

# **BOLIN CREEK WATERSHED**

## **Geomorphic Analysis and Potential Site Identification for Stormwater Structures and Retrofits**



**TOWN OF CARRBORO**  
NORTH CAROLINA

Prepared By:



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## **Project Summary Bolin Creek Geomorphic Analysis**

### **Introduction**

Earth Tech provided services to the Town of Carrboro during the spring and summer of 2007 to evaluate the stability of the entire Bolin Creek Watershed. This project was performed as the first step of the Towns of Carrboro and Chapel Hill as partners in the Bolin Creek Watershed Restoration Team (BCWRT) to rehabilitate the watershed and to one day have its biological integrity improved to the extent that Bolin Creek can be removed from the Federal (303d) list of impaired streams. The ultimate goal of this project is for the findings of this study to aid in the decision making process to evaluate, prioritize and fund the individual projects which are presented herein. The funds for the project were provided by Clean Water Management Trust Fund (CWMTF) stormwater mini- grant #S-003, with matching funds provided by the Towns of Carrboro and Chapel Hill.

Previous studies in the Bolin Creek watershed have included a Watershed Restoration Plan (WRP) and a Local Watershed Plan (LWP). This project continues the process initiated by these efforts and provides supplemental information focusing on geomorphology of the streams within the watershed, and solutions addressing specific areas of stream instability.

### **Methods**

The field work consisted of professionals from Earth Tech and the BCWRT performing a qualitative survey of all perennial and intermittent streams within the watershed. Ephemeral systems were surveyed when a specific geomorphic instability indicated that further investigation of the ephemeral system was necessary to fully understand the cause and magnitude of the problem. The survey was conducted between May 7<sup>th</sup>, 2007 and June 21<sup>st</sup>, 2007. Weather during the survey was generally dry and sunny, and no streams were observed during or immediately following a storm event. GIS data was used to create a field map atlas of 35 pages, and the streams on each page were systematically walked by the survey crews. Walks using these field maps were completed from the upper watershed to the lower watershed, so that the walk ended at the confluence of Bolin Creek with Booker Creek. Each field crew carried a sub-foot accuracy global positioning system (GPS) unit, a digital camera, field assessment forms, a set of field maps showing 2-foot topography, roads and streams, and a set of maps with high resolution aerial photography.

When specific areas of instability were identified, they were semi-quantitatively surveyed in order to fill out a field assessment form. The parameters which are recorded by the form are used to understand the channel dimension, cause of the problem, and stability of

*Bolin Creek Watershed*  
*Geomorphic Analysis and Potential Site Identification for Stormwater BMP and Retrofits*

the reach at each location. In addition, at each location a sub-foot GPS coordinate was recorded, a photograph was taken, and notes were recorded in a field book and on field maps for later reference. The “Raw Data” for each of these locations was compiled together and provided to the BCWRT for their use in future evaluations of the watershed’s condition. In the project site summaries contained in this report, each title page contains a “Raw Data Name” reference to a specific GPS point, and a reference to an Index Sheet, which were the 35 field maps used during the field evaluation. The index sheets and raw data maps showing the GPS points and notes for each observed stream reach, are contained in **Appendix D**.

After completion of the stream surveys, the sites was prioritized and approximately 50 sites were selected for consideration by Earth Tech and BCWRT as potential sites to be used as one of the final 30 project sites. To prioritize the sites, Earth Tech considered the input BCWRT members, along with professional judgment to give each site a qualitative score of 1 to 10. Because, at this point, pollutant loads and sediment export rates had not been calculated for any site, it was important to focus on the qualitative observations of geomorphic instability collected in the raw data. The most influential considerations in the ranking were the severity of the problem and the urgency of needing the problem fixed, as shown from the raw data, followed by ease of construction and opportunity for public involvement and education. Following the prioritization, 32 sites were selected for consideration by the Town of Carrboro and the Town of Chapel Hill as best management practice (BMP) installation or retrofit projects.

Each of these final sites were analyzed for feasibility, cost benefit, net reduction in loading of nutrients and suspended solids, anticipated reductions in runoff quantity and potential baseflow augmentation to the receiving channel. A second set of field visits were made to each of the 32 potential BMP sites, at which time additional notes, photographs and GPS data was collected. In particular, notes were made on constraints such as potential size restrictions, presence of existing utilities, and potential alternative treatments. A brief GIS analysis of each site was then undertaken, consisting of delineation of the site watersheds, analysis of land use in each watershed, and calculation of percent imperviousness. Areas of land use type were calculated using 1996 land cover data for Orange County available from the North Carolina Center for Geographic Information and Analysis. Because this data was out of date for several of the sites, the land use data was updated when necessary using 2005 aerial photography provided by the Towns of Carrboro and Chapel Hill. Percent imperviousness was calculated using GIS polygons representing roads, driveways, parking lots and other impervious features, which were provided by Carrboro and Chapel Hill. The inputs of drainage area, percent imperviousness, and land use type were used to estimate pollutant load rates for each watershed using the Simple Method (Schueler et. al., 2007). An annual rainfall depth of 46.2 inches was assumed for the calculation, based on Orange County rainfall data available from the National Oceanographic and Atmospheric Association.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMP and Retrofits*

For sites where sediment reduction through stabilization of streambanks was the primary focus, a modified BANCS model was used to estimate annual stream bank erosion rates (Rosgen, 2006). The BANCS model uses the combined inputs of Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) with a graph showing a relation between the two variables and stream bank erosion rates for a particular area. An estimate of BEHI was measured for each bank at each stream stabilization site for the length of the bank and then combined with a rough estimate of NBS to estimate stream bank erosion rates in tons per year using a North Carolina graph.

The results of this analysis, along with site descriptions and photos are found in the project specific reports that follow.

Construction costs were estimated using a combination of standard quantities and prices following North Carolina Department of Transportation (NCDOT) specifications, recent cost estimates for other projects calculated by professionals at Earth Tech, and equations that predict the cost of BMP construction as a function of potential storage volume (Schueler, et. al. 2007). Earth Tech first began by developing line item cost estimates using standard quantities of materials for given areas and measurements. CADD software was relied upon to measure acreages and distances in order to calculate needed quantities of materials. These construction costs were then compared with equations that have been developed by several researchers to predict the cost of new and retrofit construction of different types of BMPs. In many cases, particularly with stormwater wetlands, the line item cost estimates were very similar to what research has shown as the actual cost of construction for a BMP. Where there was a discrepancy between the two, however, the equation-predicted figure was used. In addition, the contingency cost for each project was adjusted depending on site conditions. Sites that are harder to access or near utility right of ways were given a higher contingency cost.

Research has shown that maintenance costs for stormwater wetlands and wet detention ponds typically range from 3-5% of the base construction cost per year (Center for Watershed Protection, 2007). To err on the side of caution, the higher figure of 5% was used to estimate annual BMP maintenance costs for all the proposed BMP sites.

### **Data Summary**

During the stream survey, a total of 115 GPS points were collected that specifically relate to an area of geomorphic instability, and are represented on a field form (See **Appendix C**). Other GPS points were taken that highlight notable features of concern or interest within the watershed, or that simply represent continuations of problem areas, but are not noted on a field form. **Table 1** provides a summary of the raw data recorded on the field form for each location, and shows the number of GPS points collected on Bolin Creek or its tributaries, the types of stream conditions present at each point and the observed type of problem at the point. Multiple indications of stream condition and multiple types of problems were observed at many of the points. Stream condition observations have been

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMP and Retrofits*

grouped into general stream observations (changes in stream dimension and stream profile), and observations of specific symptoms indicating stream change such as bed and bank scour, and bank failure.

**Table 1.** Summary of raw data collected during the stream survey

<b>I. Location Within Watershed</b>	
	<b># of GPS Points</b>
Bolin Creek	14
Tributaries	101
<b>II. Stream Condition Observations</b>	
	<b># of GPS Points</b>
<b>Observations of Stream Dimension Change</b>	
Aggrading	12
Downcutting	56
Widening	40
Total	108
<b>Observations of Stream Profile Change</b>	
Slope Failure	4
Headcutting	13
Total	17
<b>Observations of Specific Symptoms of Instability</b>	
Bed Scour	15
Bank Failure	35
Bank Scour	49
Sediment Deposition	6
Channelized	6
Total	111
<b>III. Type of Problem</b>	
	<b># of GPS Points</b>
Pond Outfalls	25
Stream Crossings	29
Impacted Buffer	13
Utility impacts	23
Channel Modification	17
Confluence	4
Beaver Activity	1
Other	33

### **BMP Site Summary**

A total of 32 potential BMP sites were identified during the course of this study. After evaluation of each site and its contributing watershed for pollutant loads, impervious surface and sediment contribution, and after completion of a conceptual-level cost estimate, the sites were prioritized according to a ranking system that is modeled on a similar system recommended by Schueler, et. al (2007). Four criteria were chosen to rank each site: “Cost per pollutant removed”, “Project Visibility”, “Construction Access”, and “Critical Nature of Project”.

The “Cost per pollutant removed” criterion was chosen out of a desire to compare the relative cost/benefit of each site, as the overarching goal of the Bolin Creek Watershed Restoration efforts is to reduce pollutants in the watershed, and thereby remove Bolin Creek from the 303(d) list. However, because of a lack of available information showing what specific pollutant is the primary cause of biological impairment in Bolin Creek, this criterion has been split into two separate criteria; cost per ton of sediment reduced, and cost per pound of nutrients reduced. Therefore, two separate prioritization tables have been produced: one for sites where the primary target is removal of nutrients and another for those sites where the primary target is sediment reduction through streambank stabilization. To compare the two different types of projects directly against one another was considered impractical without knowing the relative effects of the differing pollutants on the biological integrity of Bolin Creek.

The “project visibility” and “construction access” criteria were chosen because they were considered to be easy to judge based on site visits and available aerial photography and topographic GIS data. The final criterion of “Critical Nature of Project”, was chosen to account for the potential for future exacerbation of the observed problem at each site, if action is not immediately taken. While this criterion reflects more qualitative engineering judgment than quantitative analysis, it was felt that it was important to give a higher ranking to sites where problems are expected to increase steadily or even exponentially in the future. The justification for each site rank in this criterion is listed below in **Table 4**.

The BMP Ranking criteria and the points allocated to each criteria are represented in **Table 2**.

**Table 3** presents a summary of each BMP site, with scoring of each criterion and total scores for each site.

**Table 5** shows the prioritization of the sediment reduction projects, while **Table 6** presents the prioritization of the nutrient reduction projects.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMP and Retrofits*

**Table 2. BMP Ranking Criteria and Point Allocation**

<b>BMP Ranking Criteria (20 Total Points Possible)</b>		<b>Possible Points</b>
<b>1</b>	<b>Cost/Ton of Sediment Reduced</b>	<b>5</b>
	Less than \$50	[5]
	Between \$50 and \$200	[4]
	Between \$200 and \$300	[3]
	Between \$300 and \$500	[2]
Greater than \$500	[1]	
<b>2</b>	<b>Cost/ lb of Nutrients Removed</b>	<b>5</b>
	Less than \$9,500	[5]
	Between \$9,500 and \$23,000	[4]
	Between \$23,000 and \$50,000	[3]
	Between \$50,000 and \$80,000	[2]
Greater than \$80,000	[1]	
<b>3</b>	<b>Project Visibility</b>	<b>5</b>
	Poor (site cannot be seen from street)	[1]
	Good (site adjacent to a street)	[3]
	Excellent (site adjacent to a highly traveled street or public property)	[5]
<b>4</b>	<b>Construction Access</b>	<b>5</b>
	Poor	[1]
	Good	[3]
	Excellent	[5]
<b>5</b>	<b>Critical Nature of Project</b>	<b>5</b>
	Critical (exponential increase of problem is expected if project is delayed; i.e. headcut causes channel incision which causes decades of channel instability and is order of magnitudes higher if you wait to repair)	[5]
	Very High (problem will increase in future at a steady rate)	[4]
	High (problem will increase, but range of future impact is limited)	[3]
	Medium (problem is severe but not expected to increase significantly)	[2]
	Low (problem is present, but stable, no expected increase)	[1]

