject to change due to unforeseen hardships such as utility or construction conflicts.

Table 13
Problem Area D

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1	No Action	$3,154,200	-	-	-
2	Purchasing Structures	-	$3,154,200	$2,858,800	1.1
4	Elevating Structures	$120,500	$3,033,700	$2,124,000	1.4
5*	Levee Options	-	$3,154,200	$107,000	29.5

* Recommended Alternative

The recommended improvement alternative was also examined for any adverse impact on the 1% annual chance flood WSE to satisfy the County's no-rise criteria. Table 14 shows comparison of the WSE of the existing and improved conditions. Since there might be unforeseen constraints, such as utility crossings, the proposed improvement was designed with a slightly lower WSE than the existing condition.

Table 14
1% Annual Flood Stages at Area D

	Existing Condition	Improved Condition	Δ h (FT)
X-21,523	560.8	560.7	-0.1
X-22,302	560.9	560.8	-0.1
X-22,911	561.0	561.0	0.0

Problem Area E

In area E, there are three commercial buildings located at Polk Street (Old U.S. 521) that are flooding in BFE of FCF. Average depth of FCF flooding is 2.8 feet (with flood depths ranging from 0.3 to 7.2 feet). Within the FIRM floodplain limits, one apartment building has a flood depth of 4.9 feet.

The analysis in Problem Area E showed two feasible alternatives for all three buildings: purchasing structures, and protecting structures with levee E. Two buildings were also analyzed for elevating. Alternative 5, the levee, includes a 600-LF earthen berm with one pump station protecting three flooding commercial structures along Polk Street (Old U.S. 521) with lowest finished floors below the BFE of

FCF. The benefits, costs, and B:C ratios for alternatives in Area E are shown in Table 15. Levee E is recommended because the B:C ratio is 11.0. Note that the recommended improvement alternative is still subject to change due to unforeseen hardships such as utility or construction conflicts.

Table 15
Problem Area E

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1	No Action	$5,198,600	-	-	-
2	Purchasing Structures	-	$5,198,600	$2,498,200	2.1
4	Elevating Two Structures	$22,500	$29,900	$181,600	0.2
5*	Levee Options	-	$5,198,600	$109,700	47.4

* Recommended Alternative

The recommended improvement alternative was also examined for any adverse impact on the 1% annual chance flood WSE to satisfy the County's no-rise criteria. Table 16 shows comparison of the WSE of the existing and improved conditions. Since there might be unforeseen constraints, such as utility crossings, the proposed improvement was designed with a little lower WSE than the existing condition.

Table 16
1% Annual Flood Stages at Area E

	Existing Condition	Improved Condition	Δ h (FT)
X-20,014	560.6	560.5	-0.1
X-20,662	560.7	560.7	0.0
X-20,905	560.7	560.7	0.0

Problem Area F

In Area F, there are four commercial buildings located upstream of NC 51 and Leitner Drive that are flooding in BFE of FCF. Average depth of FCF flooding is 3.3 feet (with flood depths ranging from 1.6 to 5.2 feet). Within the FIRM floodplain limits, three buildings are flooding with an average depth of 1.6 feet.

The analysis in Problem Area F showed only one hydraulically feasible alternative: purchasing structures. Structure elevation was not feasible due to the size and structural characteristics of the buildings. The benefit, cost, and B:C ratio for the alternative in Area F are shown in Table 17. The No Action alternative is recommended.

Table 17
Problem Area F

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1*	No Action	$3,999,600	-	-	-
2	Purchasing Structures	-	$3,999,600	$10,179,800	0.4

* Recommended Alternative

Problem Area G

In Area G, there are seven commercial buildings located at Towne Centre Boulevard and NC 51 that are flooding in BFE of FCF. Average depth of FCF flooding is 2.9 feet (with flood depths ranging from 1.1 to 5.6 feet). Within the FIRM floodplain limits, four buildings are flooding with an average depth of 1.9 feet (with flood depths ranging from 0.4 to 3.4 feet). The field observation confirmed existence of a newly built keystone wall, but this wall does not provide any flood protection for the FCF structures.

The analysis in Problem Area G showed two feasible alternatives for all seven buildings: purchasing structures, and protecting structures with floodwall G. Alternative 5, levee construction, is recommended because its B:C ratio is greater than the other investigated alternative and also greater than 1.0.

The levee in Problem Area G includes a 500-LF floodwall and 3,400-LF earthen berm with two pump stations to protect seven flooding commercial structures with lowest finished floors below the FCF flood elevation (see Figure E-7). This levee construction satisfies no net increase in BFE only if this improvement is paired with implementation of the proposed alternative in Problem Area H, a constructed off-line wetland.

Note that the recommended improvement alternative is still subject to change due to unforeseen hardships such as utility or construction conflicts. The benefits, costs, and B:C ratios for alternatives considered in Area G are shown in Table 18.

Table 18
Problem Area G

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1	No Action	$5,286,600	-	-	-
2	Purchasing Structures	-	$5,286,600	$21,546,100	0.2
5*	Levee Options	-	$5,286,600	$1,813,300	2.9

* Recommended Alternative

The recommended improvement alternative was also examined for any adverse impact on the 1% annual chance flood WSE to satisfy the County's no-rise criteria. Table 19 shows comparison of the WSE of the existing and improved conditions. Since there might be unforeseen constraints, such as utility crossings, the proposed improvement was designed with a slightly lower WSE than the existing condition.

Table 19
1% Annual Flood Stages at Area G

	Existing Condition	Improved Condition	Δ h (FT)
X-16,050	559.1	557.4	-1.7
X-16,139	559.1	558.1	-1.0
X-16,740	559.1	558.0	-1.1
X-17,291	559.6	558.6	-1.0
X-17,918	559.9	559.2	-0.7
X-18,711	560.0	559.4	-0.6
X-19,276	560.1	559.8	-0.3

Problem Area H

In area H, there are 15 multi-residential apartment buildings located at two complexes on Meadow Creek Lane and Sabal Point Drive that are flooding in BFE of FCF. Average depth of FCF flooding is 2.1 feet (with flood depths ranging from 0.1 to 4.1 feet). Within the FIRM floodplain limits, eight apartment buildings are flooded with an average depth of 1.0 foot (with flood depths ranging from 0.2 to 2.2 feet).

The analysis of improvement in Problem Area H showed the two feasible alternatives: purchasing structures, and protecting structures by levees on both banks of Little Sugar Creek. The benefits, costs, and B:C ratios for each alternative in Area H are shown in Table 20.

The levee on the right bank should include a 400-LF floodwall (where there is inadequate space for an earthen levee) and 2,100-LF earthen berm with one pump station to protect eight flooding 2-story multi-residential structures along Meadow Creek Lane with lowest finished floors below the FCF flood elevation (see Figure E-7). The levee on the left bank includes a 1,900-LF earthen levee with one pump station protecting seven 2-story multi-residential structures which are flooding along Sabal Point Drive with lowest finished floors below the FCF flood elevation.

The proposed alternative also includes the construction of an approximate 6-acre off-line wetland to compensate the flow conveyance removed by the levees. It resulted in a net decrease of the BFE about 1.0 foot near below and upstream of Lancaster Highway (Old U.S. 521). This net decrease in the BFEs between Lancaster Highway (Old U.S. 521) and NC 51 benefits flooding problem Area G. The decrease in BFE enables the construction of the levee in Problem Area G without additional excavation to compensate conveyance reduction by the constructed levee. The hydraulic feasibility of the improvement in Area G is determined by executing improvement in Area H.

Water quality enhancing benefits can be estimated by applying the procedures and values developed for the Neuse River Rules. The drainage area of Little Sugar Creek at Lancaster Highway (Old U.S. 521) is approximately 31,500 acres (49.2 sq. mi) and has an overall impervious area of approximately 20%. A constructed off-line wetland will enhance water quality by reducing sediments and nutrients, as well as enhancing die-off of fecal coliforms. The proposed 6-acre off-line wetland can produce water quality benefits exceeding $250,000 of present value. The B:C ratio for the improvement including water quality benefit is shown as Alternative 5 in Table 20. Bank stabilization is also included for the length of the levee. It should be noted that the recommended improvement alternative is still subject to change due to unforeseen hardships such as utility or construction conflicts.

Table 20
Problem Area H

Alternative	Description	Damages	Benefits	Costs	B:C Ratio
1	No Action	$3,621,400	-	-	-
2	Purchasing Structures	-	$3,621,400	$13,427,200	0.3
5*	Levee Options: Levee/Wall Wetland/Channel Widening	-	-	 $1,656,300 $1,779,000	-
	Levee Options Total	-	$3,621,400	$3,435,300	1.1
	Levee Options with Water Quality Enhancement Benefit	-	$3,871,400	$3,435,300	1.1

* Recommended Alternative

The recommended improvement alternative was also examined for any adverse impact on the 1% annual chance flood WSE to satisfy the County's no-rise criteria. Table 21 shows comparison of the WSE of the existing and improved conditions. Since there might be unforeseen constraints, such as utility crossings, the proposed improvement was designed with a slightly lower WSE than the existing condition.

Table 21
1% Annual Flood Stages at Area H

	Existing Condition	Improved Condition	Δ h (FT)
X-11,888	554.0	554.0	0.0
X-12,251	554.1	554.1	0.0
X-13,338	555.6	554.7	-1.1
X-14,026	556.4	555.0	-1.4
X-14,598	556.6	554.8	-1.8
X-15,252	557.2	555.1	-2.1
X-15,757	557.3	555.6	-1.7
X-15,997	557.7	556.6	-1.1

Problem Area I – "Not Clustered"

Thirty-four structures are scattered throughout the Lower Little Sugar Creek watershed and do not permit the usual clustering. For analysis purposes, they are assigned as Area I, "Not Clustered." The floodwall protection of these properties was not feasible, and therefore the economic data for the levee option alternative was not calculated.

The economic data pertaining to non-clustered structures economic analysis is presented in Table 22. The alternative with B:C ratio greater than 1.0 is recommended for implementation and is shown in bold letters in the table. Out of 34 non-clustered structures, there are 12 structures recommended for elevation, and 22 for no action. Nine structures (from the 22 no action) with a large building footprint were not considered for elevation, because elevating would not be a practical solution. There are seven Pre-FIRM structures among the non-clustered structures marked with an asterisk (*) in Table 22. The land use type, finished floor elevations, flooding depths in FCF and FIRM are presented in Appendix in Table A-2.