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMP and Retrofits*

**Table 3.** Summary of Final BMP Sites and Scoring

Final Site Name	Type of Project	Cost of Construction	Location	Cost/ton of sediment		Cost/ lb nutrients Removed		Project Visibility		Construction Access		Critical Nature of Project*		Total Score Nutrient Projects	Total Score Sediment Projects
					(pts)		(pts)		(pts)		(pts)		(pts)		
1	Dam Retrofit	\$30,964	Outside	\$21.46	5			Poor	1	Excellent	5	High	3		14
2	BMP- Retrofit	\$43,879	Carrboro			\$8,200.78	5	Excellent	5	Excellent	5	Low	1	16	
3	Stream Bank Stabilization	\$31,734	Outside	\$197.53	4			Poor	1	Good	3	Critical	5		13
4	BMP- Retrofit	\$73,509	Carrboro			\$98,769.50	1	Poor	1	Poor	1	Medium	2	5	
5	BMP- Retrofit	\$22,660	Carrboro			\$10,031.09	4	Good	3	Excellent	5	High	3	15	
6	BMP- Retrofit	\$34,578	Carrboro			\$15,307.01	4	Good	3	Excellent	5	High	3	15	
7	BMP- Retrofit	\$100,619	Carrboro			\$44,542.49	3	Good	3	Excellent	5	Very High	4	15	
8	BMP- Retrofit	\$19,017	Carrboro			\$3,504.29	5	Good	3	Excellent	5	Medium	2	15	
9	Stream Bank Stabilization	\$18,215	Carrboro	\$191.92	4			Good	3	Good	3	Medium	2		12
10	BMP-New Construction	\$48,336	Carrboro			\$9,121.72	5	Poor	1	Good	3	Medium	2	11	
11	BMP- New Construction	\$30,323	Chapel Hill			\$28,285.41	3	Excellent	5	Excellent	5	Medium	2	15	
12	BMP- New Construction	\$69,358	Chapel Hill			\$22,467.50	4	Poor	1	Good	3	Medium	2	10	
13	BMP- New Construction	\$25,688	Chapel Hill			\$2,353.10	5	Poor	1	Poor	1	Medium	2	9	
14	BMP- New Construction	\$25,688	Chapel Hill			\$6,416.48	5	Good	3	Excellent	5	Medium	2	15	
15	BMP- Retrofit	\$27,266	Chapel Hill			\$23,281.67	4	Poor	1	Good	3	Very High	4	12	
16	Stream Bank Stabilization	\$56,479	Carrboro	\$282.81	3			Excellent	5	Poor	1	Medium	2		11
17	Stream Bank Stabilization	\$66,649	Carrboro	\$1,098.79	1			Poor	1	Poor	1	Very High	3		6
18	BMP- New Construction	\$17,416	Chapel Hill			\$14,828.54	4	Good	3	Good	3	Very High	4	14	
19	Stream Bank Stabilization	\$8,884	Carrboro	\$319.81	2			Excellent	5	Excellent	5	Medium	2		14
20	Stream Bank Stabilization	\$49,479	Chapel Hill	\$26.04	5			Excellent	5	Good	3	Very High	4		17
21	Stream Bank Stabilization	\$52,104	Chapel Hill	\$74.33	4			Good	3	Poor	1	Critical	5		13
22	Stream Bank Stabilization	\$72,526	Chapel Hill	\$38.42	5			Excellent	5	Excellent	5	Very High	4		19
23	BMP- Retrofit	\$32,030	Chapel Hill			\$65,099.01	2	Poor	1	Poor	1	Low	1	5	
24	BMP- New Construction	\$107,541	Chapel Hill	\$285.11	3	\$49,502.23	3	Good	3	Poor	1	Critical	5	12	
25	BMP- New Construction	\$84,571	Chapel Hill			\$52,133.47	2	Poor	1	Poor	1	Low	1	5	
26	BMP- New Construction	\$69,375	Chapel Hill			\$83,059.38	1	Poor	1	Poor	1	Low	1	4	
27	BMP- New Construction	\$38,554	Chapel Hill			\$213,283.40	1	Poor	1	Poor	1	Low	1	4	
28	BMP- New Construction	\$36,660	Chapel Hill			\$22,209.33	4	Poor	1	Poor	1	Low	1	7	
29	BMP- New Construction	\$81,218	Chapel Hill	\$144.51	4	\$40,728.87	3	Poor	1	Poor	1	Very High	4	9	
30	BMP- Retrofit	\$28,501	Chapel Hill			\$3,625.74	5	Poor	1	Poor	1	High	3	10	
31	BMP- New Construction	\$20,130	Chapel Hill	\$38.91	5	\$15,809.47	4	Poor	1	Good	3	High	3	11	
32	Stream Restoration	\$207,000	Chapel Hill	\$3,522.80	1			Excellent	3	Poor	1	Low	1		6

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**Table 4. Justification of Critical Nature criterion for each site.**

Justification of Critical Nature rankings for each site	Reasoning
1	The incised dam outfall is probably widening and the sediment problem will increase, but the extent of future impact upstream and downstream will be limited
2	The problem at this site is not worsening.
3	The headcut at this site will continue to work upstream, and incise a greater length of stream if not addressed.
4	Nothing imminent or critical at this site.
5	There is potential damage to adjacent streams from the current configuration of the BMP outlet.
6	There is potential damage to adjacent streams from the current configuration of the BMP outlet.
7	There is potential damage to adjacent streams from the current configuration of the BMP outlet.
8	is presently stable, but there is some danger of damage to channel due to concentrated flows.
9	The extent of bank erosion is relatively small.
10	Due to headcut downstream of the site.
11	High nutrient contributions and potential for channel damage due to concentrated flows.
12	Some modest instability from discharges.
13	Some modest instability from discharges.
14	Some modest instability from discharges.
15	Active headcuts are present at this site.
16	The annual contribution is not expected to increase.
17	Bank wasting is likely increasing here.
18	The conditions at this site will likely get worse.
19	Sediment contribution is expected to be constant here.
20	Relatively high wasting banks, stream will continue to widen.
21	Stability of this hillside needs to happen.
22	Stability of this hillside needs to happen.
23	No expected increase in problem here.
24	Active increase in 3' headcut at this site.
25	No expected increase in problem here.
26	No expected increase in problem here.
27	No expected increase in problem here.
28	No expected increase in problem here.
29	At least three active headcuts on this channel will create an incised gully over time, with expected increase in sediment contribution.
30	Hillside erosion is occurring here and will worsen, but extent of impact will likely be limited upstream and downstream.
31	Ditch in floodplain will continue to erode, but impact upstream and downstream will be limited.
32	Stream is channelized, but stable; no expected increase in sediment contributions.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 5.** Prioritization of Sites Specifically Targeted at Nutrient Reduction

<b>Final Site Name</b>	<b>Type of Project</b>	<b>Cost of Construction</b>	<b>Location</b>	<b>Total Score Nutrient Projects</b>
2	BMP- Retrofit	\$43,879	Carrboro	16
5	BMP- Retrofit	\$22,660	Carrboro	15
6	BMP- Retrofit	\$34,578	Carrboro	15
7	BMP- Retrofit	\$100,619	Carrboro	15
8	BMP- Retrofit	\$19,017	Carrboro	15
11	BMP- New Construction	\$30,323	Chapel Hill	15
14	BMP- New Construction	\$25,688	Chapel Hill	15
18	BMP- New Construction	\$17,416	Chapel Hill	14
15	BMP- Retrofit	\$27,266	Chapel Hill	12
24	BMP- New Construction	\$107,541	Chapel Hill	12
10	BMP- New Construction	\$48,336	Carrboro	11
31	BMP- New Construction	\$20,130	Chapel Hill	11
12	BMP- New Construction	\$69,358	Chapel Hill	10
30	BMP- Retrofit	\$28,501	Chapel Hill	10
13	BMP- New Construction	\$25,688	Chapel Hill	9
29	BMP- New Construction	\$81,218	Chapel Hill	9
28	BMP- New Construction	\$36,660	Chapel Hill	7
4	BMP- Retrofit	\$73,509	Carrboro	5
23	BMP- Retrofit	\$32,030	Chapel Hill	5
25	BMP- New Construction	\$84,571	Chapel Hill	5
26	BMP- New Construction	\$69,375	Chapel Hill	4
27	BMP- New Construction	\$38,554	Chapel Hill	4

**Table 6.** Prioritization of Sites Specifically Targeted at Sediment Reduction

<b>Final Site Name</b>	<b>Type of Project</b>	<b>Cost of Construction</b>	<b>Location</b>	<b>Total Score Sediment Projects</b>
22	Stream Bank Stabilization	\$72,526	Chapel Hill	19
20	Stream Bank Stabilization	\$49,479	Chapel Hill	17
1	Dam Retrofit	\$30,964	Outside	14
19	Stream Bank Stabilization	\$8,884	Carrboro	14
3	Stream Bank Stabilization	\$31,734	Outside	13
21	Stream Bank Stabilization	\$52,104	Chapel Hill	13
9	Stream Bank Stabilization	\$18,215	Carrboro	12
16	Stream Bank Stabilization	\$56,479	Carrboro	11
17	Stream Bank Stabilization	\$66,649	Carrboro	6
32	Stream Restoration	\$207,000	Chapel Hill	6

### **Discussion of Specific Sources of Instability**

The specific project sites address many of the water quality issues that Bolin Creek faces, however it is important to note that the projects in this report represent the types of projects that could be implemented throughout the watershed. A summary of key sources of instability and other observations made during the field investigation for the Bolin Creek Watershed follows:

1. **Stream Channelization** – Stream channelization is one of the most significant impacts that has occurred to the reaches in the Bolin Creek Watershed. Channelization was, at one time, a common means of dealing with a stream that was in the way, or that flooded neighboring properties. By deliberately lowering the stream elevation, overtopping of the banks would often be eliminated. The intentional carrying of higher flows within the channel is exactly opposite of natural processes where a stable stream will utilize access to a floodplain to dissipate the energy that is above the capacity of the stream channel. As a result, the higher flows which are now contained within the streambank are flows that greatly exceed the allowable shear stress of the channel. In the end, channelization results in streams that down cut to bedrock or saproilite and then begin to widen as exceedingly high shear stresses causes bank scour and thus a lateral movement of the streambank due to its erosion. The mass wasting of these banks is a significant cause of excess sediment in this watershed. Several of these selected projects are bank stabilization projects and the anticipated reductions in sediment loading indicate the magnitude of this problem.

Another result of channelization is the loss of instream habitat and structure that can be found in the stable pool-riffle sequence of natural channel. Pools provide essential habitat and drought refuge areas for proper biological function. It should be noted that this is a problem on many reaches that are not a part of one of the proposed sites for stormwater BMPs included in this report.

2. **Culverts and Channel Crossings** - A significant amount of the instability in the Bolin Creek Watershed may have been started by the construction of stream crossings for roadways. The resulting channel contraction that occurs at most culverts may have caused the erosion on the downstream side that leads to a tail cut, and thus channel incision ( no longer accessing the floodplain), a lowering of groundwater base, and continued instability that may exist for decades. Head-cuts can result from a depressed invert elevation, and work upstream until it hits some form of grade control. Overly wide crossings cause deposition of sediments when the wider channel becomes shallower in depth, thus reducing the shear stress needed to carry sediment. Backwater from floodplain encroachment of roadways

*Bolin Creek Watershed*  
*Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

causes a loss of velocities, thus lowering shear stress, and a lack of sediment transport results.

It is difficult to have a road crossing and maintain a natural cross section, flood plain relief for proper sediment transport and flow capacity. Current DOT standards have improved with this regard and in the future, road crossings in this watershed should utilize floodplain culverts and main channel culverts that maintain a wider flow path with a base flow channel at the natural bed elevation.

3. Utility Impacts – The installation of sewer lines and other utilities within the floodplains of streams was the perceived cause of apparent channel relocations throughout the watershed. For the most part, these impacts occurred long ago and the remaining degradation is primarily in the form of channel instability from channelization, as mentioned in item #1. Current impacts were observed in several locations in the form of unstable channel crossings, culvert installations, and removal of woody riparian vegetation that is essential to channel stability. It will require a continued effort between the towns and the utility providers to minimize these future impacts, as well as to monitor them.
4. Bank Wasting – Streambank wasting is probably the largest cause of the degradation of the biological integrity of the streams within the Bolin Creek watershed, because of the large amount of sediment that is exported through bank wasting processes. There are very few streams in the watershed that do not possess mass wasting banks on outer meander bends and lower riffle sections. Any effort to manage stormwater in the future by reducing peak flow rates of runoff and total volume will aid in establishing stability in the watershed by reducing the shear stress experienced by these banks. Direct modification of all streams within the watershed is impractical, thus particular reaches that are identified as supplying the greatest amounts of sediment should be targeted and treated. While the Geomorphic Assessment identified the most unstable reaches within the watershed, an analysis of the estimated quantities of sediment produced by all unstable reaches within the watershed was beyond the scope of this effort. Notwithstanding this, many of the BMPs proposed in this report are targeted at treating what were observed to be the worst reaches.
5. Direct Discharges to the Channel – In many cases, a definite impact was observed at the location of stormwater outlets within, or very near the channel. This concentrated and sediment-starved stormwater causes channel instability in the form of mass wasting of banks and channel incision. Even when discharges occur onto the floodplain, but within 10-15 feet of the channel itself, mass wasting of downstream banks is present as well as a headcut through the stream bank up to the point of discharge.

The placement of BMP outlets in the floodplain, unfortunately, may also have the same effect. When possible, any discharge in a near-channel region should be diffused by use of level spreaders or substantial energy dissipation basins. Observations indicate that an “apron” at the outlet is grossly insufficient at energy dissipation and flow diffusion.

6. Railroads and Streams- The team observed multiple direct impacts from stormwater systems of railway lines. There is no treatment of the stormwater that is collected by the ditches associated with the fill and cut of the railway grade. This concentrated flow could be treated before discharging it to an ephemeral, intermittent, or perennial stream in a variety of ways, including retrofit of BMPs alongside the railway lines.
  
7. Recreation Impacts – Greenway trails, paved and unpaved, and recreational activities are causing a substantial impact to the reaches within the Bolin Creek watershed. Bolin Creek itself is suffering multiple locations of instability that are created simply by the foot traffic on the banks. Trails and greenways that are located close to the channel affect the vegetation along the streambank and cause mass wasting to occur. Paved greenways do not typically have stormwater treatment and therefore cause a concentration of flows from the impervious surface and associated grading. This concentration flow typically outfalls onto the floodplain or streambank at low points in the trail and causes instability. Paved greenways trails should be constructed in a manner that acknowledges the risk of placing an impervious surface in the riparian zone. Level spreaders, dissipater basins, etc. should be used to handle the stormwater that collects from these surfaces. It is recommended that any future greenway plans include strategies for education and outreach as part of the greenway development.

Unpaved trails result in a compacted soil that behaves in a similar manner to an impervious surface except that the trail is normally a concaved depression. This depression and resistance to percolation results in concentration of flows down these paths and erosion of the trail. The sediment from the trails is often discharged directly into the channel at a low point.

Individuals using these trails and riparian areas are normally there to enjoy the stream, not harm it. “Education and outreach” would dramatically improve many of the impacts that were observed. Stream crossings can be designated and stabilized, trails kept away from the streambank, etc. and the citizens of these communities would most likely be very receptive to the suggestions. Information kiosks at strategic locations could start this process at a relatively low cost.

8. Stormwater Runoff – As with any urban watershed, the development in the Bolin Creek watershed has caused an increase in the peak flow rates and total runoff volume that reaches the receiving channels. It is evident that increases and the concentration of runoff are the major problem in the watershed. However, specific observations, such as a headcut in an intermittent channel, are indicators that the instability created by stream crossings or direct alterations of the channel may be the more significant catalyst for channel instability in many cases. Increased stormwater flows that are “trapped” down inside a channel and not allowed to dissipate energy via a floodplain only serve to exacerbate the instability of an incised channel. Earth Tech strongly believes that our field experiences and completed restoration projects indicate that the increase in stormwater flows can be accommodated by reconnection with the floodplain and proper bank stabilization practices. Earth Tech encourages the use of these practices to stabilize problematic reaches where the sediment contributions are degrading the biological integrity of the system.

In other cases, especially with ephemeral channels, increased stormwater flows are the perceived cause of instability in the form of channel scour. There are many ephemeral channels in the Bolin Creek watershed which are suffering from scour. These upper slope positions in less developed parts of the watershed can be observed to have no significant debris scour of significance, much less erosion of soil beneath the leaf litter. After investigating the cause of the scour in the ephemeral reaches, Earth Tech made the conclusion that concentration of storm flows from drainage networks were the prevailing cause of this instability. These ephemeral channels offer a location for dissipation of energy from the concentrated and increased flows from development. There are many opportunities in the Bolin Creek Watershed to reduce peak flows, nutrient contributions, and directly eliminate erosion by using BMPs within these reaches.

Increases in nutrient export via stormwater runoff are also a likely cause of biological degradation of the streams in the watershed. Although the geomorphic assessment can not pinpoint the most severe cases of this problem within the watershed, direct pipe discharges and the observation that the majority of this watershed has development with no water quality treatment, indicates that a significant amount of nutrient loading is occurring in this watershed.

Increases in water temperature are another expected cause of biological degradation within this watershed. Increases in impervious areas are usually associated with warmer stormwater runoff temperatures. This study has not addressed this issue. However, many of the BMPs that are outlined in this report are known to reduce this problem.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

The BMPs outlined in the 32 conceptual projects address the various causes of instability that were observed. By using these projects as a guide, the BCWRT should be able to conceive and implement other projects to improve the biological integrity of Bolin Creek in the years to come.

## **Acknowledgements**

The following persons contributed to this study through their efforts in assisting with field work, coordination, prioritizing of sites, report production and analysis:

### **Earth Tech**

Russel Barbour- field work

Bryan Dick- project manager, field work leader, report writing and BMP conceptual designer, quality control

Ian Jewell- field work, GIS analysis, conceptual design production, report and map production, cost estimates

Ron Johnson- quality control

Kevin Lapp- GIS work, field map production

Rene Remy- conceptual design production, water quality analysis, cost estimates

### **Town of Carrboro**

Will Autry

Trish McGuire

Randy Dodd

### **Town of Chapel Hill**

Trish D'Arconte

### **NC Division of Water Quality**

Paul Clark

Steve Kroeger

Periann Russel

### **US Environmental Protection Agency**

Tony Able

## **Table of Contents**

SITE 1 .....	1
SITE 2 .....	9
SITE 3 .....	17
SITE 4 .....	27
SITE 5 .....	33
SITE 6 .....	41
SITE 7 .....	47
SITE 8 .....	53
SITE 9 .....	59
SITE 10 .....	67
SITE 11 .....	73
SITE 12 .....	81
SITE 13 .....	87
SITE 14 .....	93
SITE 15 .....	99
SITE 16 .....	107
SITE 17 .....	115
SITE 18 .....	121
SITE 19 .....	129
SITE 20 .....	137
SITE 21 .....	143
SITE 22 .....	151
SITE 23 .....	157
SITE 24 .....	163
SITE 25 .....	171
SITE 26 .....	179
SITE 27 .....	185
SITE 28 .....	191
SITE 29 .....	197
SITE 30 .....	205
SITE 31 .....	211
SITE 32 .....	219
References .....	227

### **APPENDICES**

- Appendix A. BMP Details
- Appendix B. Photo Log
- Appendix C. Raw Data Forms for Final Sites
- Appendix D. Raw Data Maps

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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## **SITE 1**

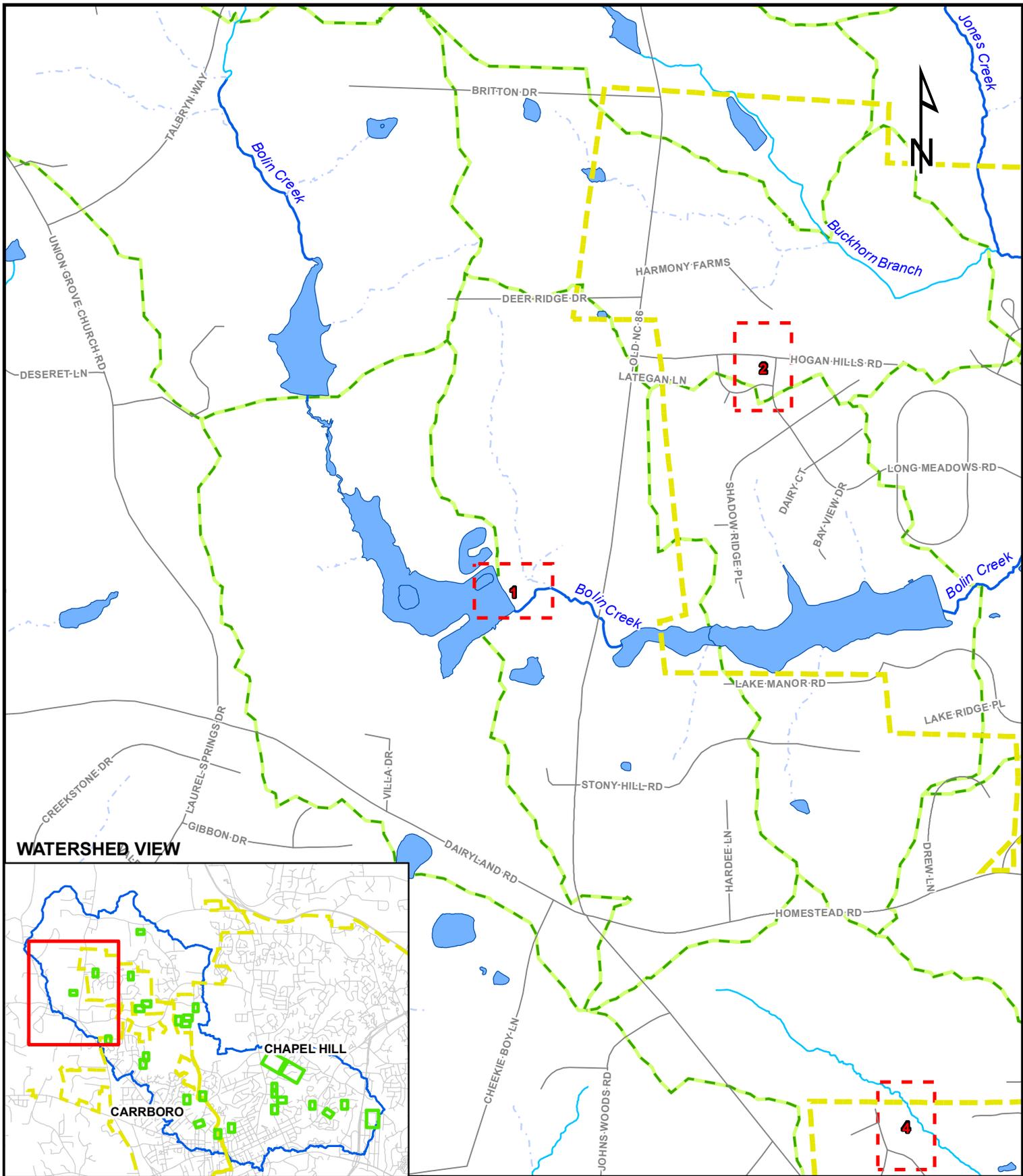
### **Dam Outfall Repair on Bolin Creek**

Index Sheet No.: 4

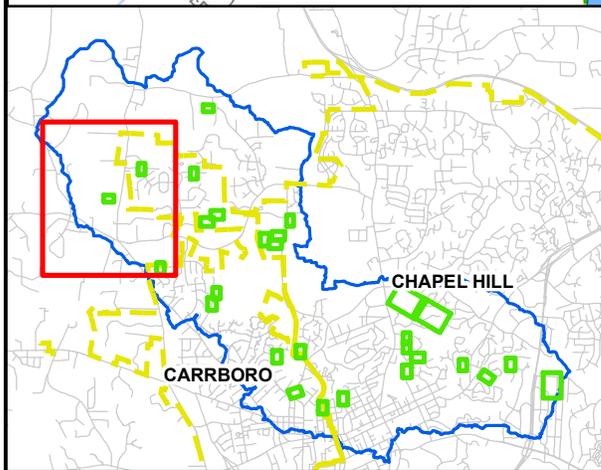
Raw Data Name: IJ 04



Estimated Construction Cost: \$31,000



**WATERSHED VIEW**



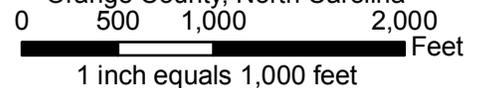
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 1  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



### **Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site1	553.9	20.5	3.7%

### **Location**

Site 1 is located to the west of Old NC 86. To access Site 1, park along the shoulder of Old NC 86 just before it crosses Bolin Creek and follow Bolin Creek upstream until reaching a dam.

### **Problem Description**

Site 1 consists of an actively eroding, deeply incised pond spillway outlet situated on Bolin Creek. The outlet channel is approximately 250 feet in length, and has dimensions of approximately 8 feet wide by 6 feet deep. This spillway is improperly constructed and serves as the only outlet for the relatively large lake on Bolin Creek. The slope of the spillway channel is approximately 4% which is too steep to serve as a constant flow channel of native soils with no hardening of the channel. The spillway invert has down-cut approximately 3 feet over the years and a beaver dam now sets the headwater elevation for the lake, which his approximately 2 feet above the invert

The chief problem with this site is the significant amount of sediment that is estimated to be exported by the site, due to the instability of the spillway channel. During site visits, Earth Tech consistently observed that the channel downstream of the lake was covered in a fine, red clay sediment. As the lake itself is a significant barrier to suspended sediment, the downstream siltation is an indicator of the massive sediment loading that is occurring to Bolin Creek due to this relatively short reach. Using a modified BANCS model for predicting streambank erosion rates (Rosgen, 2006), a total bank erosion rate of 1444.4 tons/year was estimated for this site, as shown in **Table 1.1**.

A secondary problem with this site is the observed loss of base flow due to the hydrologic disconnect created by the lake. In July of 2007, a slight base flow was observed in Bolin Creek at locations immediately upstream of the un-named lake that is in-line. The lake is presumed to have a higher rate of evaporation than it does incoming flow, as there was no baseflow discharge from the lake during the afore mentioned observation period. Also, the saturated hyporheic zone indicated a steady drawdown of water surface in the lake during the observation visit. Thus, indications are that the lake has terminated the baseflow in Bolin Creek during dry summer months. Active baseflow conditions were observed within a few hundred feet downstream of Old NC 86.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 1.1**

Pre-Treatment	
Estimated Total Sediment Export	1444.4 tons/year
Erosion per length of Channel	5.8 tons/yr/ft
Pounds of Nitrogen	2888.9 lbs/year
Pounds of Phosphorus	1444.4 lbs/year
Post-Treatment	
Estimated Total Sediment Export	1.3 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	2.5 lbs/year
Pounds of Phosphorus	1.3 lbs/year

**Proposed Solution**

The solution to limiting erosion rates at this site is to construct new pond outlets consisting of a vertical riser in the pond and a properly designed overflow spillway, and to fill and vegetate the existing outfall channel (See Plan View). Filling the outfall channel should reduce erosion rates to nearly 0 tons/yr, as the chief source of sediment at this point is the outfall channel itself.

In addition to the benefits received by reducing sediment export rates, this project could potentially provide a location for base flow augmentation, which was observed to be a major water quality problem in this area. Creating an incremental, controlled discharge from the pond would provide a steady flow of water that could augment the missing baseflow. This would have a beneficial effect on the stream biota downstream.

In order to provide the controlled discharge of water from the pond, and in order to gain landowner cooperation, it will likely be necessary to raise the maximum water level of the pond, by raising the elevation of the top of the dam. This extra storage would provide the volume that can be used to restore baseflow downstream of the lake via a controlled release for an extended period of up to a few weeks. Specific design parameters of this site would dictate the actual time of delayed discharge and further Proposed Solution is necessary to accurately plan for this baseflow augmentation effort. The landowner most likely uses the pond for fishing and other recreation, and relies on the current water level for these activities. Installing a means of continuously discharging water would lower the water level, thereby impacting the landowner's use of the pond. By raising using a temporary storage volume above the existing permanent pool elevation, the goal of baseflow augmentation can be met while also meeting the needs of the landowner. The lake elevation will actually be higher on average than it is today, and the surface area and depth would increase, both of which are likely to be desirable to the landowner for fish pond management. As long as frequent rainfall occurs, the landowner will actually have a larger volume of water that is continually maintained in his lake.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

With stability of the existing outlet in question, the landowner will also benefit from the assurance that his pond dam is less likely to be irreversibly damaged by a major rainfall event.