Table 22
Problem Area I - "Not Clustered"

Structure Description	No Action	Purchasing Structure			Elevating Structure			
	Damages	Benefit	Cost	B:C	Damages	Benefit	Cost	B:C
2200 Huntingtowne Farms Ln*	$203,600	$203,600	$351,400	0.6	**$6,700**	**$196,900**	**$30,000**	**5.4**
7700 Woodstream Dr*	$261,800	$261,800	$3,545,800	0.6	**$9,600**	**$252,200**	**$64,000**	**3.4**
7734 Covey Chase Dr	$24,000	$24,000	$269,500	0.1	$9,400	$14,600	$30,000	0.4
2025 Sharon Lakes Rd*	$74,600	$74,600	$299,400	0.3	-	-	-	-
2021 Sharon Lakes Rd*	$99,900	$99,900	$597,400	0.2	-	-	-	-
8401 Sharon Lakes Rd	$85,300	$85,300	$1,093,400	0.1	-	-	-	-
8301 Sharon Lakes Rd*	$44,000	$44,000	$165,000	0.3	$6,800	$37,200	$60,000	0.6
1937 Sharon Rd West	$237,900	$237,900	$892,500	0.3	-	-	-	-
1941 Sharon Rd West	$112,400	$112,400	$892,500	0.1	-	-	-	-
1933 Sharon Rd West	$38,400	$38,400	$198,300	0.2	$8,500	$29,900	$30,000	0.8
2210 Sharon Rd West	$29,000	$29,000	$372,100	0.1	$12,000	$17,000	$30,000	0.4
7540 Quail Meadow Ln	$109,500	$109,500	$445,900	0.2	-	-	-	-
7541 Quail Meadow Ln	$291,300	$291,300	$445,900	0.7	-	-	-	-
7520 Quail Meadow Ln	$131,900	$131,900	$445,900	0.3	-	-	-	-
8840 Gruenewald Ln	$64,700	$64,700	$182,200	0.4	**$9,400**	**$55,300**	**$30,000**	**1.4**
2431 Bergen Ct	$30,500	$30,500	$161,900	0.2	$8,500	$22,000	$30,000	0.6
2425 Bergen Ct	$70,600	$70,600	$170,000	0.4	**$8,800**	**$61,800**	**$30,000**	**1.6**
2419 Bergen Ct	$95,400	$95,400	$178,200	0.5	**$9,200**	**$86,200**	**$30,000**	**2.2**
2413 Bergen Ct	$91,900	$91,900	$176,200	0.5	**$9,400**	**$82,500**	**$30,000**	**2.1**
8842 Leipzig Dr	$52,200	$52,200	$171,300	0.3	**$8,900**	**$43,300**	**$30,000**	**1.1**
8834 Leipzig Dr	$17,000	$17,000	$170,700	0.1	$8,900	$8,100	$30,000	0.2
2744 Heidleburg Ln	$80,800	$80,800	$165,500	0.5	**$8,900**	**$72,200**	**$30,000**	**1.9**
2737 Heidleburg Ln	$34,600	$34,600	$177,000	0.2	$9,100	$25,500	$30,000	0.7
2715 Heidleburg Ln	$23,800	$23,800	$167,700	0.1	$9,000	$14,800	$30,000	0.4
2707 Heidleburg Ln	$87,600	$87,600	$171,100	0.5	**$9,100**	**$78,500**	**$30,000**	**2.0**
2105 Longleaf Dr*	$49,600	$49,600	$70,500	0.7	**$6,000**	**$43,600**	**$30,000**	**1.2**
2113 Longleaf Dr*	$49,700	$49,700	$73,400	0.7	**$5,900**	**$43,800**	**$30,000**	**1.2**
2300 Turnberry Ln	$44,900	$44,900	$147,400	0.3	$8,400	$36,500	$30,000	0.9
2304 Turnberry Ln	$14,200	$14,200	$137,700	0.1	$8,000	$6,200	$30,000	0.2
2310 Turnberry Ln	$27,000	$27,000	$153,300	0.2	$8,700	$18,300	$30,000	0.5
2301 Oldenburg Dr	$73,900	$73,900	$135,100	0.5	**$7,900**	**$66,000**	**$30,000**	**1.7**
9840 Pineville-Mathews Rd	$212,000	$212,000	$3,267,700	0.1	-	-	-	-
412 Mallard Dr	$20,200	$20,200	145,100	0.1	$9,700	$10,500	$30,000	0.3
418 Mallard Dr	$45,100	$45,100	136,100	0.3	$9,400	$35,700	$30,000	0.9
Total 12 structures recommended for elevation	$1,181,600	-	-	-	$99,500	$1,082,100	$394,000	2.2

4. CONCLUSIONS AND RECOMMENDATIONS

There are 248 structures within the FCF boundaries along Lower Little Sugar Creek. From that, 109 structures have a lowest finished floor elevation below the BFE of FCF. Of the 109 flooding structures, 67 are residential land use, (40 single-family and 27 multi-family buildings), and 42 are commercial structures.

Several alternatives were considered to resolve flooding damage and bank stability problems in the Lower Little Sugar Creek watershed. Based on the flood damage assessment and B:C analysis, the recommended improvements for the Lower Little Sugar Creek Watershed include a combination of floodwalls, elevating structures, and leaving some flooded structures unprotected (Figure 21). The damages estimated to structures within the FCF are $28,493,200 (2001 dollars). The total estimated cost for the proposed improvements is $6,898,900. Some structures are left unprotected because, relative to the damage assessment, it is not cost-effective to purchase or protect these properties.

Along Lower Little Sugar Creek, a series of floodwalls and levees mitigate flood damage for 48 structures. For those structures where floodwalls are infeasible as a protection option, options analyzed included the elevation of structures, buyout, or no action. It was recommended to elevate 31 structures. There 30 structures recommended for no action, because the low B:C ratios indicate it is not cost-effective to take action.

The recommendations include further exploration of bank stabilization and/or stream restoration needs within the Lower Little Sugar Creek watershed. Note that the channel was only observed from road crossing vantage points, and further investigation is necessary to prioritize stream bank and channel repairs. Surveys of bank erosion sites are recommended to determine the rate at which erosion is occurring and to help prioritize future bank restoration projects in the watershed.

During field visits, little aquatic wildlife was observed in Lower Little Sugar Creek and its major tributaries. According to the Mecklenburg County Department of Environmental Protection (MCDEP) monitoring records, from 1994 to 1998 overall water quality has remained fairly consistent in the Lower Little Sugar Creek watershed. Review of ambient water quality data dating back to 1968 does not reveal significant trends in most of the data over time or by location along the creeks. Current Water Quality Index values indicate an average of “Fair-Good” water quality for Lower Little Sugar Creek. The aquatic fauna communities throughout the watershed have consistently ranked “Poor” and “Fair,” while fish sampling ranked, on average, “Fair-Good,” which results in a less than desirable diversity of species. This may indicate that aquatic habitat conditions limit these communities to some extent. While aquatic life is present in the creeks, the sand and silt benthic material (with little instream features such as boulders and woody debris) does not provide a protective habitat, and bottom dwelling communities are not as abundant and diverse as may be desired. Bank stabilization projects may improve aquatic habitat; however, the stream bank restoration project in the Huntingtowne Farms area did not seem to influence the aquatic communities (Roux, 1999). The best chance of improving aquatic conditions and water quality may lie in combining stream bank and bottom stabilization with the creation of diverse in-stream habitat (Roux, 1999, 2000).

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Figure 12 Study No. 1, (Lower) Little Sugar Watershed Proposed Improvements, Sheet 1

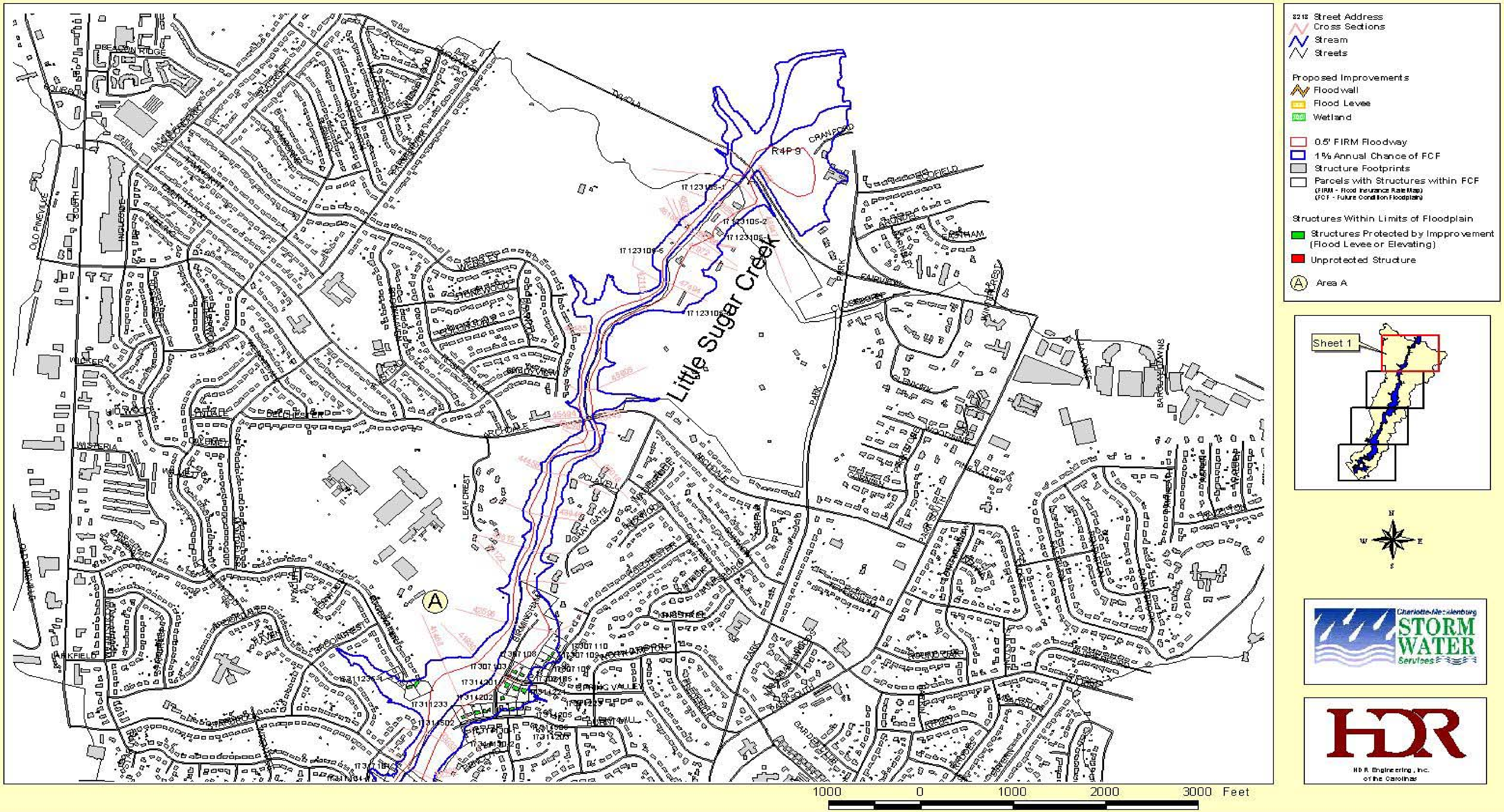
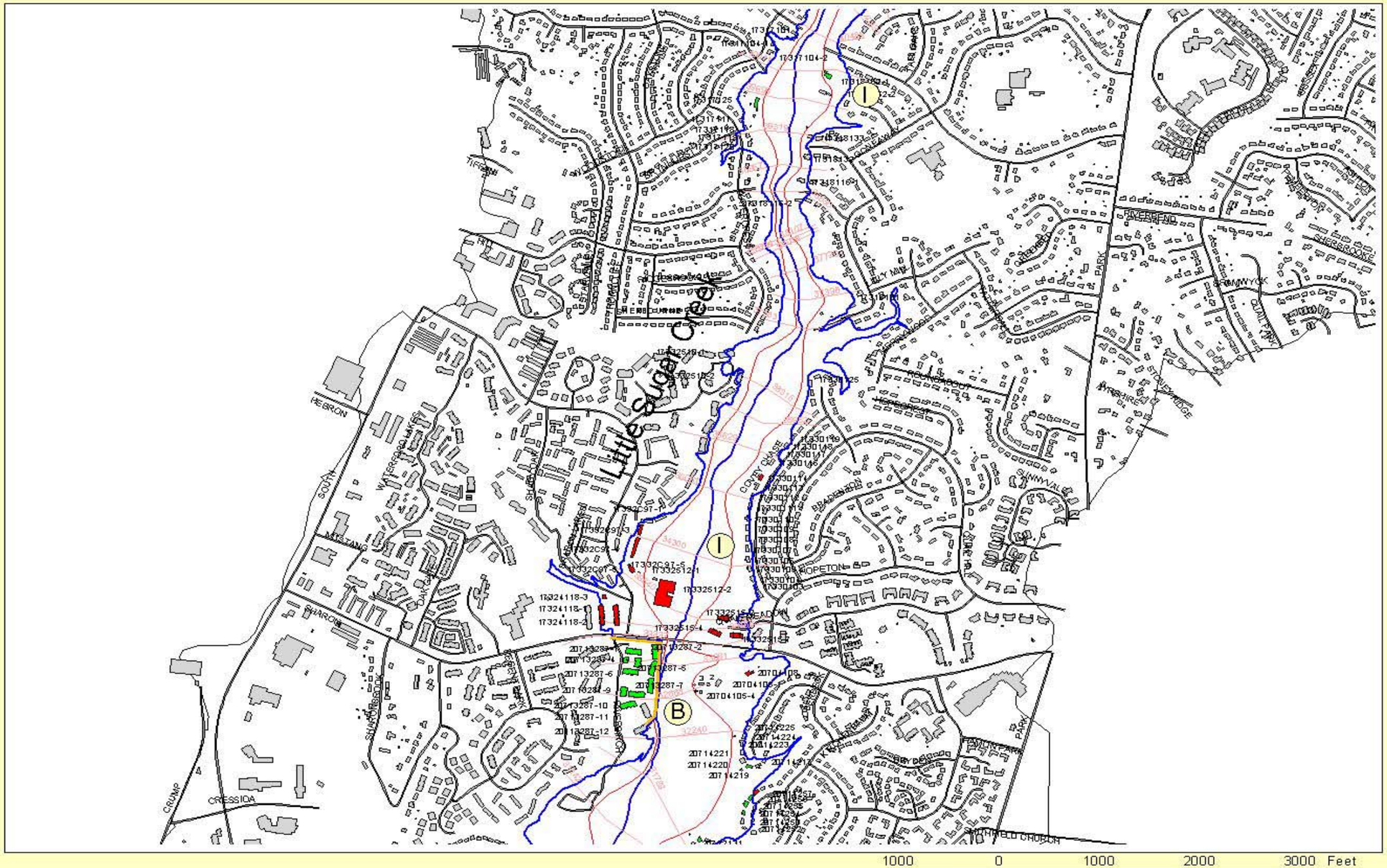