**Constraints**

The chief constraint at this site is landowner cooperation. The primary outlet will be somewhat limiting, as it will require the dewatering of the lake to complete. Dam safety considerations must be addressed and the proper agencies made aware of the retrofit to the outlet. In addition, vegetation removal will be required for some of the work to be completed.

**Alternatives**

No alternatives are anticipated at this site.

**Cost-Estimate Breakdown**

**Table 1.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only.

**Table 1.2**

**SITE 1 Construction Costs**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Concrete Overflow Structure	1.0	Ea	3000	\$3,000
Excavation	400.0	CY	15.00	\$6,000
Site Preparation and Plantings	0.1	AC	7500.00	\$750
Rip Rap Class B	5.0	Tons	45.00	\$225
Filter Fabric	15.0	SY	5.00	\$75
Silt Fence	300.0	FT	3.75	\$1,125
Construction Safety Fence	500.0	LF	2.50	\$1,250
Construction Entrance	1.0	Ea	2500.00	\$2,500
Pond Outlet Structure	1.0	Ea	12000.00	\$12,000
<b>Total</b>				<b>\$26,925</b>

Mobilization (5%)	1.0	LS	\$1,346
Contingencies (10%)	1.0	LS	\$2,693

Total + Mobilization and Contingencies **\$30,964**

**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	\$1,548
--	-----	------	---------

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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**SITE 1**

CONSTRUCT OVERFLOW SPILLWAY  
IN NATIVE SOIL

RAISE DAM ELEVATION TO HAVE  
TEMPORARY STORAGE OF 18"

EXISTING STREAM CHANNEL

Bolin Creek

FILL EXISTING, ACTIVELY ERODING SPILLWAY

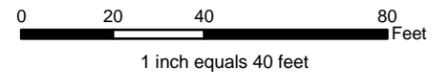
**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



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**CONCEPTUAL PLAN VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 1**

CONSTRUCT OVERFLOW SPILLWAY  
IN NATIVE SOIL

RAISE DAM ELEVATION TO HAVE  
TEMPORARY STORAGE OF 18"

EXISTING STREAM CHANNEL

Bolin Creek

FILL EXISTING, ACTIVELY ERODING SPILLWAY

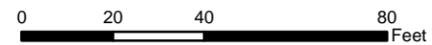
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

**BOLIN CREEK WATERSHED**  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



1 inch equals 40 feet

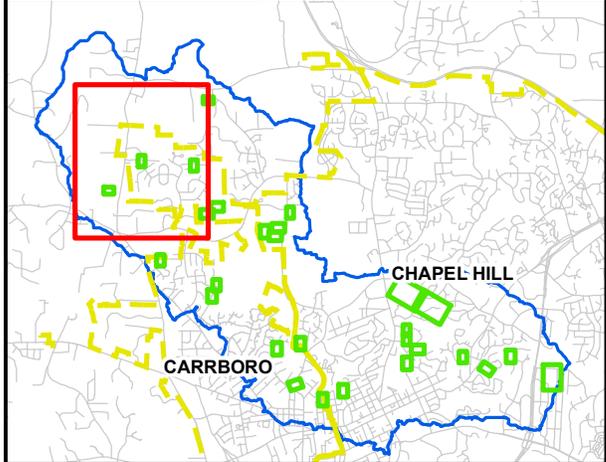
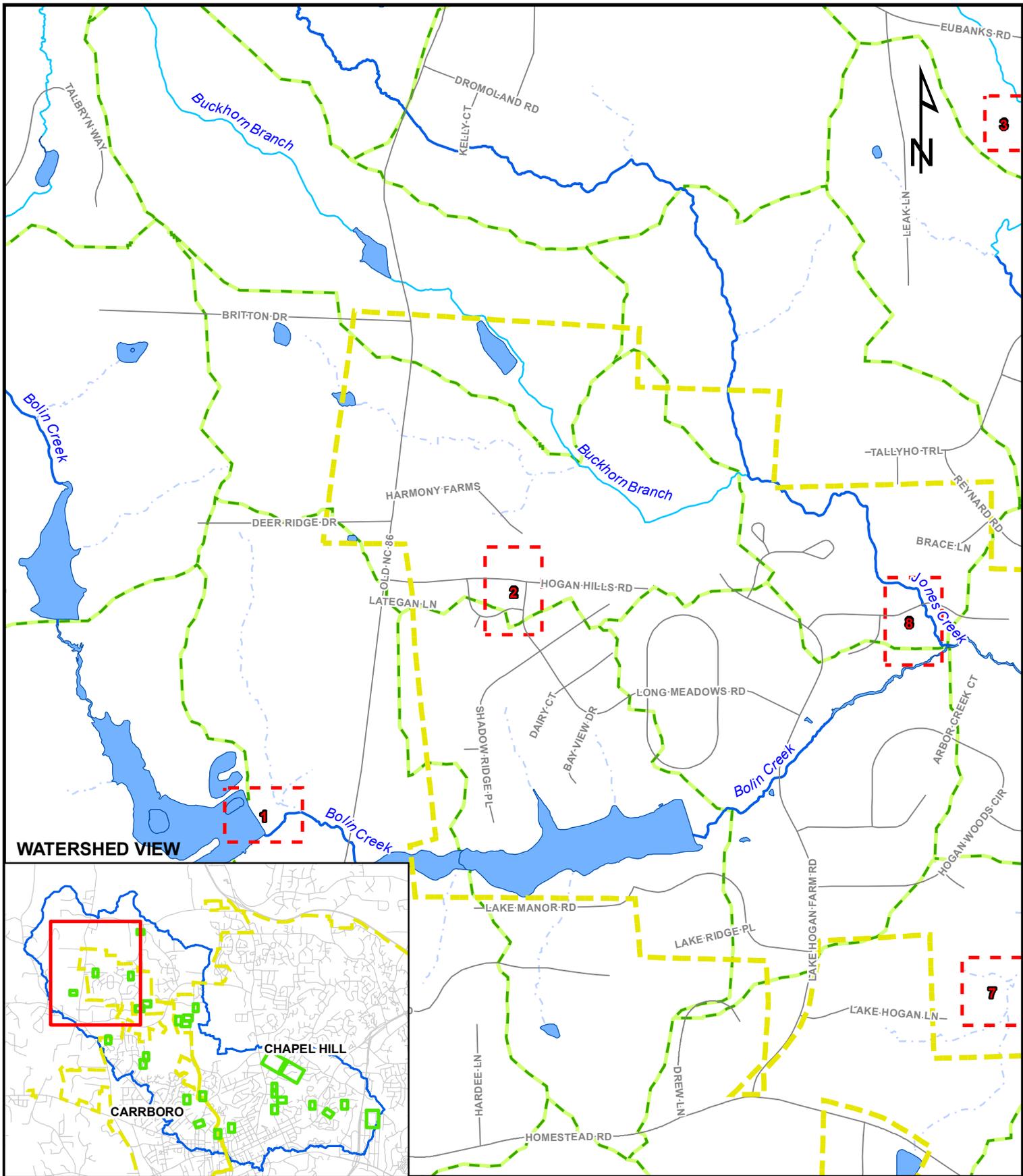
**SITE 2**

**Retrofit of Existing Stormwater Pond**

Index Sheet No.: 5  
Raw Data Name: BD 100



Estimated Construction Cost: \$44,000



**Legend**

	Ambient Monitoring		Orange County Roads
	Benthic Monitoring		Subwatersheds
	Fish Sampling		Perennial Stream
	Municipal Boundary		Intermittent Stream
			Ephemeral Stream
			Stream, unknown flow

**EarthTech**  
A tyco International Ltd. Company

**SITE 2  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 2	5.0	2.3	45.2%

**Location**

Site 2 is located at the corner of Hogan Hills Rd and Long Meadows Rd in the subdivision of Lake Hogan Farms.

**Problem Description**

The continuing development of the Lake Hogan Farms subdivision was observed to be impacting the surrounding stream systems, including Jones Creek and Bolin Creek. A number of small sediment basins, which were likely built during construction of the subdivision, are still in existence in various parts of the subdivision. These provide an opportunity for stormwater BMP retrofits for water quality treatment and the attenuation of peak flows, which should help to alleviate the stress on the surrounding streams. It should be noted that the BMPs that are in place were predominantly designed for the control of water quantity, not quality.

Site 2 is an existing stormwater basin was designed under an old ordinance whereby the basin discharges all rainfall events at a 10 year flow rate. The basin is composed of a flat, shallow depression with sparse plantings of hardwood saplings scattered throughout. The basin currently collects the runoff of Hogan Hills Rd and surrounding rooftops. The basin inlet is a reinforced concrete pipe and the outlet is a concrete vertical riser structure with a 6 inch diameter orifice which has an invert that is even with the basin's bottom elevation. This configuration creates a negative hydraulic effect, where a 1 year recurrence interval event is effectively discharged as a 10 year event. Also, with no permanent pool, soils that do not infiltrate, and no functional wetland system, this basin would not classify as any BMP that would be found in today's NC BMP manual. If the orifice were smaller, it would function to reduce the peak flow rates leaving the sites, and nothing more. Both the inlet and the outlet structures are located on the same side of the basin, further making the basin ineffective by not allowing sediment to settle and not obtaining enough nutrient treatment due to the flow path being only a few feet in length.

**Analysis**

**Proposed Solution**

The existing basin of Site 2 is a prime candidate for a BMP retrofit in the form of a stormwater wetland to provide water quality treatment. To properly function as a wetland, this site should have a few permanent pools established and the soil amended so that plants will thrive. To accommodate the needed hydrology, the outlet structure should be modified to temporarily store approximately 6 inches of water depth and the outlet orifice would be sized to handle the excess, while reducing the runoff rate of the 10 year storm down to a 2 year storm. This can be accomplished by creating several

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

orifices in increasing size as the stage increases in the pond. To allow the proper resonance time, the flow length must be increased by adding a berm and forcing the flow coming from the inlet pipe to be routed to the furthest point of the pond away from the outlet. Other pools and low marsh benches could be built to create the appropriate diversity of habitat for various aquatic and semi-aquatic plants, which will provide treatment of stormwater for nutrients. The site is a desirable one for a stormwater BMP in that the amount of earthwork will be minimal.

The current nutrient export rates, and potential benefit of a stormwater wetland here have been calculated based on land use, drainage area and percent imperviousness of the drainage area, and are displayed in **Table 2.1**:

**Table 2.1**

SITE 2	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	12.29	1.24	167.06
STORM WATER WETLAND TREATMENT REMOVAL %	40.00%	35.00%	85.00%
NET REDUCTION	4.92	0.43	142.00
FUTURE CONDITION	7.37	0.81	25.06

**Constraints**

The biggest constraint at this site could potentially be landowner cooperation and land acquisition. If the neighborhood does not want standing water near their home, then the outlet would have to be retrofitted to reduce peak flows and perhaps A landowner that lives adjacent to the site was spoken to during field visits and stated that the site was unsightly now that they had removed wetland vegetation and regarded it witching the past 2 years. If work is done to the make the existing basin into a stormwater wetland for water quality treatment, the design must be such as to satisfy the neighbors and perform better than the previous basin.

**Alternatives**

If the adjacent property owners do not want the wetland near their home, then the outlet would have to be retrofitted to reduce peak flows and possibly amend the retrofit the basin with a permeable soil layer, to allow some storage through infiltration. Cost would be similar to the wetland, but treatment would be significantly less. A compromise may be reached by allowing underground storage through a porous medium and a mantle of topsoil to support plant growth. This would achieve treatment of the stormwater, but the retrofit would begin to become much more expensive due to the amount of earthwork and required addition of porous medium.

**Cost-Estimate Breakdown**

**Table 2.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

*Bolin Creek Watershed  
 Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 2.2**  
**SITE 2 Construction Costs**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	27573.0	CF	Equation Derived	\$38,156
<b>Total</b>				<b>\$38,156</b>
Mobilization (5%)	1.0	LS		\$1,908
Contingencies (10%)	1.0	LS		\$3,816
Total + Mobilization and Contingencies				<b>\$43,879</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		<b>\$2,194</b>

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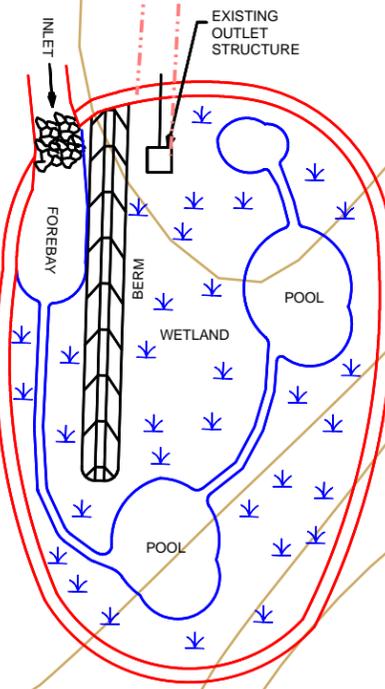


**SITE 2**

**HOGAN HILLS RD**

**LONG MEADOWS DR**

**LONG MEADOWS DR**

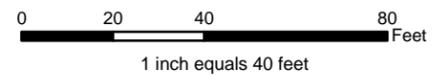


**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



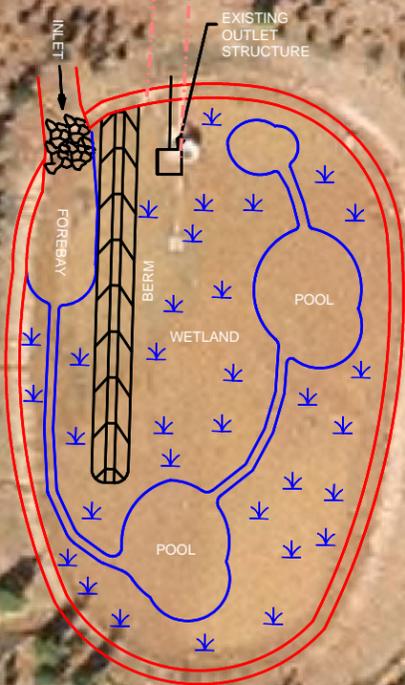


**SITE 2**

**HOGAN HILLS RD**

**LONG MEADOWS DR**

**LONG MEADOWS DR**



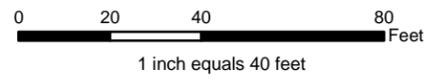
**Legend**

- - - Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- - - Stream, unknown flow



**AERIAL PHOTO VIEW**

**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits



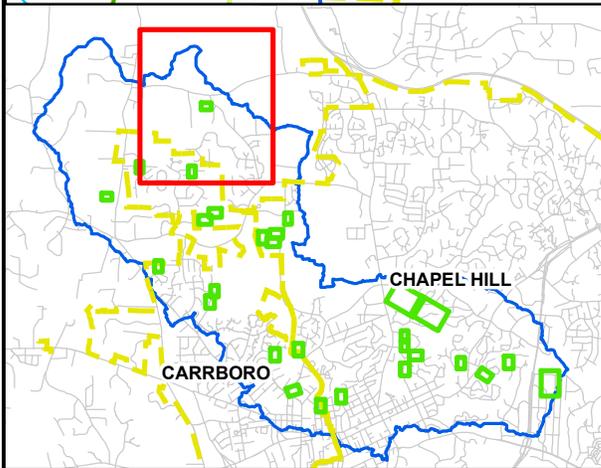
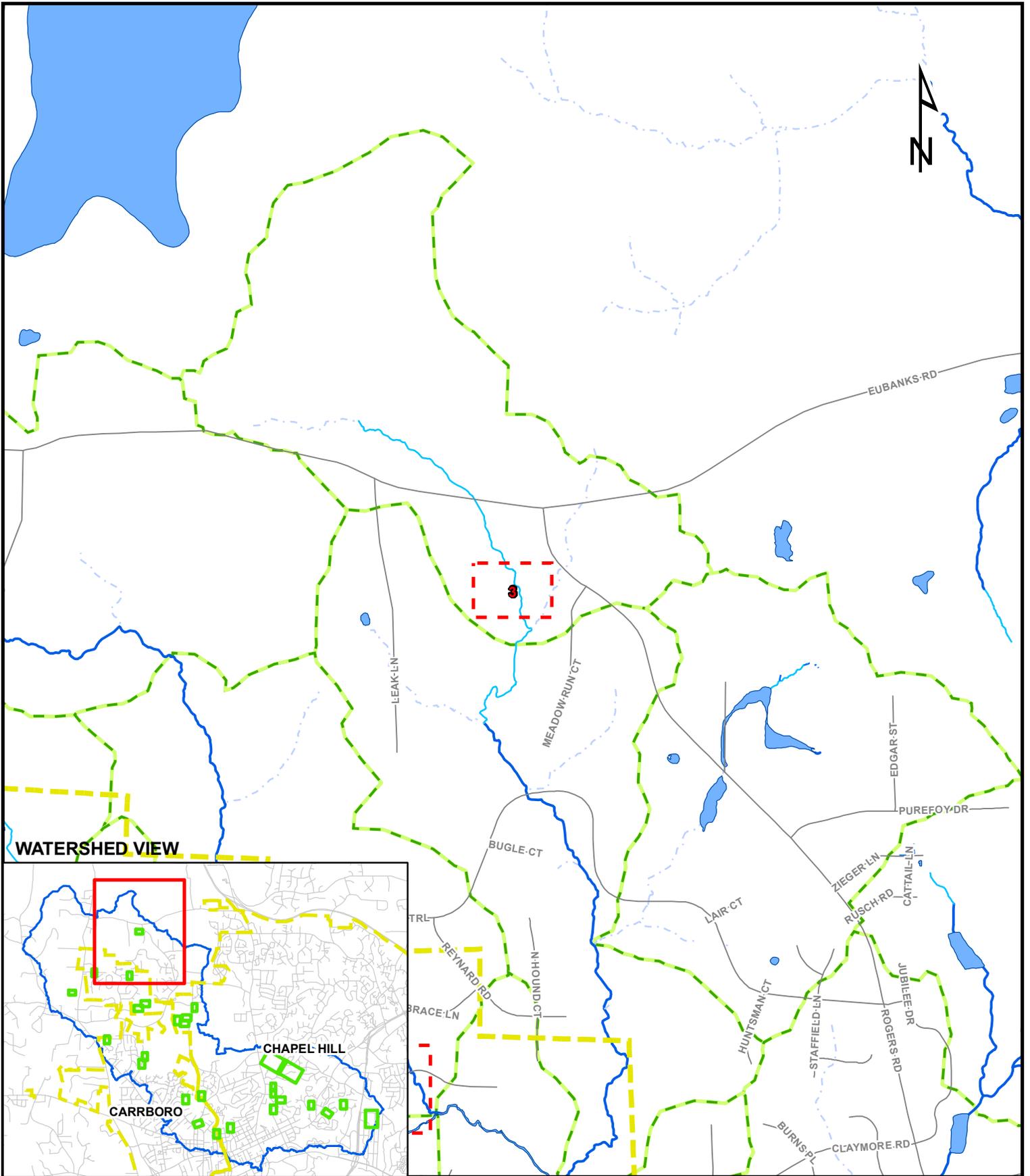
## **SITE 3**

### **Stabilization of Headcut on Intermittent Channel**

Index Sheet No.: 7  
Raw Data Name: BD 27



Estimated Construction Cost: \$19,200-\$54,000



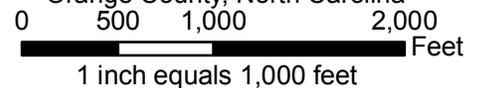
**Legend**

-  Ambient Monitoring
-  Benthic Monitoring
-  Fish Sampling
-  Municipal Boundary
-  Orange County Roads
-  Subwatersheds
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow



**SITE 3  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 3	127.2	2.4	1.9%

**Location**

Site 3 is located to the southwest of the intersection of Rogers Rd and Eubanks Rd. Access to the site can be obtained by following a powerline easement west from Rogers Rd until it reaches a stream.

**Problem Description**

The primary problem at Site 3 is a headcut in a channel which was observed to be an intermittent stream channel. The stream has a headcut which is progressing upstream towards the powerline. The difference between the bed elevation upstream and downstream of the headcut is approximately 4 feet. Upstream of the headcut, the channel is relatively stable, shows very little incision, and still accesses its floodplain. Downstream of the headcut, the stream channel is incised for its entire length until it reaches a residential area and converges with a larger channel. Actively eroding banks along this reach are contributing sediment to the watershed, and as the headcut continues to work upstream, which will continue to add a significant amount of sediment to the system during this downcutting process. Once the channel can no longer access its floodplain, the shear stress will continue to increase, and continue to add massive sediment loads to receiving waters. The process of channel incision is much, much easier to stop than it is to repair. The typical stream restoration is a project of massive proportion and effort that is focused on restoring channel stability by providing a proper channel geometry and a shear stress reducing floodplain. The channel downstream is in trouble and would take an expensive project to repair. The channel upstream of the headcut is still in great shape and could be maintained by stopping the headcut.

Sediment export rates from bank erosion have been estimated and are shown in **Table 3.1**.

**Table 3.1**

Pre-Treatment	
Estimated Total Sediment Export	160.9 tons/year
Erosion per length of Channel	2.7 tons/yr/ft
Pounds of Nitrogen	321.9 lbs/year
Pounds of Phosphorus	160.9 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.3 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	0.5 lbs/year
Pounds of Phosphorus	0.3 lbs/year

### **Proposed Solution**

To stop the advancing headcut, grade control structures should be used in the stream channel. Grade control structures are commonly employed in stream restoration practices, where a hard, immovable mass is needed to limit degradation of the bed of a channel. These structures are available in several different forms, the most common of which are the cross vane, log vane and grade control vane. These vanes are most often constructed from rock or logs to provide the needed mass, while also providing habitat and a natural appearance.

Several grade control vanes should be constructed at the upstream end of the advancing headcut. This will serve two functions by defining pools for energy dissipation and acting as a back-up for the downstream grade control. Three more should be constructed in sequence on the headcut itself and then backfilled, in order to create a “step-pool” feature. This will provide a more gradual transition between the two different streambed elevations, dissipate the confined energy and also aid in the prevention of any future degradation in the upstream channel. Along with this treatment, a bankfull bench should be built in the incised channel downstream for approximately 50 feet in order to lower near bank stresses on the banks that could potentially degrade and cut around the grade control structures.

There is a nearby powerline easement to this site which should provide easy construction access from nearby Rogers Rd.

### **Constraints**

Implementation of the work at this site will require some removal of over-story hardwood trees. Period maintenance will be required if a stormwater wetland is built in the floodplain. Because the project is adjacent to a utility easement, memorandums of agreement (MOA) or memorandums of understanding (MOU) may be required to implement work.

### **Alternatives**

Several alternatives are possible at this site:

Alternative 1: As mentioned above, build three grade control vanes structures in the area of the headcut to create a “step-pool”, and place several more grade control structures upstream. Construct a bankfull bench downstream by sloping the streambank back.

Alternative 2: Implement the work mentioned in Alternative A, and also restore the downstream channel until its confluence with the next downstream tributary. Upstream, redefine the channel as it flows through the power line easement.

Construct a stormwater wetland in the adjacent floodplain of the stream. This wetland will serve to attenuate peak flows and thus help to alleviate stress on the downstream channel. Another benefit of side channel storage is it’s potential to augment baseflow. A flow splitting device should be placed in the stream channel, which will allow a portion

of the increased storm flows to be diverted into the wetland. The bottom elevation of the permanent pools of the wetland should not be lower than the bed of the stream channel, so that water stored in the wetland can properly infiltrate and recharge the stream channel. Though clay soils have low permeability, saturated soils can and do provide baseflow, as they do in a natural system. Micro-topographic features of the natural terrain retain small amounts of runoff, slowly infiltrate into piedmont soils and thus recharge aquifers and provide for baseflow in intermittent and perennial streams.

Alternative 3: Construct only the grade control upstream of the headcut. This would be the lowest cost option, but should provide the necessary grade control to stop the advance of the headcut.

### **Cost-Estimate Breakdown**

**Table 3.2, 3.3 and 3.4** show conceptual itemized cost estimates for the three alternatives. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997). The contingency fee for this site has been increased due to the difficulty of access and proximity to a utility easement.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 3.2**  
**SITE 3 ALTERNATIVE 1**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	60.0	CY	15.00	\$900
Site Preparation and Planting	0.0	AC	7500.00	\$150
Rip Rap Class B	5.0	Tons	45.00	\$225
Filter Fabric	15.0	SY	5.00	\$75
Grade Control Vanes	6.0	EA	3000.00	\$18,000
Silt Fence	500.0	FT	3.75	\$1,875
Construction Safety Fence	665.0	LF	2.50	\$1,663
Construction Entrance	1.0	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$25,388</b>

Mobilization (5%)	1.0	LS	\$1,269
Contingencies (20%)	1.0	LS	\$5,078

Total + Mobilization and Contingencies **\$31,734**

**Table 3.3**  
**SITE 3 ALTERNATIVE 2**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	60.0	CY	15.00	\$900
Stormwater Wetland	8375.0	CF	Equation Derived	\$16,550
Site Preparation and Planting	0.1	AC	7500.00	\$750
Rip Rap Class B	5.0	Tons	45.00	\$225
Filter Fabric	15.0	SY	5.00	\$75
Grade Control Vanes	6.0	EA	3000.00	\$18,000
Silt Fence	500.0	FT	3.75	\$1,875
Construction Safety Fence	665.0	LF	2.50	\$1,663
Construction Entrance	1.0	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$42,538</b>

Mobilization (5%)	1.0	LS	\$2,127
Contingencies (20%)	1.0	LS	\$8,508

Total + Mobilization and Contingencies **\$53,172**

**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	\$2,659
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*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 3.4**  
**SITE 3 ALTERNATIVE 3**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	0.0	CY	15.00	\$0
Site Preparation and Planting	0.0	AC	7500.00	\$0
Rip Rap Class B	5.0	Tons	45.00	\$225
Filter Fabric	15.0	SY	5.00	\$75
Grade Control Vanes	4.0	EA	3000.00	\$12,000
Silt Fence	100.0	FT	3.75	\$375
Construction Safety Fence	100.0	LF	2.50	\$250
Construction Entrance	1.0	Ea	2500.00	\$2,500
			<b>Total</b>	<b>\$15,425</b>
Mobilization (5%)	1.0	LS		\$771
Contingencies (20%)	1.0	LS		\$3,085
			Total + Mobilization and Contingencies	<b>\$19,281</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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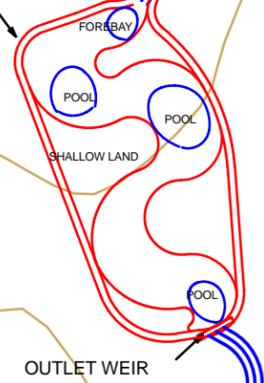