Figure 12 Study No.1, (Lower) Little Sugar Watershed Proposed Improvements, Sheet 2



Street Address
Cross Sections
Stream
Streets

Proposed Improvements
Floodwall
Flood Levee
Wetland

0.5' FIRM Floodway
1% Annual Chance of FCF
Structure Footprints
Parcels with Structures within FCF
(FIRM - Flood Insurance Rate Map)
(FCF - Future Condition Floodplain)

Structures Within Limits of Floodplain
Structures Protected by Impprovement (Flood Levee or Elevating)
Unprotected Structure

(B) Area B (I) Not Clustered

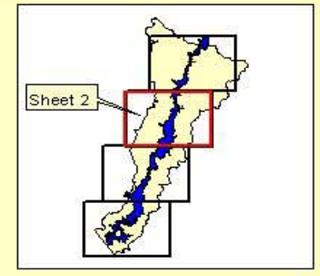


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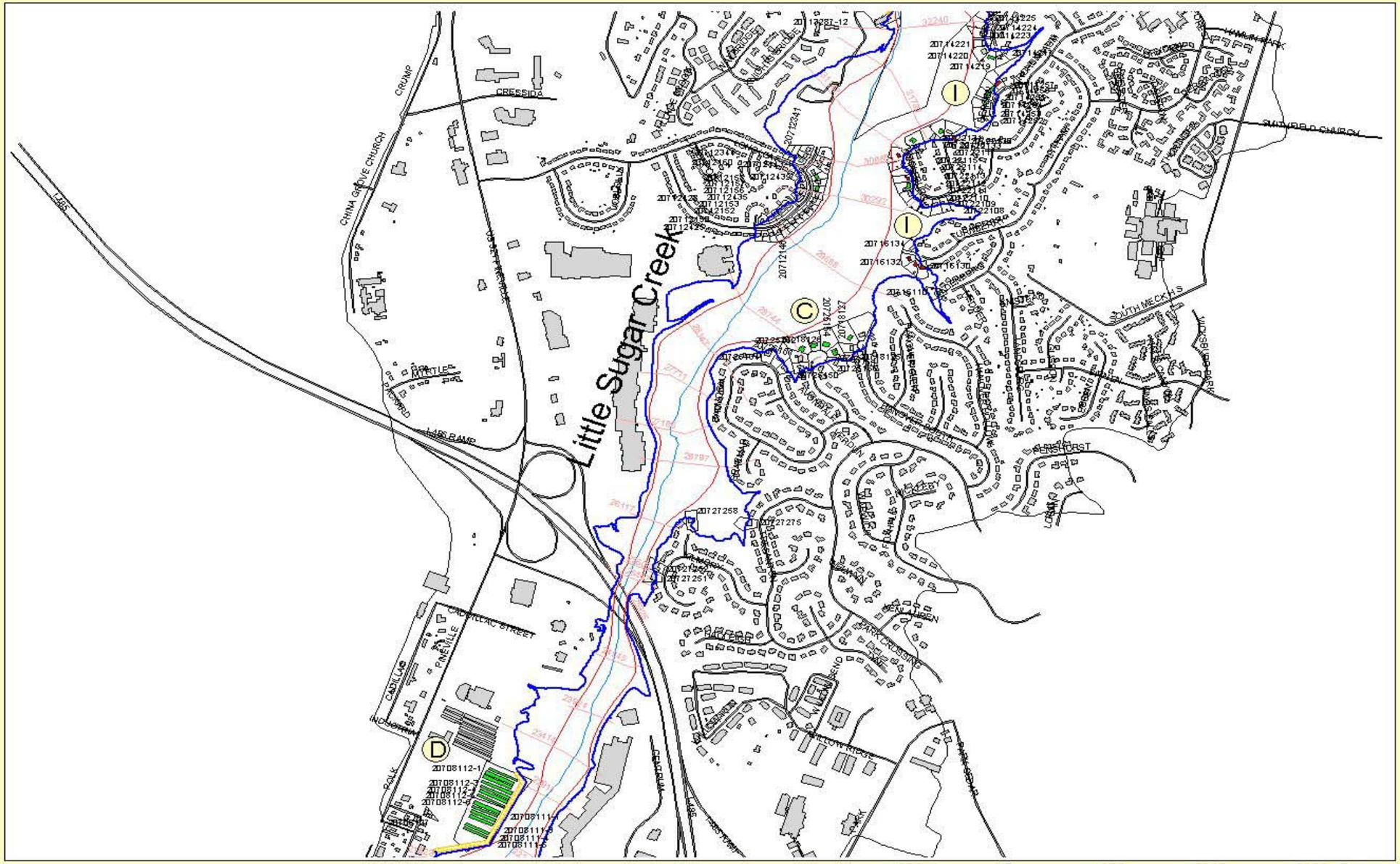
Figure 12 Study No. 1, (Lower) Little Sugar Watershed Proposed Improvements, Sheet 3



Street Address
Cross Sections
Stream
Streets

Proposed Improvements
Floodwall
Flood Levee
Wetland

0.5' FIRM Floodway
1% Annual Chance of FCF
Structure Footprints
Parcels with Structures within FCF
(FIRM - Flood Insurance Rate Map)
(FCF - Future Condition Floodplain)

Structures Within Limits of Floodplain
Structures Protected by Imprpovement (Flood Levee or Elevating)
Unprotected Structure
Ⓒ Area C Ⓓ Area D
Ⓘ Not Clustered

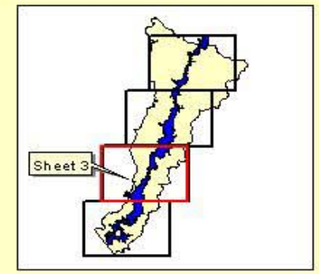


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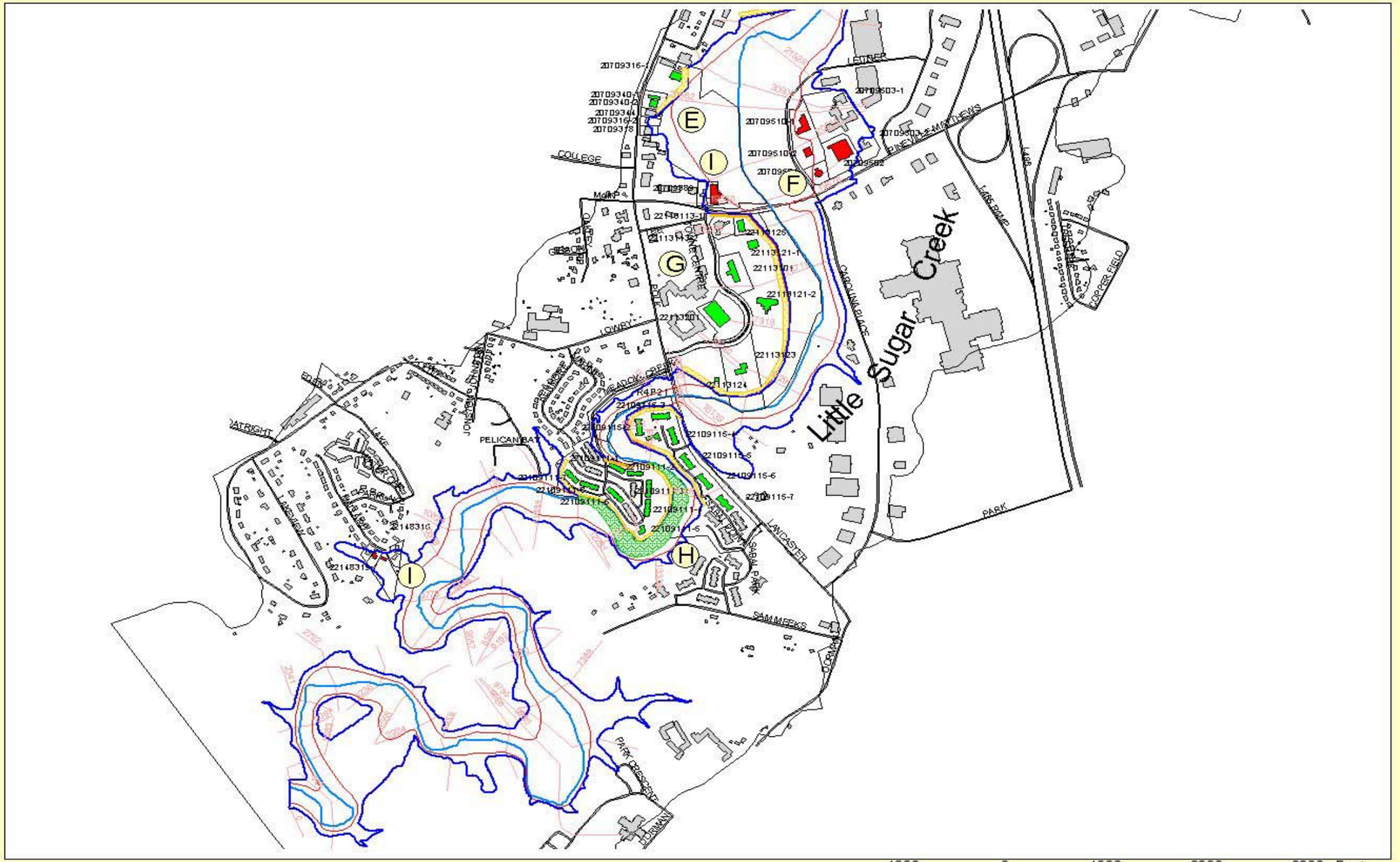
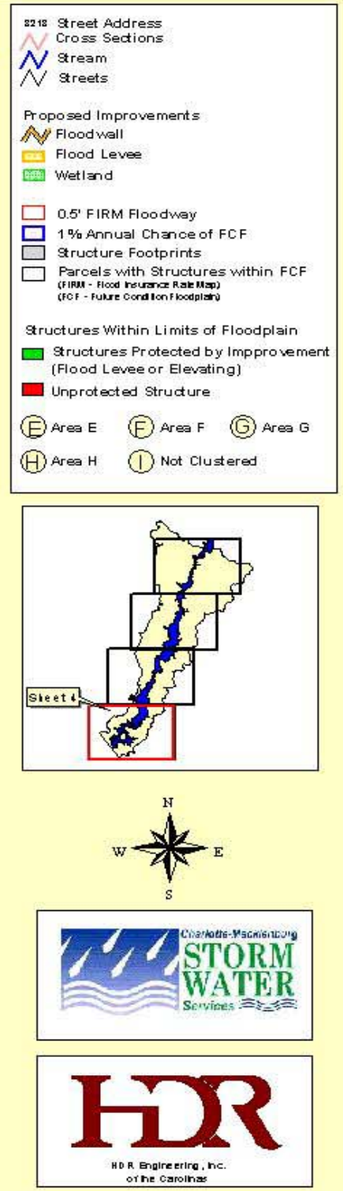
Figure 12 Study No. 1, (Lower) Little Sugar Watershed Proposed Improvements, Sheet 4