**SITE 3**

**ROGERS RD**

ALTERNATIVE 2:  
REDEFINE CHANNEL IN POWERLINE EASMENT

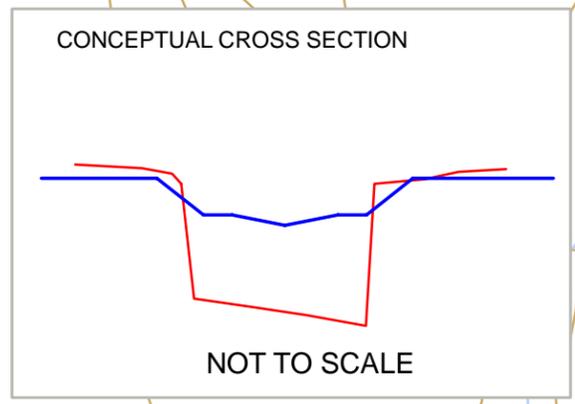
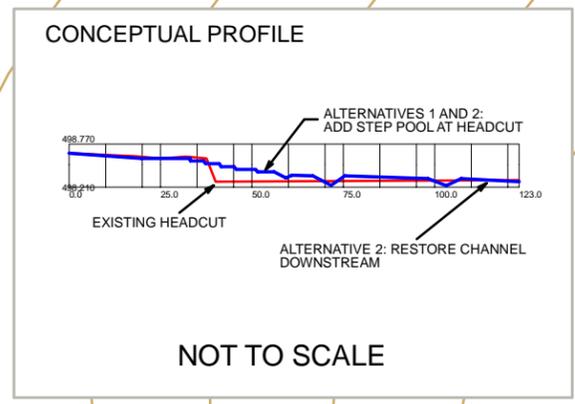
ALTERNATIVE 2:  
CONSTRUCT OFFLINE STORMWATER WETLAND  
FOR PEAK FLOW ATTENUATION



ALTERNATIVES 1, 2 AND 3- ADD GRADE CONTROL STRUCTURES UPSTREAM  
OF HEADCUT

ALTERNATIVE 1 AND 2- BUILD STEP POOL AT HEADCUT

ALTERNATIVE 2-  
RESTORE CHANNEL  
DOWNSTREAM

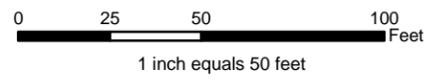


**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 3**

**ROGERS RD**

ALTERNATIVE 2:  
REDEFINE CHANNEL IN POWERLINE EASMENT

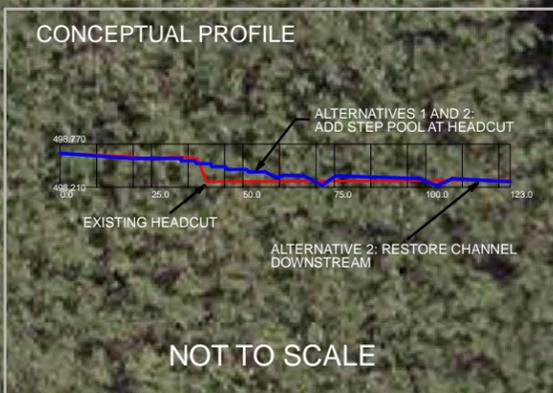
ALTERNATIVE 2:  
CONSTRUCT OFFLINE STORMWATER WETLAND  
FOR PEAK FLOW ATTENUATION

FOREBAY  
POOL  
SHALLOW LAND  
POOL  
POOL  
OUTLET WEIR

ALTERNATIVES 1, 2 AND 3- ADD GRADE CONTROL STRUCTURES UPSTREAM  
OF HEADCUT

ALTERNATIVE 1 AND 2- BUILD STEP POOL AT HEADCUT

ALTERNATIVE 2-  
RESTORE CHANNEL  
DOWNSTREAM

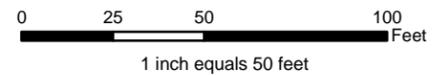


**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- - - Stream, unknown flow



**AERIAL PHOTO VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits



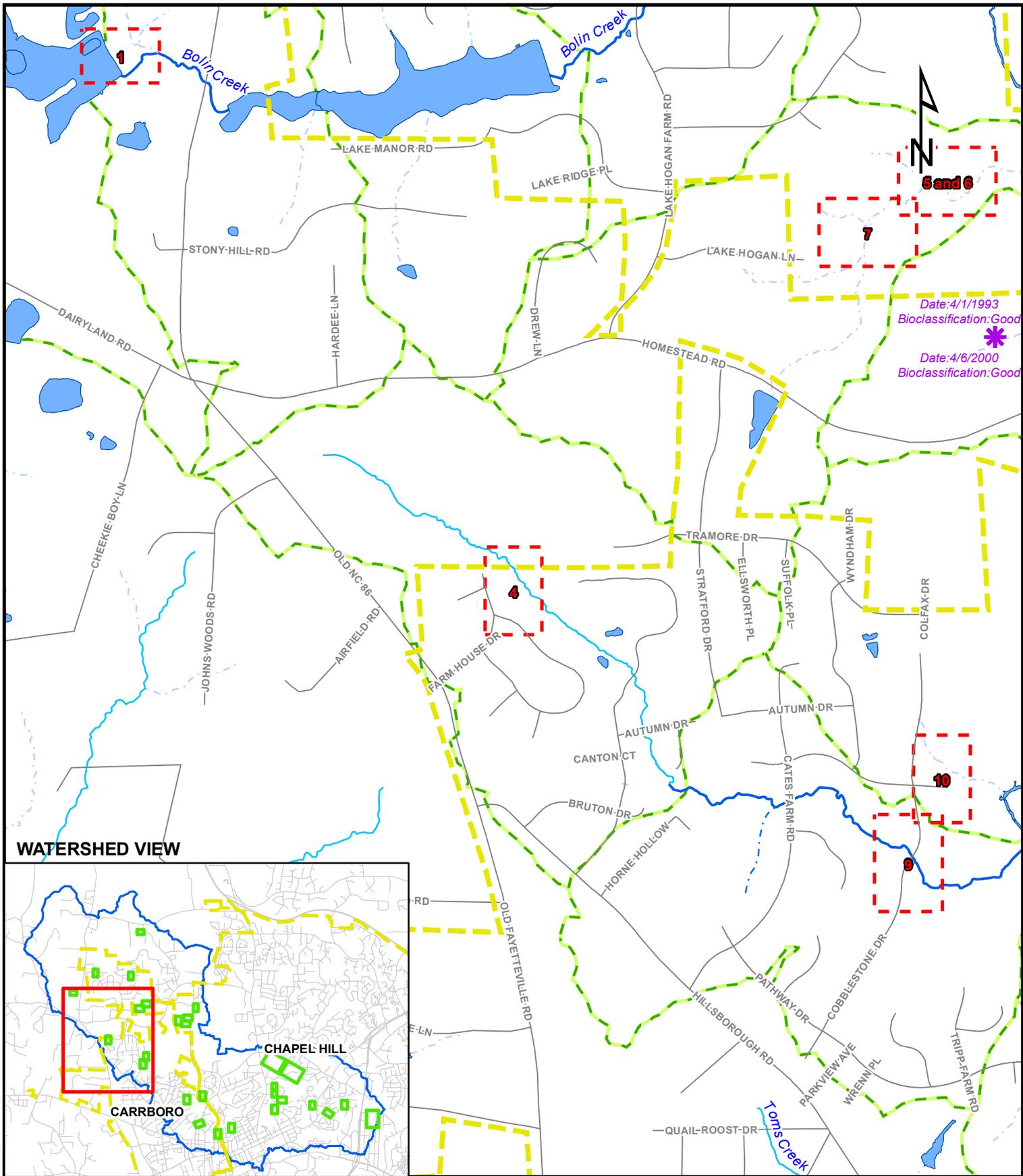
**SITE 4**

**Retrofit of Stormwater Outfall at Subdivision**

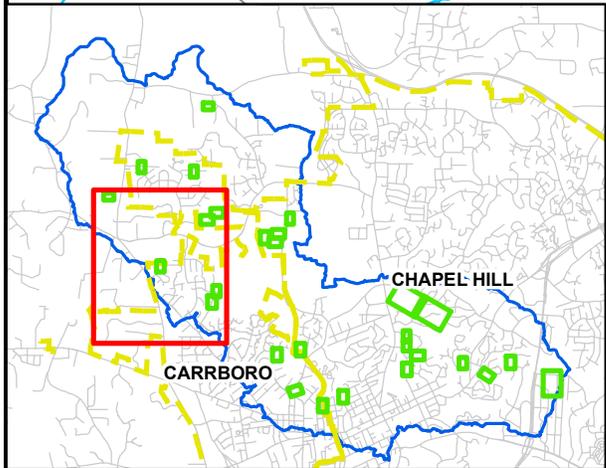
Index Sheet No.: 9  
Raw Data Name: TA 3



Estimated Construction Cost: \$73,500



**WATERSHED VIEW**



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 4  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

### **Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 4	11.8	2.6	22.2%

### **Location**

Site 4 is located approximately 200 feet to the northeast of the intersection of Sunset Creek Circle and Farmhouse Dr., in a subdivision located southeast of the intersection of Old NC 86 and Homestead Rd.

### **Problem Description**

Site 4 consists of an existing stormwater outfall structure located downhill from a subdivision, and uphill of a ditch leading into a stream. The structure is a square concrete box with two walls, which appears to collect stormwater and turn the flow 90 degrees into a ditch. Uphill of the structure is a stormwater pipe outlet and a steeply sloped, base ditch filled with rip-rap and lined with plastic sheeting leading into the structure. The drainage pipe appears to discharge the stormwater collected in the curb and gutter system of the subdivision. The ditch into which the structure turns flow is approximately 170 feet long, and leads into an incised stream channel. Bank erosion is evident where the ditch meets the stream, indicating that the velocity of the flow discharging into the stream is not sufficiently dissipated (see Appendix B-Photos).

There is no evidence that there is any water quality treatment being provided by the stormwater system at Site 4.

### **Proposed Solution**

The existing conditions of Site 4 provide a challenge for implementing a “traditional” BMP. The ditch into which the concrete structure turns flow is narrow and deep, due to an earthen berm that was constructed parallel to the contour of the very steep hillside. Fitting a typical bio-retention area with sufficient volume to treat pollutants into this confined space would be impractical. Instead, a possible solution is to construct a “bio-grade step” within the narrow area of the existing ditch, and keep the existing structure, as it does effectively turn the flow from its path straight off the side of the slope. The “bio-grade step” consists of a series of small bio-retention cells filled with a filter media, such as a mixture of sand, fines and organic mater (see Appendix A-Details). Ideally, this media will have an infiltration rate of 1.0 to 2.0 inches per hour, to optimize pollution removal (Schueler, et. al., 2007). Each cell is connected to the next cell down-slope by a pervious drain layer of sand or other media, thus allowing stormwater to filter through each cell without the expense of an under-drain. Each cell is designed to overflow to the next after reaching the desired backwater elevation.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

The surface areas of the “bio-grade step” should be planted with a mixture of woody and herbaceous native plants. The vegetation will provide filtration and stability.

Potential pollution removal rates using this method have been estimated and are shown in **Table 4.1**.

**Table 4.1**

SITE 4	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	4.20	0.37	73.80
BIORETENTION TREATMENT REMOVAL %	35.00%	45.00%	85.00%
NET REDUCTION	1.47	0.17	62.73
FUTURE CONDITION	2.73	0.21	11.07

**Constraints**

Construction access to the site could be limited by the narrow ditch and the very steep hillside. The removal of some trees to work around this ditch may be required. In addition, periodic maintenance of the bio-grade step will be required

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 4.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for the bio-grade step is derived from a cost per cubic foot treated for bioretention areas reported by Schueler, et. al. (2007). The contingency fee for this site has been increased due to the difficulty of access.