APPENDIX A

TABLE A-1

Watershed Study No. 1
Lower Little Sugar Creek Watershed
Alternative Benefit: Cost Evaluation
(Present value in 2001 dollars)

Problem Areas		BENEFIT	COST					
ID	Description	Benefit[1] in $1,000	mprovemet Cost[2] in $1,000	O&M[3] n $1,00(	Residua Damage n $1,00(	Property Buyout in $1,000	Total Cost in $1,000	B:C Ratio
A	Elevate Structures	1,031	434	-	105	-	539	1.9
B	Floodwall B	2,788	371	85	-	-	456	6.1
C	Elevate Structures	349	150	-	81	-	231	1.5
D	Levee Option D	3,154	107	-	-	-	107	29.5
E	Levee Option E	5,199	25	85	-	-	110	47.4
F	No Action	-	-	-	4,000	-	4,000	-
G	Levee Option G	5,287	1,644	169	-	-	1,813	2.9
H	Levee Option H	3,621	2,758	677	-	-	3,435	1.1
I	Elevate Structures	1,082	394	-	100	-	494	2.2

[1] Benefit is defined as the total damage **removed** by the improvement.
[2] Improvement Cost is defined as the construction cost of the improvement.
[3]O&M Costs are the operating and maintenance costs associated with the proposed improvement.

Floodwall	Description (see Figures E-8 through E-12 for locations)
B	Concrete floodwall on right bank of Lower Little Sugar Creek with one pump station.
D	Earthen berm on right bank of Lower Little Sugar Creek.
E	Earthen berm on right bank of Lower Little Sugar Creek with one pump station.
G	Combination of concrete floodwall and earthen berm on right bank of Lower Little Sugar Creek with one pump station.
H	Combination of concrete floodwall and earthen berm on the right bank and earthen levee on the left bank of Lower Little Sugar Creek with one pump station on each bank, channel improvement, and wetland construction.

The floodwall and berm construction costs include pump stations, standby generator, and contingencies. No utility relocations were considered in the analysis.

Table A-2

Watershed Study No. 1
Lower Little Sugar Creek Watershed
Flooding Structures Summary

All Elevations are based on 1988 NAVD.

Count	Parcel ID	Stream	Address	Land Use Type[1]	HEC-RAS Station	Finished Floor Elevation	FCF		FIRM		Problem Location ID
							1% Annual Chance of Flood Elevation	Flood Depth[2] (ft)	1% Annual Chance of Flood Elevation	Flood Depth[2] (ft)	
1	17307109	Little Sugar	6208 COLCHESTER PL	R	42423	573.3	578.2	4.9	576.7	3.4	A
2	17307108	Little Sugar	6214 COLCHESTER PL	R	42348	576.7	578.1	1.4	576.6	-0.1	A
3	17307103	Little Sugar	2801 SPRING VALLEY RD	R	42063	573.6	577.8	4.2	576.3	2.7	A
4	17307104	Little Sugar	2811 SPRING VALLEY RD	R	42063	576.5	577.8	1.3	576.3	-0.2	A
5	17314201	Little Sugar	2800 SPRING VALLEY RD	R	41895	574.0	577.7	3.7	576.1	2.1	A
6	17314223	Little Sugar	2810 SPRING VALLEY RD	R	41895	574.4	577.7	3.3	576.1	1.7	A
7	17314222	Little Sugar	2816 SPRING VALLEY RD	R	41895	576.7	577.7	1.0	576.1	-0.6	A
8	17314202	Little Sugar	6317 BIRMINGHAM DR	R	41727	574.0	577.6	3.6	576.0	2.0	A
9	17314204	Little Sugar	2809 BURNT MILL RD	R	41640	577.5	577.6	0.1	576.0	-1.5	A
10	17314505	Little Sugar	2729 BURNT MILL RD	R	41634	575.7	577.6	1.9	576.0	0.3	A
11	17314504	Little Sugar	2721 BURNT MILL RD	R	41595	577.1	577.5	0.4	576.0	-1.1	A
12	17314502	Little Sugar	2709 BURNT MILL RD	R	41425	576.6	577.4	0.8	576.0	-0.8	A
13	17311233	Little Sugar	2059 EDGEWATER DR	R	41260	576.7	576.9	0.2	575.4	-1.3	A
14	17311234	Little Sugar	2058 EDGEWATER DR	R	41200	575.5	576.8	1.3	575.3	-0.2	A
15	17318162-1	Little Sugar	2200 HUNTINGTON FARMS LN	C	39947	570.8	575.2	4.4	573.6	2.8	I
16	17317125	Little Sugar	7700 WOODSTREAM DR	C	39596	570.6	574.9	4.3	573.3	2.7	I
17	17330114	Little Sugar	7734 COVEY CHASE DR	R	35362	569.4	569.7	0.3	568.2	-1.2	I
18	17332C97-3	Little Sugar	2025 SHARON LAKES RD	R	34378	567.4	569.3	1.9	567.9	0.5	I
19	17332C97-4	Little Sugar	2021 SHARON LAKES RD	R	34100	567.7	569.2	1.5	567.8	0.1	I
20	17332C97-5	Little Sugar	8301 SHARON LAKES RD	C	33755	567.3	569.1	1.8	567.6	0.3	I
21	17332512-2	Little Sugar	8401 SHARON LAKES RD	C	33750	568.4	569.1	0.7	567.6	-0.8	I
22	17324118-2	Little Sugar	1937 SHARON RD WEST	R	33456	566.7	569.0	2.3	567.5	0.8	I
23	17324118-3	Little Sugar	1933 SHARON RD WEST	R	33424	567.8	569.0	1.2	567.5	-0.3	I
24	17332515-2	Little Sugar	7540 QUAIL MEADOW LN	R	33640	567.0	569.0	2.0	567.5	0.5	I
25	17332515-5	Little Sugar	7541 QUAIL MEADOW LN	R	33400	565.7	569.0	3.3	567.5	1.8	I
26	17332515-3	Little Sugar	7541 QUAIL MEADOW LN	R	33400	565.7	569.0	3.3	567.5	1.8	I
27	17332515-4	Little Sugar	7541 QUAIL MEADOW LN	R	33400	565.7	569.0	3.3	567.5	1.8	I
28	17332515-8	Little Sugar	7520 QUAIL MEADOW LN	R	33380	567.2	569.0	1.8	567.5	0.3	I
29	17332515-7	Little Sugar	7520 QUAIL MEADOW LN	R	33380	567.2	569.0	1.8	567.5	0.3	I
30	17332515-6	Little Sugar	7520 QUAIL MEADOW LN	R	33380	567.2	569.0	1.8	567.5	0.3	I
31	17324118-1	Little Sugar	1941 SHARON RD WEST	R	33337	567.3	568.3	1.0	566.9	-0.4	I
32	20713287-2	Little Sugar	2025 SHARON OAKS LN	C	33200	564.3	568.3	4.0	566.4	2.1	B
33	20713287-1	Little Sugar	2000 SHARON OAKS LN	C	33200	565.0	568.2	3.3	566.4	1.4	B
34	20713287-3	Little Sugar	8025 SHARON OAKS LN	C	33100	565.1	568.2	3.1	566.4	1.3	B
35	20713287-4	Little Sugar	2036 SHARON OAKS LN	C	33061	564.8	568.0	3.4	566.4	1.6	B
36	20713287-6	Little Sugar	2120 SHARON OAKS LN	C	32900	564.4	568.0	3.6	566.1	1.7	B
37	20713287-5	Little Sugar	2041 SHARON OAKS LN	C	32900	564.4	568.0	3.6	566.1	1.7	B
38	20704108	Little Sugar	2210 SHARON RD WEST	R	32873	567.4	568.0	0.6	566.1	-1.3	I
39	20713287-7	Little Sugar	2101SHARON OAKS LN	C	32800	564.3	567.9	3.6	566.0	1.7	B
40	20713287-8	Little Sugar	2115 SHARON OAKS LN	C	32715	565.4	567.8	2.4	565.9	0.5	B
41	20713287-8	Little Sugar	2125 SHARON OAKS LN	C	32715	567.5	567.8	0.3	565.9	-1.6	B
42	20713287-10	Little Sugar	8141 RIVER BIRCH LN	C	32600	567.1	567.8	0.7	565.9	-1.3	B
43	20714219	Little Sugar	8840 GRUENEWALD LN	R	32131	565.3	567.8	2.5	565.9	0.6	I
44	20714257	Little Sugar	2431 BERGEN CT	R	32068	566.5	567.8	1.3	565.8	-0.7	I
45	20714256	Little Sugar	2425 BERGEN CT	R	32044	565.0	567.8	2.8	565.8	0.8	I
46	20714255	Little Sugar	2419 BERGEN CT	R	32015	564.5	567.8	3.3	565.8	1.3	I
47	20714254	Little Sugar	2413 BERGEN CT	R	31983	564.5	567.7	3.2	565.8	1.3	I
48	20722133	Little Sugar	8834 LEIPZIG DR	R	31860	567.5	567.7	0.2	565.8	-1.7	I
49	20722131	Little Sugar	8842 LEIPZIG DR	R	31840	565.5	567.7	2.2	565.7	0.2	I
50	20722116	Little Sugar	2744 HEIDLEBURG LN	R	31465	564.5	567.6	3.1	565.6	1.1	I
51	20722112	Little Sugar	2744 HEIDLEBURG LN	R	30798	566.5	567.3	0.8	565.3	-1.2	I
52	20722115	Little Sugar	2744 HEIDLEBURG LN	R	30716	565.9	567.3	1.4	565.3	-0.6	I
53	20712158	Little Sugar	2105 LONGLEAF DR	R	30507	564.3	567.2	2.9	565.2	0.9	I
54	20722111	Little Sugar	2744 HEIDLEBURG LN	R	30475	564.0	567.2	3.2	565.2	1.2	I
55	20712156	Little Sugar	2113 LONGLEAF DR	R	30334	564.3	567.2	2.9	565.2	0.9	I

Table A-2 (Continue)

Watershed Study No. 1
Lower Little Sugar Creek Watershed
Flooding Structures Summary

All Elevations are based on 1988 NAVD.

Count	Parcel ID	Stream	Address	Land Use Type[1]	HEC-RAS Station	Finished Floor Elevation	FCF 1% Annual Chance of Flood Elevation	FCF Flood Depth[2] (ft)	FIRM 1% Annual Chance of Flood Elevation	FIRM Flood Depth[2] (ft)	Problem Location ID
56	20716132	Little Sugar	2300 TURNBERRY LN	R	29876	565.0	567.1	2.1	565.1	0.1	I
57	20716130	Little Sugar	2310 TURNBERRY LN	R	29876	566.0	567.1	1.1	565.1	-0.9	I
58	20716131	Little Sugar	2304 TURNBERRY LN	R	29876	567.0	567.1	0.1	565.1	-1.9	I
59	20716110	Little Sugar	2301 OLDENBURG DR	R	29868	563.9	567.1	3.2	565.1	1.2	I
60	20718127	Little Sugar	9200 HANOVER SOUTH TL	R	29228	563.7	567.0	3.3	564.9	1.2	C
61	20725155	Little Sugar	10301 AVONDALE AV	R	29019	565.6	566.9	1.3	564.9	-0.7	C
62	20725154	Little Sugar	10300 AVONDALE AV	R	28995	564.0	566.9	2.9	564.9	0.9	C
63	20725153	Little Sugar	10308 AVONDALE AV	R	28900	565.8	566.9	1.1	564.8	-1.0	C
64	20725152	Little Sugar	10312 AVONDALE AV	R	28777	566.5	566.8	0.3	564.8	-1.7	C
65	20708112-7	Little Sugar	10811 PINEVILLE RD	C	22631	555.6	561.0	5.4	558.7	3.1	D
66	20708112-6	Little Sugar	10811 PINEVILLE RD	C	22631	556.7	561.0	4.3	558.7	2.0	D
67	20708112-5	Little Sugar	10811 PINEVILLE RD	C	22631	556.7	561.0	4.3	558.7	2.0	D
68	20708112-4	Little Sugar	10811 PINEVILLE RD	C	22631	557.1	561.0	3.9	558.7	1.6	D
69	20708112-3	Little Sugar	10811 PINEVILLE RD	C	22631	557.1	561.0	3.9	558.7	1.6	D
70	20708112-2	Little Sugar	10811 PINEVILLE RD	C	22631	557.8	561.0	3.2	558.7	0.9	D
71	20708112-1	Little Sugar	10811 PINEVILLE RD	C	22631	558.0	561.0	3.0	558.7	0.7	D
72	20708111-6	Little Sugar	10811 PINEVILLE RD	C	22312	553.4	560.9	7.5	558.6	5.2	D
73	20708111-5	Little Sugar	10811 PINEVILLE RD	C	22312	554.4	560.9	6.5	558.6	4.2	D
74	20708111-1	Little Sugar	10811 PINEVILLE RD	C	22312	556.3	560.9	4.6	558.6	2.3	D
75	20708111-3	Little Sugar	10811 PINEVILLE RD	C	22312	556.4	560.9	4.5	558.6	2.2	D
76	20708111-4	Little Sugar	10811 PINEVILLE RD	C	22312	556.5	560.9	4.4	558.6	2.1	D
77	20708111-2	Little Sugar	10811 PINEVILLE RD	C	22312	556.5	560.9	4.4	558.6	2.1	D
78	20709316	Little Sugar	400 POLK ST	C	20750	553.5	560.7	7.2	558.4	4.9	E
79	20709340-1	Little Sugar	316 N POLK ST	C	20651	559.9	560.7	0.8	558.4	-1.5	E
80	20709340-2	Little Sugar	314 N POLK ST	C	20600	560.4	560.7	0.3	558.4	-2.0	E
81	20709510-1	Little Sugar	9925 LEITNER DR	C	20338	555.5	560.7	5.2	558.4	2.9	F
82	20709510-2	Little Sugar	9925 LEITNER DR	C	19900	557.4	560.6	3.2	558.3	0.9	F
83	20709389	Little Sugar	9840 PINEVILLE-MATHEWS RD	C	19665	560.3	560.6	0.3	558.2	-2.1	I
84	20709502	Little Sugar	9610 PINEVILLE-MATHEWS RD	C	19646	559.0	560.6	1.6	558.2	-0.8	F
85	20709501	Little Sugar	9620 PINEVILLE-MATHEWS RD	C	19590	557.3	560.5	3.2	558.2	0.9	F
86	22113125	Little Sugar	9835 PINEVILLE-MATHEWS RD	C	19357	557.7	560.2	2.5	558.1	0.4	G
87	22113121-1	Little Sugar	391 TOWNE CENTRE BV	C	19000	557.2	560.1	2.9	558.0	0.8	G
88	22113101	Little Sugar	401 TOWNE CENTRE BV	C	18870	558.2	560.1	1.9	558.0	-0.2	G
89	22113121-2	Little Sugar	425 TOWNE CENTRE BV	C	18250	554.7	559.9	5.2	557.8	3.1	G
90	22113201	Little Sugar	400 TOWNE CENTRE BV	C	17967	558.6	559.9	1.3	557.8	-0.8	G
91	22113123	Little Sugar	515 TOWNE CENTRE BV	C	17016	553.8	559.4	5.6	557.2	3.4	G
92	22113124	Little Sugar	605 TOWNE CENTRE BV	C	16452	554.0	559.1	1.1	556.9	-1.1	G
93	22109115-3	Little Sugar	12504 SABAL POINT DR	R	15800	554.0	557.4	3.4	555.5	1.5	H
94	22109115-2	Little Sugar	12508 SABAL POINT DR	R	15252	553.1	557.2	4.1	555.3	2.2	H
95	22109111-1	Little Sugar	12737 MEADOW CREEK LN	R	14800	554.7	556.8	2.1	554.9	0.2	H
96	22109111-2	Little Sugar	12745 MEADOW CREEK LN	R	14650	554.8	556.6	1.8	554.7	-0.1	H
97	22109115-1	Little Sugar	12512 SABAL POINT DR	R	14598	553.0	556.6	3.6	554.7	1.7	H
98	22109115-4	Little Sugar	12500 SABAL POINT DR	R	14500	553.8	556.6	2.8	554.6	0.8	H
99	22109115-5	Little Sugar	12501 SABAL POINT DR	R	14400	555.1	556.5	1.4	554.6	-0.5	H
100	22109115-6	Little Sugar	12505 SABAL POINT DR	R	14200	556.3	556.4	0.1	554.5	-1.8	H
101	22109111-3	Little Sugar	12801 MEADOW CREEK LN	R	14100	553.6	556.4	2.8	554.5	0.9	H
102	22109115-7	Little Sugar	12506 SABAL POINT DR	R	13900	554.5	556.2	1.7	554.3	-0.2	H
103	22109111-4	Little Sugar	12815 MEADOW CREEK LN	R	13700	553.7	556.0	2.3	554.1	0.4	H
104	22109111-5	Little Sugar	12821 MEADOW CREEK LN	R	13338	555.1	555.6	0.5	553.7	-1.4	H
105	22109111-6	Little Sugar	12845 MEADOW CREEK LN	R	12569	553.5	554.5	1.0	552.6	-0.9	H
106	22109111-8	Little Sugar	12901 MEADOW CREEK LN	R	12350	552.1	554.2	2.1	552.3	0.2	H
107	22109111-7	Little Sugar	12915 MEADOW CREEK LN	R	12150	552.1	554.1	2.0	552.1	0.0	H
108	22148318	Little Sugar	418 MALLARD DR	R	9945	549.5	551.6	2.1	549.6	0.1	I
109	22148319	Little Sugar	412 MALLARD DR	R	9945	551.1	551.6	0.5	549.6	-1.5	I

[1]Land Use Type R is Residential. Land Use Type C is Commercial.
[2]Shading indicates all flooding depths being equal or exceeding 4 feet.

Table A-3

Watershed Study No. 1
Lower Little Sugar Creek Watershed
Repetitive Loss Database

	RL Number	Community Number	Date of Loss	Address	City	State	ZIP Code	Pay Building	Pay Cont
1	5276	370158	19901023	5042 SENTINEL POST RD	CHARLOTTE	NC	282267447	$5,870	$0
2	5276	370158	19940818	5042 SENTINEL POST RD	CHARLOTTE	NC	282267447	$5,643	$0
3	5276	370158	19950827	5042 SENTINEL POST RD	CHARLOTTE	NC	282267447	$108,426	$10,870
4	5276	370158	19790323	5042 SENTINEL POST RD	CHARLOTTE	NC	282267447	$3,504	$0
5	5276	370158	19820610	5042 SENTINEL POST RD	CHARLOTTE	NC	282267447	$5,101	$0
6	9041	370159	19850515	511 QUEENS RD	CHARLOTTE	NC	282071423	$8,020	$0
7	9041	370159	19851121	511 QUEENS RD	CHARLOTTE	NC	282071423	$15,320	$1,235
8	9041	370159	19870228	511 QUEENS RD	CHARLOTTE	NC	282071423	$10,953	$0
9	9075	370159	19920617	3404 COMMONWEALTH AVE	CHARLOTTE	NC	282056229	$6,018	$0
10	9075	370159	19930323	3404 COMMONWEALTH AVE	CHARLOTTE	NC	282056229	$6,363	$0
11	9394	370159	19901011	3008 HARBINGER CT	CHARLOTTE	NC	282053849	$1,741	$0
12	9394	370159	19930323	3008 HARBINGER CT	CHARLOTTE	NC	282053849	$3,241	$0
13	9394	370159	19950827	3008 HARBINGER CT	CHARLOTTE	NC	282053849	$4,063	$0
14	18140	370159	19940816	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$1,833	$0
15	18140	370159	19950828	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$22,962	$14,100
16	18140	370159	19950828	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$1,588	$5,300
17	18140	370159	19790323	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$5,649	$5,000
18	18140	370159	19820610	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$17,703	$8,834
19	18140	370159	19831206	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$1,794	$0
20	18140	370159	19790323	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$0	$1,000
21	18140	370159	19820610	5952 SHARON VIEW RD	CHARLOTTE	NC	282266846	$340	$2,410
22	18150	370159	19790929	700 KENILWORTH AVE	CHARLOTTE	NC	282042829	$0	$25,000
23	18150	370159	19820610	700 KENILWORTH AVE	CHARLOTTE	NC	282042829	$0	$78,800
24	26970	370159	19820610	2718 CHILTON PL	CHARLOTTE	NC	282072656	$0	$1,387
25	26970	370159	19850515	2718 CHILTON PL	CHARLOTTE	NC	282072656	$1,765	$3,563
26	26970	370159	19850607	2718 CHILTON PL	CHARLOTTE	NC	282072656	$0	$1,903
27	26970	370159	19850817	2718 CHILTON PL	CHARLOTTE	NC	282072656	$2,277	$1,545
28	26970	370159	19950827	2718 CHILTON PL	CHARLOTTE	NC	282072656	$7,700	$6,800
29	26980	370159	19901012	4601 PERTH CT	CHARLOTTE	NC	282153324	$2,418	$0
30	26980	370159	19910111	4601 PERTH CT	CHARLOTTE	NC	282153324	$1,220	$0
31	26981	370159	19901012	4619 PERTH CT	CHARLOTTE	NC	282153355	$3,908	$0
32	26981	370159	19910111	4619 PERTH CT	CHARLOTTE	NC	282153355	$2,290	$0
33	26982	370159	19820610	2009 MILTON RD	CHARLOTTE	NC	282152467	$3,418	$0
34	26982	370159	19850817	2009 MILTON RD	CHARLOTTE	NC	282152467	$1,723	$0
35	26982	370159	19890924	2009 MILTON RD	CHARLOTTE	NC	282152467	$9,135	$0
36	26982	370159	19901012	2009 MILTON RD	CHARLOTTE	NC	282152467	$7,153	$0
37	26982	370159	19910111	2009 MILTON RD	CHARLOTTE	NC	282152467	$9,094	$0
38	26983	370159	19820610	4528 PERTH CT	CHARLOTTE	NC	282153323	$8,035	$0
39	26983	370159	19890924	4528 PERTH CT	CHARLOTTE	NC	282153323	$4,280	$0
40	26983	370159	19901012	4528 PERTH CT	CHARLOTTE	NC	282153323	$1,908	$0

Table A-3 (Continue)

Watershed Study No. 1
Lower Little Sugar Creek Watershed
Repetitive Loss Database