**Table 4.2**

**Site 4 Construction Cost**

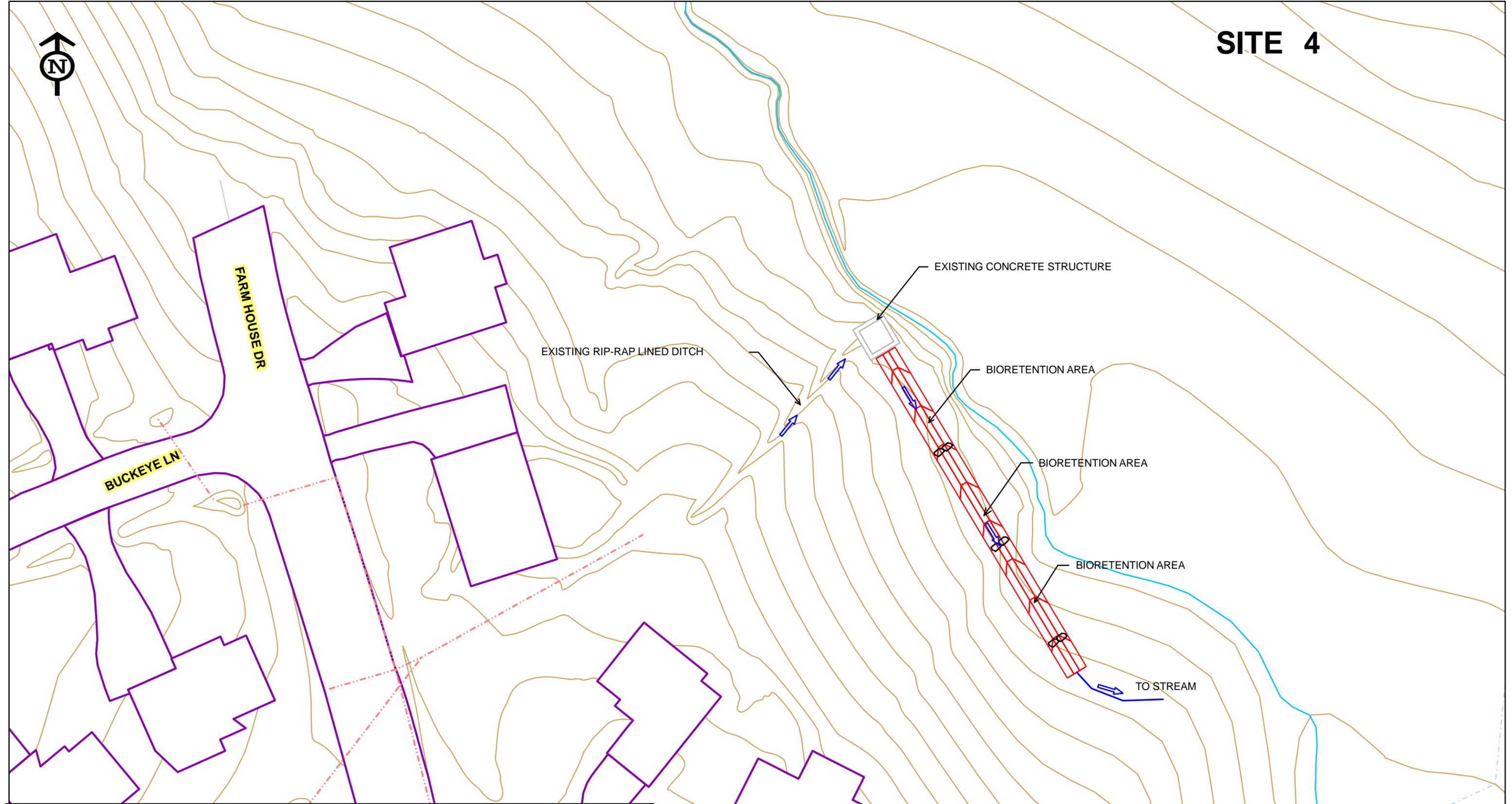
Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-grade Step	4854.0	CF	12.62	\$61,257
<b>Total</b>				<b>\$61,257</b>

Mobilization (5%)	1.0	LS	\$3,063
Contingencies (15%)	1.0	LS	\$9,189

Total + Mobilization and Contingencies			<b>\$73,509</b>
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**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	<b>\$3,675</b>
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EXISTING RIP-RAP LINED DITCH

EXISTING CONCRETE STRUCTURE

BIORETENTION AREA

BIORETENTION AREA

BIORETENTION AREA

TO STREAM

FARM HOUSE DR

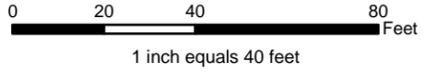
BUCKEYE LN

**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 4**

**FARM HOUSE DR**

**BUCKEYE LN**

EXISTING RIP-RAP LINED DITCH

EXISTING CONCRETE STRUCTURE

BIORETENTION AREA

BIORETENTION AREA

BIORETENTION AREA

TO STREAM

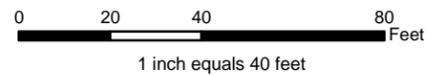
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

**BOLIN CREEK WATERSHED**  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

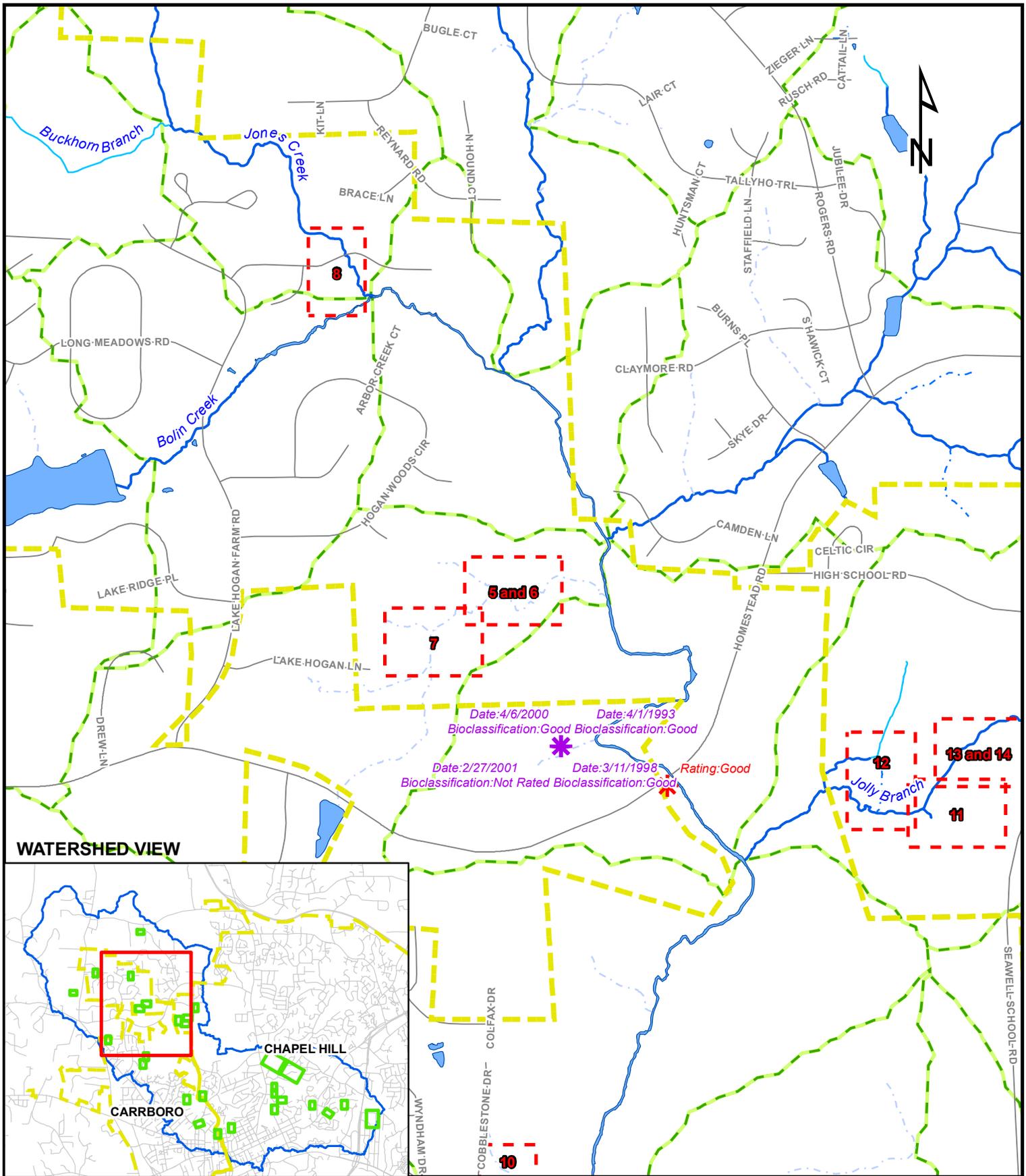


## **SITE 5**

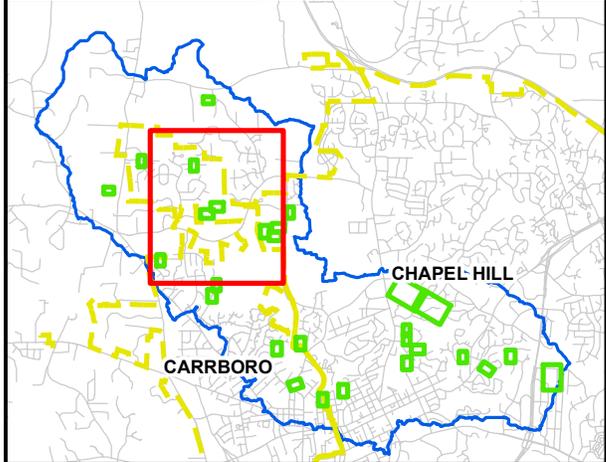
Index Sheet No.: 11  
Raw Data Name: None



Estimated Construction Cost: \$22,700



**WATERSHED VIEW**



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 5 and 6  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 5	3.2	1.0	29.6%

**Location**

Site 5 is located east of N. Cammelia Drive in the subdivision of Winmore, which is located off of Homestead Rd. At the time of this report, the subdivision was still under construction.

**Problem Description**

Site 5 is an existing stormwater BMP that was initially designed to act as a sediment basin during the construction of the subdivision Winmore, and which, according to the Winmore site plan, will be converted into a “pocket wetland” following construction. At the time of this report, the basin was still acting its capacity as a sediment basin. These BMP’s are good examples of how the science of watershed management has progressed over the last few years. There are several features of the BMP that would be very different in order to meet the current BMP guidelines of the State. Earth Tech believes that the BMP’s such as this one can benefit from retrofits that provide stability to the receiving channel and enhance water quality treatment.

The velocity dissipater of the basin outlet consists only of a rip-rap apron, with no pre-formed scour depression. During the field investigation, the aprons were observed to be showing indications of instability, “cut-arounds” and demonstrated a consistent problem of concentrated flows eroding the floodplain within the riparian zone. In most cases, the erosive forces of concentrated flows had yet to truly cause gullies, but the process has begun. There were headcuts beginning to form in the streambank where the concentrated flows joined the channel. These will most likely work their way through the floodplain from the channel, causing channel instability and contributing significant amounts of sediment to the stream.

The basin currently has no overflow spillway. Though this is not a requirement for North Carolina permits, many states require secondary spillways to be installed on stormwater structures in order to reduce the risk of the massive sediment inputs to a natural system when a structures berm is overtopped and fails. Earth Tech witnessed this effect on a site in north Raleigh in the spring of 2007 when a channel was completely denuded by clay silt after the failure of an upstream sediment basin.

The vegetated swale leading into the basin is relatively steep and showing definitive signs of eroding or incision. There are no check dams, or hydraulic structures that would serve to reduce channel velocities to a point lower than the critical shear stress velocity for the designed flexible lined channel.

**Proposed Solution**

Potential retrofits to this BMP include improving the swale leading into the wetland, construction of an overflow spillway, and using a pre-formed scour hole or energy dissipater basin (stilling basin) with a level spreader at the outlet discharge location. The swale may be retrofitted with grade control steps to flatten slopes incrementally or may be retrofitted to act as a “bio grade” steps as suggested in other sites within the Bolin Creek watershed. This will provide some storage of storm flow for base flow augmentation and reduce the erosive velocities that are present in the existing channel. The overflow spillway would provide some insurance from berm failure during high intensity rainfall events.

A pre-formed scour hole or other energy dissipater basin that is placed at the outlet pipe from the wetland will serve to adequately retain high energy flows and encourage energy dissipating turbulence at the desired location of the outlet. The existing aprons are not depressed and flows are apparently quickly flowing over or around the apron and onto native soils. A level spreader would provide for diffused flows verses the concentrated flows that exist with the current design. The stream bank should be vegetated with appropriate plants to create a filter strip between the level spreader and the channel, which will assist with floodplain stability and nutrient treatment.

**Table 5.1** shows an estimated decrease in pollutant load on this site as a result of the proposed treatment. Because the site is still under construction, the percent impervious surface used in this calculation is based off a projected percent impervious, based on typical percentages in subdivision areas.

**Table 5.1**

SITE 5	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	9.92	1.57	292.55
STORM WATER WETLAND TREATMENT	20.00%	17.50%	42.50%
NET REDUCTION	1.98	0.27	124.33
FUTURE CONDITION	7.94	1.29	168.21

**Constraints**

There are few constraints to this retrofit. Site access is very good, but working in the riparian zone will require permitting and sensitivity to the channel.

**Alternatives**

There are no proposed alternative for this project.