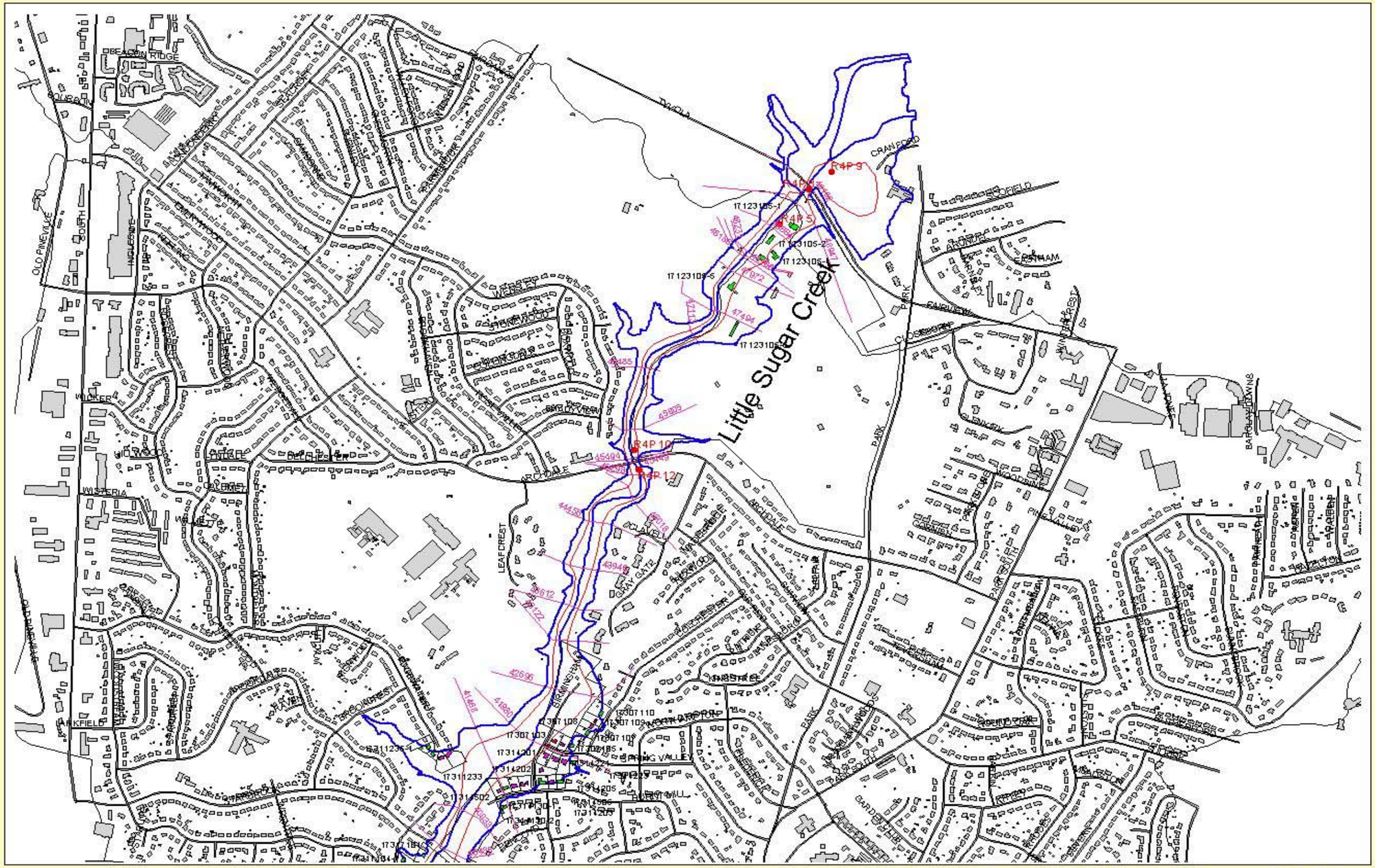
	RL Number	Community Number	Date of Loss	Address	City	State	ZIP Code	Pay Building	Pay Cont
41	26983	370159	19910111	4528 PERTH CT	CHARLOTTE	NC	282153323	$2,445	$0
42	26984	370159	19890924	4512 PERTH CT	CHARLOTTE	NC	282153323	$2,491	$0
43	26984	370159	19901012	4512 PERTH CT	CHARLOTTE	NC	282153323	$1,908	$0
44	26984	370159	19910111	4512 PERTH CT	CHARLOTTE	NC	282153323	$1,580	$0
45	26985	370159	19780622	4539 PERTH CT	CHARLOTTE	NC	282153322	$4,138	$0
46	26985	370159	19820610	4539 PERTH CT	CHARLOTTE	NC	282153322	$5,214	$0
47	26985	370159	19890924	4539 PERTH CT	CHARLOTTE	NC	282153322	$9,296	$0
48	26985	370159	19901012	4539 PERTH CT	CHARLOTTE	NC	282153322	$5,320	$0
49	26986	370159	19890924	4532 PERTH CT	CHARLOTTE	NC	282153323	$3,394	$0
50	26986	370159	19901012	4532 PERTH CT	CHARLOTTE	NC	282153323	$2,418	$0
51	26986	370159	19910111	4532 PERTH CT	CHARLOTTE	NC	282153323	$2,200	$0
52	26987	370159	19780622	4520 PERTH CT	CHARLOTTE	NC	282153337	$10,284	$0
53	26987	370159	19820610	4520 PERTH CT	CHARLOTTE	NC	282153337	$17,939	$0
54	26987	370159	19840329	4520 PERTH CT	CHARLOTTE	NC	282153337	$1,718	$0
55	26987	370159	19850817	4520 PERTH CT	CHARLOTTE	NC	282153337	$1,550	$0
56	26987	370159	19890924	4520 PERTH CT	CHARLOTTE	NC	282153337	$8,983	$0
57	26987	370159	19901012	4520 PERTH CT	CHARLOTTE	NC	282153337	$6,819	$0
58	26987	370159	19910111	4520 PERTH CT	CHARLOTTE	NC	282153337	$2,923	$0
59	26988	370159	19890924	4536 PERTH CT	CHARLOTTE	NC	282153340	$3,765	$0
60	26988	370159	19901012	4536 PERTH CT	CHARLOTTE	NC	282153340	$2,967	$0
61	26988	370159	19910111	4536 PERTH CT	CHARLOTTE	NC	282153340	$1,590	$0
62	27024	370159	19800215	816 NORWOOD DR	CHARLOTTE	NC	282083426	$1,826	$0
63	27024	370159	19820610	816 NORWOOD DR	CHARLOTTE	NC	282083426	$2,807	$0
64	36823	370159	19790415	1308 BRAEBURN RD	CHARLOTTE	NC	282114771	$1,708	$0
65	36823	370159	19790905	1308 BRAEBURN RD	CHARLOTTE	NC	282114771	$5,004	$0
66	44825	370159	19820610	500 OLD BELL RD	MATTHEWS	NC	28105	$1,002	$1,663
67	44825	370159	19901022	500 OLD BELL RD	MATTHEWS	NC	28105	$1,208	$2,212
68	48372	370159	19950827	4039 ABINGDON RD	CHARLOTTE	NC	282113822	$18,058	$6,841
69	48372	370159	19820610	4039 ABINGDON RD	CHARLOTTE	NC	282113822	$7,497	$1,978
70	48372	370159	19890922	4039 ABINGDON RD	CHARLOTTE	NC	282113822	$3,713	$0
71	50775	370159	19810906	1242 ROMANY RD	CHARLOTTE	NC		$1,265	$0
72	50775	370159	19820610	1242 ROMANY RD	CHARLOTTE	NC		$3,347	$0
73	52592	370159	19891001	3801 COUNTRY CLUB DR	CHARLOTTE	NC	282053213	$6,618	$220
74	52592	370159	19901011	3801 COUNTRY CLUB DR	CHARLOTTE	NC	282053213	$2,427	$310
75	52592	370159	19940801	3801 COUNTRY CLUB DR	CHARLOTTE	NC	282053213	$23,770	$4,738
76	52592	370159	19950826	3801 COUNTRY CLUB DR	CHARLOTTE	NC	282053213	$11,187	$4,702
77	53919	370158	19850607	608 KENLOUGH DR	CHARLOTTE	NC	282092853	$1,013	$0
78	53919	370158	19870618	608 KENLOUGH DR	CHARLOTTE	NC	282092853	$652	$680
79	53919	370158	19940719	608 KENLOUGH DR	CHARLOTTE	NC	282092853	$4,130	$2,493
80	56878	370159	19870910	217 WELLINGFORD ST	CHARLOTTE	NC	282136635	$3,744	$0

Table A-3 (Continue)

Watershed Study No. 1
Lower Little Sugar Creek Watershed
Repetitive Loss Database

Count	RL Number	Community Number	Date of Loss	Address	City	State	ZIP Code	Pay Building	Pay Cont
81	56878	370159	19820610	217 WELLINGFORD ST	CHARLOTTE	NC	282136635	$7,346	$0
82	56878	370159	19901012	217 WELLINGFORD ST	CHARLOTTE	NC	282136635	$3,500	$0
83	56878	370159	19910329	217 WELLINGFORD ST	CHARLOTTE	NC	282136635	$3,154	$0
84	56878	370159	19950828	217 WELLINGFORD ST	CHARLOTTE	NC	282136635	$10,532	$0
85	64458	370159	19820714	227 CHILLINGWORTH LN	CHARLOTTE	NC	282113007	$1,849	$0
86	64458	370159	19920616	227 CHILLINGWORTH LN	CHARLOTTE	NC	282113007	$13,132	$1,175
87	64458	370159	19950827	227 CHILLINGWORTH LN	CHARLOTTE	NC	282113007	$4,865	$0
88	64459	370159	19890922	2422 CLOISTER DR	CHARLOTTE	NC	282113914	$2,587	$250
89	64459	370159	19820610	2422 CLOISTER DR	CHARLOTTE	NC	282113914	$3,550	$2,900
90	64460	370159	19901010	5129 DOLPHIN LN	CHARLOTTE	NC	282153101	$7,729	$600
91	64460	370159	19930324	5129 DOLPHIN LN	CHARLOTTE	NC	282153101	$2,014	$0
92	64461	370159	19820610	400 ALLENDALE PL	CHARLOTTE	NC	282114103	$4,848	$2,726
93	64461	370159	19920615	400 ALLENDALE PL	CHARLOTTE	NC	282114103	$4,777	$0
94	64461	370159	19940818	400 ALLENDALE PL	CHARLOTTE	NC	282114103	$2,796	$0
95	70400	370159	19930313	2009 MILTON RD	CHARLOTTE	NC	282152467	$1,755	$0
96	70400	370159	19940729	2009 MILTON RD	CHARLOTTE	NC	282152467	$2,130	$0
97	70400	370159	19950827	2009 MILTON RD	CHARLOTTE	NC	282152467	$2,270	$0
98	70401	370159	19930313	4539 PERTH CT	CHARLOTTE	NC	282153322	$1,335	$0
99	70401	370159	19940729	4539 PERTH CT	CHARLOTTE	NC	282153322	$1,726	$0
100	70402	370159	19930313	4520 PERTH CT	CHARLOTTE	NC	282153337	$1,130	$0
101	70402	370159	19940729	4520 PERTH CT	CHARLOTTE	NC	282153337	$1,928	$0
102	70402	370159	19950827	4520 PERTH CT	CHARLOTTE	NC	282153337	$2,290	$0
103	73978	370159	19890922	5130 DOLPHIN LN	CHARLOTTE	NC	282153102	$3,355	$0
104	73978	370159	19950828	5130 DOLPHIN LN	CHARLOTTE	NC	282153102	$41,518	$0
105	74906	370159	19890922	5331 DOLPHIN LN	CHARLOTTE	NC	282152205	$1,242	$0
106	74906	370159	19950827	5331 DOLPHIN LN	CHARLOTTE	NC	282152205	$3,337	$0
107	77727	370159	19930323	1100 WILHAVEN DR	CHARLOTTE	NC	282114062	$1,128	$0
108	77727	370159	19950826	1100 WILHAVEN DR	CHARLOTTE	NC	282114062	$7,992	$0
109	80103	370159	19901212	5515 RUTH DR	CHARLOTTE	NC	282152227	$3,394	$0
110	80103	370159	19950827	5515 RUTH DR	CHARLOTTE	NC	282152227	$4,564	$0
111	87688	370159	19891001	3032 HANSON DR	CHARLOTTE	NC	282072620	$1,105	$0
112	87688	370159	19950827	3032 HANSON DR	CHARLOTTE	NC	282072620	$44,189	$0
113	87689	370159	19920615	2500 CLOISTER DR	CHARLOTTE	NC	282113916	$4,582	$0
114	87689	370159	19950827	2500 CLOISTER DR	CHARLOTTE	NC	282113916	$2,624	$0

Figure A-1 Study No. 1, (Lower) Little Sugar Watershed Existing Conditions, Sheet 1

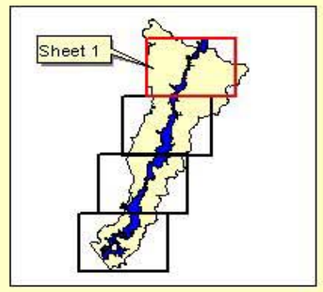


Field Photos
2218 Street Address
Cross Sections
Stream
Streets
0.5' FIRM Floodway
1% Annual Chance of FCF
Structure Footprints
Parcels with Structures within FCF
(FIRM - Flood Insurance Rate Map)
(FCF - Future Condition Floodplain)

Flood Status of Structures
- Finished Floor Above BFE within FCF
- Flood Depth 0 - 4 ft
- Flood Depth 4 ft or greater

Pre/Post - FIRM Structure Status*
- Pre-FIRM
- Post-FIRM

*FIRM Maps were established in 1973

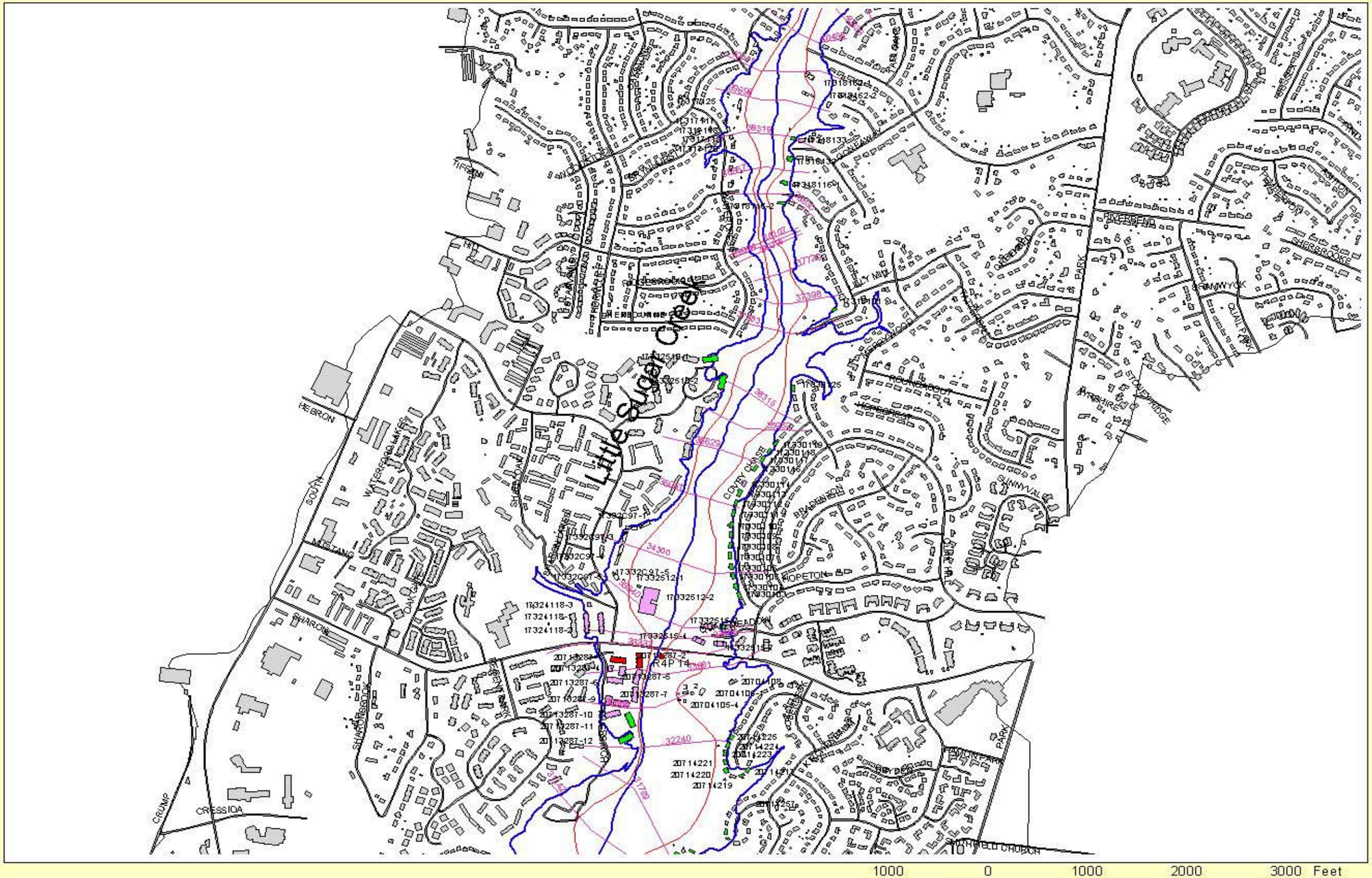


N W E S

Charlotte-Mecklenburg STORM WATER Services

HDR Engineering, Inc. of the Carolinas

Figure A-1 Study No.1, (Lower) Little Sugar Watershed Existing Conditions, Sheet 2

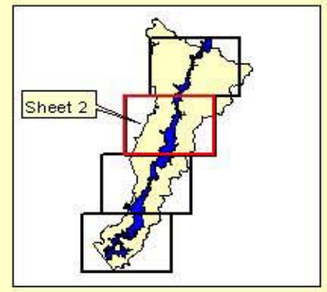


- Field Photos
- 3213 Street Address
- Cross Sections
- Stream
- Streets
- 0.5' FIRM Floodway
- 1% Annual Chance of FCF
- Structure Footprints
- Parcels with Structures within FCF
  (FIRM - Flood Insurance Rate Map)
  (FCF - Future Condition Floodplain)

Flood Status of Structures
- Finished Floor Above BFE within FCF
- Flood Depth 0 - 4 ft
- Flood Depth 4 ft or greater

Pre/Post - FIRM Structure Status*
- Pre-FIRM
- Post-FIRM

*FIRM Maps were established in 1973

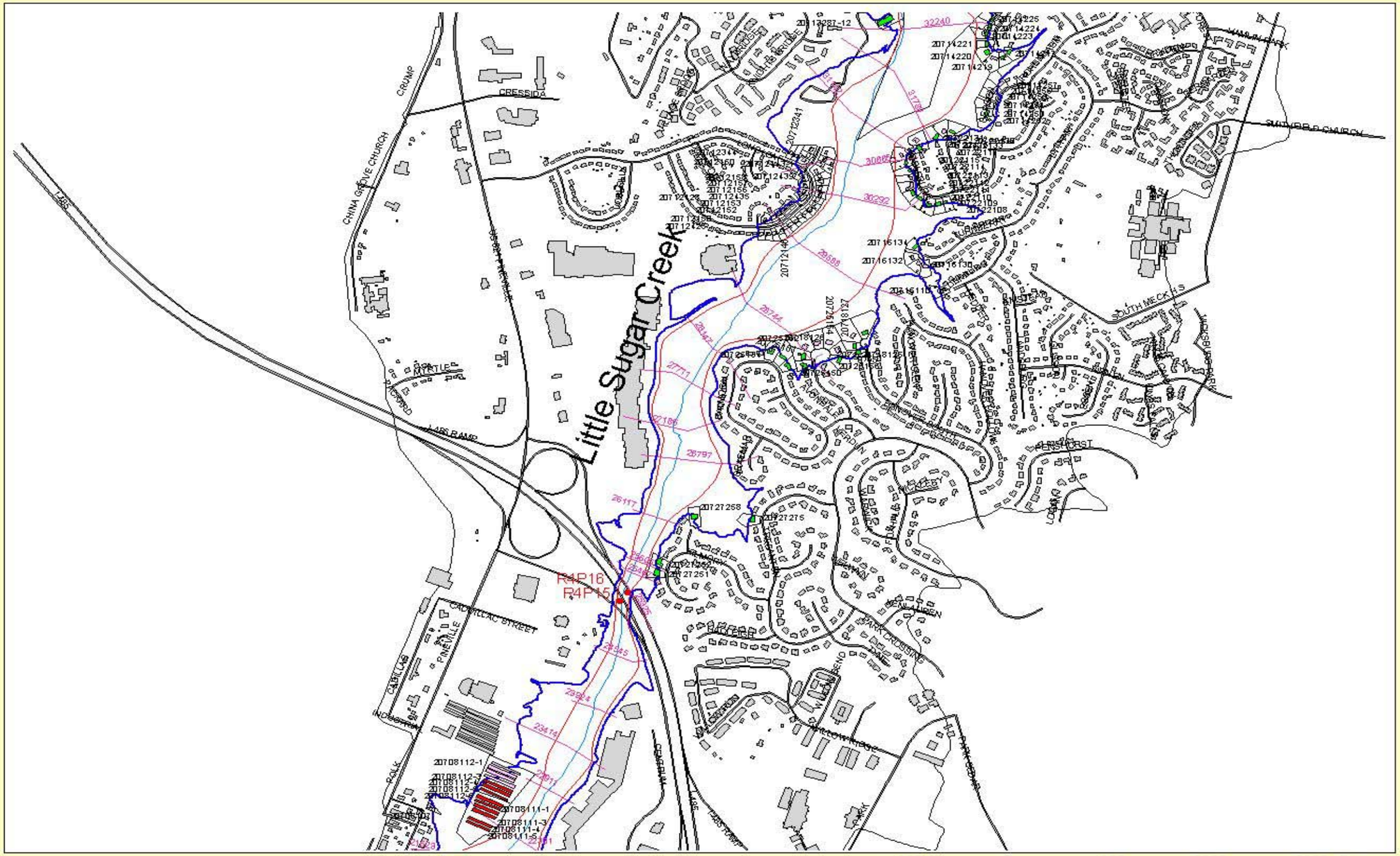


N W E S

Charlotte-Mecklenburg STORM WATER Services

HDR Engineering, Inc. of the Carolinas

Figure A-1 Study No. 1, (Lower) Little Sugar Watershed Existing Conditions, Sheet 3

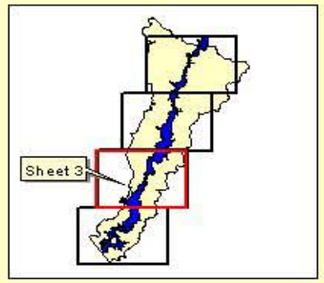


- Field Photos
- 3218 Street Address
- Cross Sections
- Stream
- Streets
- 0.5' FIRM Floodway
- 1% Annual Chance of FCF
- Structure Footprints
- Parcels with Structures within FCF
  (FIRM - Flood Insurance Rate Map)
  (FCF - Future Condition Floodplain)

Flood Status of Structures
- Finished Floor Above BFE within FCF
- Flood Depth 0 - 4 ft
- Flood Depth 4 ft or greater

Pre/Post - FIRM Structure Status*
- Pre-FIRM
- Post-FIRM

*FIRM Maps were established in 1973

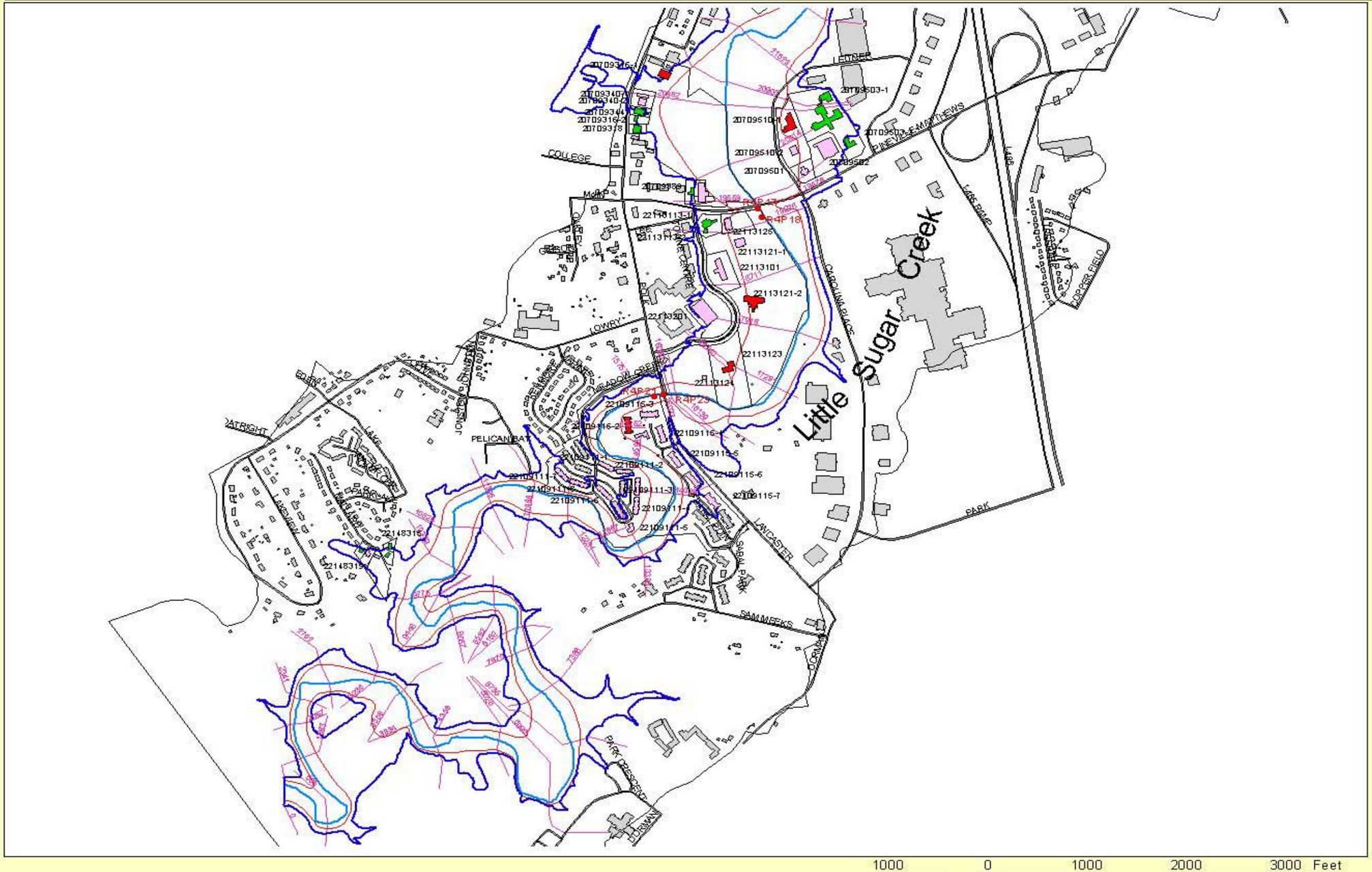


N W E S

Charlotte-Mecklenburg STORM WATER Services

HDR Engineering, Inc. of the Carolinas

Figure A-1 Study No. 1, (Lower) Little Sugar Watershed Existing Conditions, Sheet 4

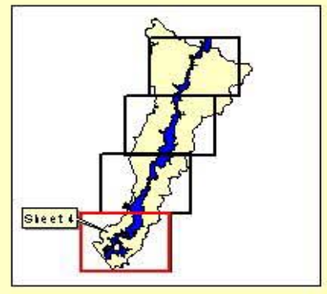


- Field Photos
- 8218 Street Address
- Cross Sections
- Stream
- Streets
- 0.5' FIRM Floodway
- 1% Annual Chance of FCF
- Structure Footprints
- Parcels with Structures within FCF
  (FIRM - Flood Insurance Rate Map)
  (FCF - Future Condition Floodplain)

Flood Status of Structures
- Finished Floor Above BFE within FCF
- Flood Depth 0 - 4 ft
- Flood Depth 4 ft or greater

Pre/Post - FIRM Structure Status*
- Pre-FIRM
- Post-FIRM

*FIRM Maps were established in 1973



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Charlotte-Mecklenburg STORM WATER Services

HDR Engineering, Inc. of the Carolinas

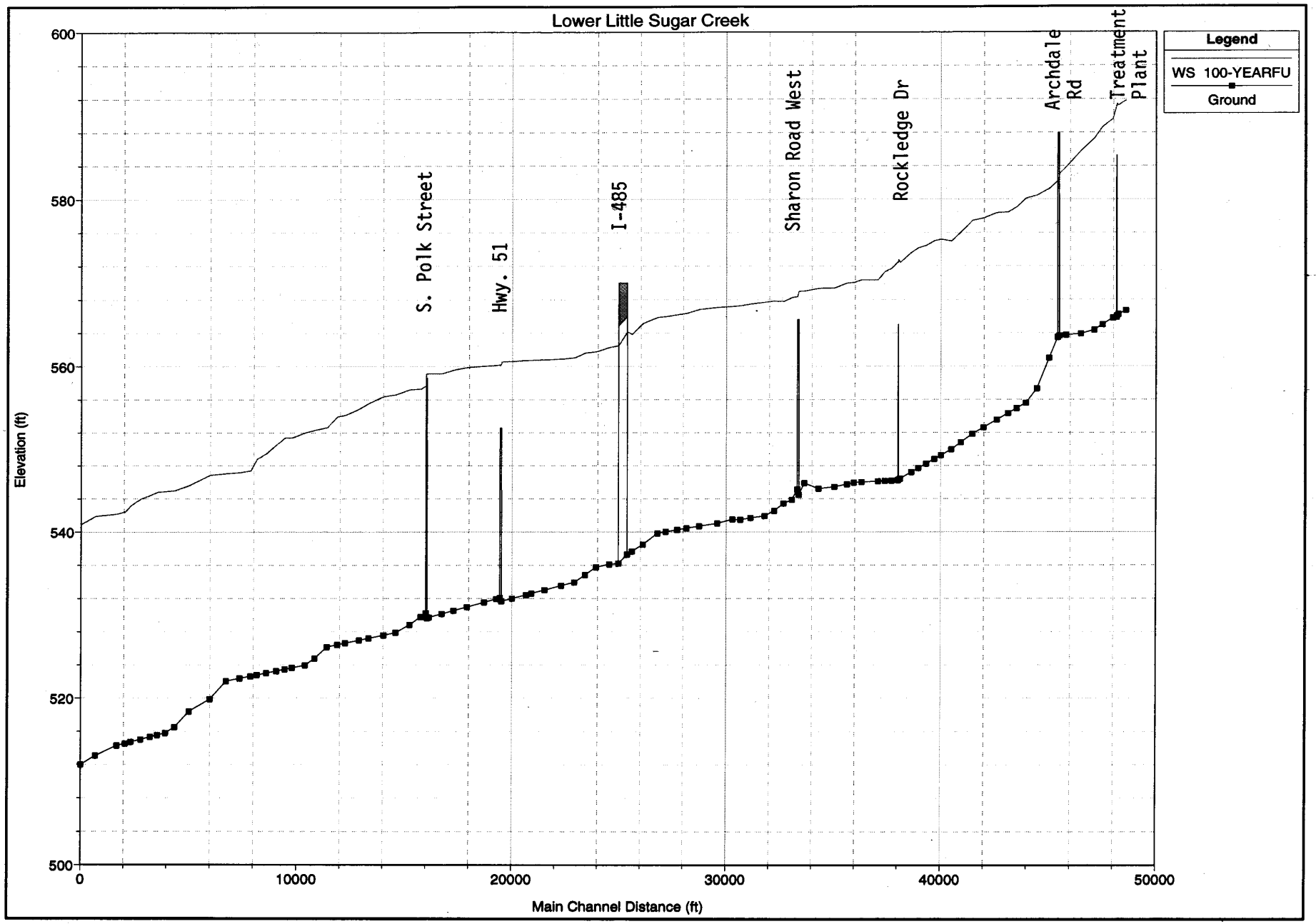
Lower Little Sugar Creek
Legend
WS 100-YEARFU
Ground
S. Polk Street
Hwy. 51
I-485
Sharon Road West
Rockledge Dr
Archdale Rd
Treatment Plant
Elevation (ft)
600
580
560
540
520
500
0
10000
20000
30000
40000
50000
Main Channel Distance (ft)

FIGURE A-2

APPENDIX B

Lower Little Sugar Creek View U/S Roll #4 Photo #4
LOOKING UPSTREAM OF SUGAR CREEK WASTEWATER TREATMENT PLANT (WWTP). SLOPING, VEGETATED BANKS.

Lower Little Sugar Creek View U/S Roll #4 Photo #5
UPSTREAM FACE OF BRIDGE CROSSING TO WWTP. SAND DEPOSITION AND DEBRIS ACCUMULATION. SCOUR PRESENT ON CENTER PIER.

Lower Little Sugar Creek View U/S Roll #4 Photo #10
SHALLOW, WIDE CHANNEL UPSTREAM OF ARCHDALE ROAD BRIDGE CROSSING.

Lower Little Sugar Creek View D/S Roll #4 Photo #12
ROCKY BOTTOM MATERIAL AT ARCHDALE ROAD BRIDGE CROSSING. VEGETATED BANKS.

Lower Little Sugar Creek View U/S Roll #4 Photo #13
SANITARY SEWER CROSSING UPSTREAM OF SHARON ROAD WEST. SHALLOW, WIDE, REALIGNED CHANNEL.

Lower Little Sugar Creek View D/S Roll #4 Photo #14
SHALLOW FLOW DOWNSTREAM OF SHARON ROAD WEST BRIDGE CROSSING.

Lower Little Sugar Creek View D/S Roll #4 Photo #15
WELL VEGETATED OVERBANKS DOWNSTREAM OF I-485 BRIDGE CROSSING.

Lower Little Sugar Creek View (under bridge) Roll #4 Photo #16
I-485 THREE BRIDGE CROSSING (WEST BOUND, EAST BOUND, AND EAST BOUND RAMP).

Lower Little Sugar Creek View D/S Roll #4 Photo #17
GRASSY VEGETATED BANKS DOWNSTREAM OF HWY 51 (PINEVILLE-MATTHEWS ROAD) BRIDGE CROSSING.

Lower Little Sugar Creek View D/S Roll #4 Photo #18
DOWNSTREAM FACE OF BRIDGE CROSSING HIGHWAY 51 (PINEVILLE-MATTHEWS ROAD).

Lower Little Sugar Creek View U/S Roll #4 Photo #20
VIEW OF DEVELOPMENT UPSTREAM OF HIGHWAY 51 (PINEVILLE-MATTHEWS ROAD).

Lower Little Sugar Creek View D/S Roll #4 Photo #21
RIFFLES DOWNSTREAM OF POLK ROAD BRIDGE CROSSING. LOWER LEFT BANK EROSION. TOE IS UNPROTECTED.

Lower Little Sugar Creek View D/S Roll #4 Photo #23
DOWNSTREAM FACE OF POLK ROAD BRIDGE CROSSING.