**Cost-Estimate Breakdown**

**Table 5.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

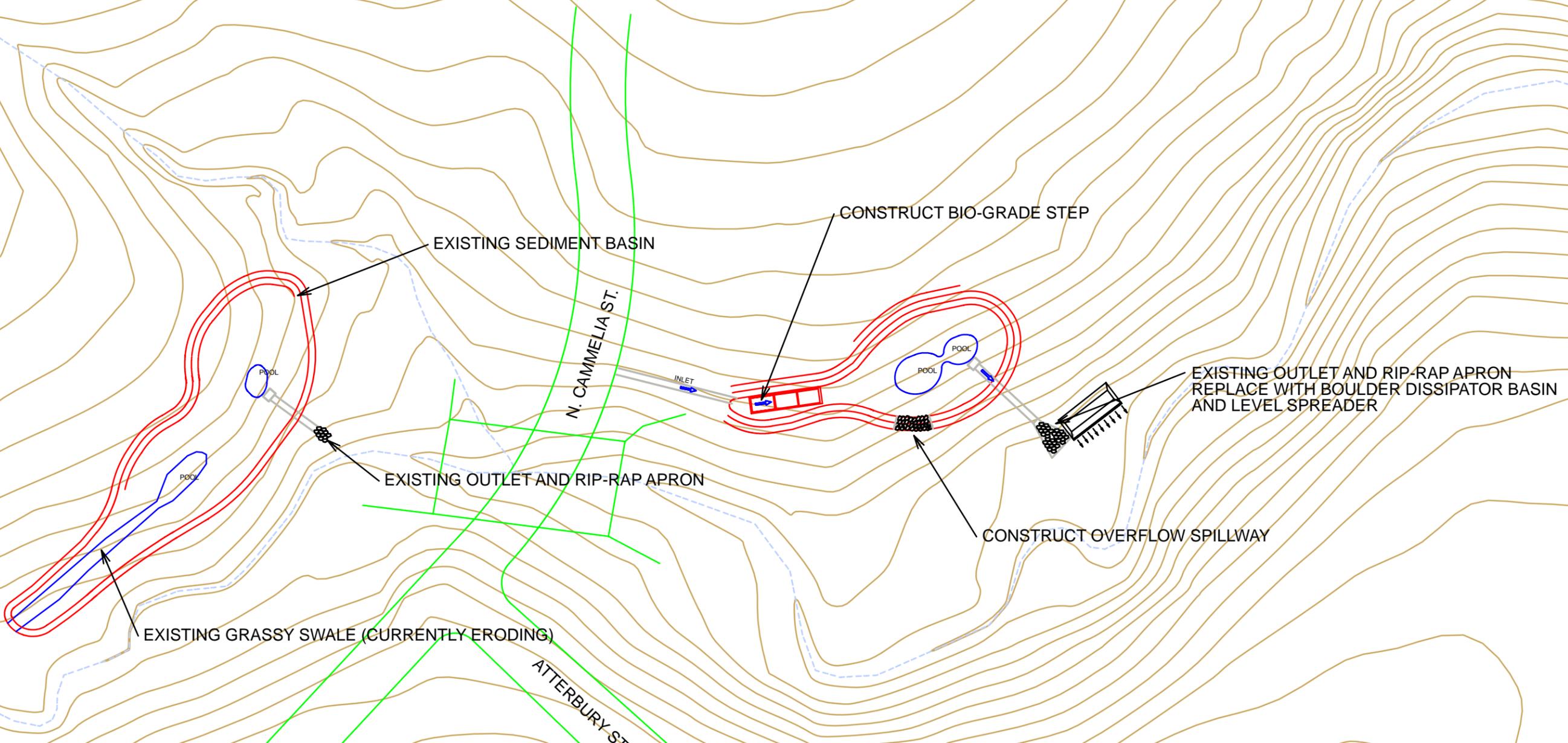
*Bolin Creek Watershed  
 Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 5.2**  
**Site 5 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	10741.0	CF	Equation Derived	\$19,704
<b>Total</b>				<b>\$19,704</b>
Mobilization (5%)	1.0	LS		\$985
Contingencies (10%)	1.0	LS		\$1,970
Total + Mobilization and Contingencies				<b>\$22,660</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		<b>\$1,133</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- · - · - Stream, unknown flow
- Contours




**EarthTech**  
A tyco International Ltd. Company

**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 25 50 100 Feet  
1 inch equals 50 feet



# SITE 5 and 6



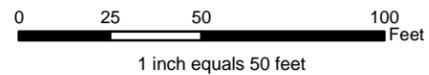
### Legend

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



### AERIAL PHOTO VIEW

BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits

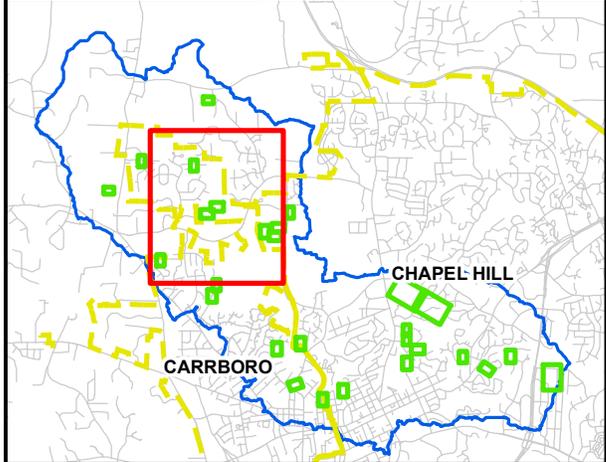
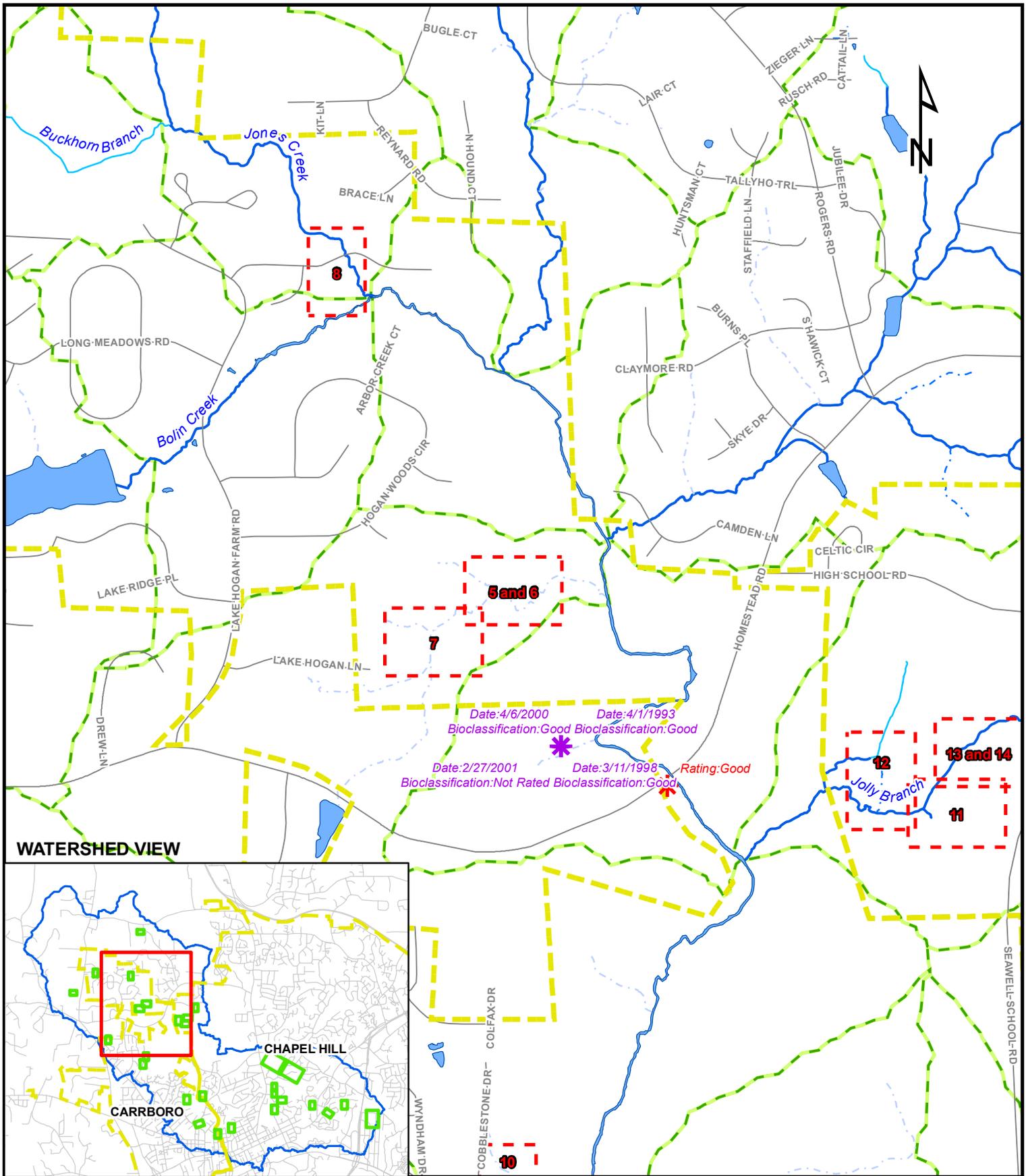


## **SITE 6**

Index Sheet No.: 11  
Raw Data Name: None



Estimated Construction Cost: \$35,000



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow

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**SITE 5 and 6 VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 6	4.5	1.3	30.0%

**Location**

Site 6 is located west of N. Cammelia Drive in the subdivision of Winmore, which is located off of Homestead Rd. At the time of this report, the subdivision was still under construction.

**Problem Description**

This basin is similar to the basin mentioned in Site 5. The problems and proposed solution here are the same as Site 5.

**Proposed Solution**

Refer to Site 5 solution.

Table 5.1 shows an estimated decrease in pollutant load on this site as a result of the proposed treatment. Because the site is still under construction, the percent impervious surface used in this calculation is based off a projected percent impervious, based on typical percentages in subdivision areas.

**Table 6.1**

SITE 6	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	9.92	1.57	292.55
STORM WATER WETLAND TREATMENT	20.00%	17.50%	42.50%
NET REDUCTION	1.98	0.27	124.33
FUTURE CONDITION	7.94	1.29	168.21

**Constraints**

Refer to Site 5 description.

**Alternatives**

No alternatives are proposed for this site.

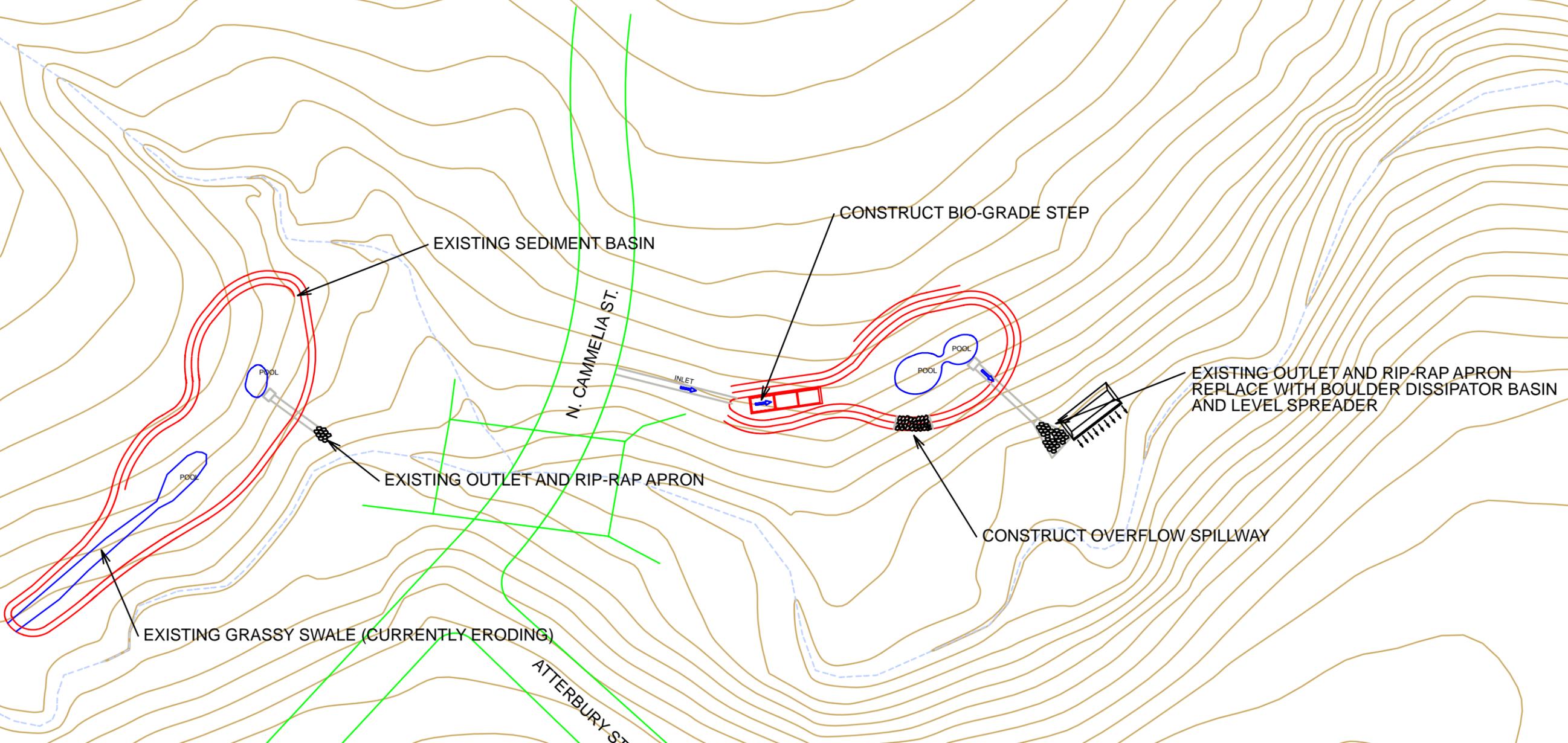
**Cost-Estimate Breakdown**

Table 5.2 shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

*Bolin Creek Watershed  
 Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 6.2**  
**Site 6 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	19628.0	CF	Equation Derived	\$30,067
<b>Total</b>				<b>\$30,067</b>
Mobilization (5%)	1.00	LS		\$1,503
Contingencies (10%)	1.00	LS		\$3,007
<b>Total + Mobilization and Contingencies</b>				<b>\$34,578</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		\$1,729



**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- · - · - Stream, unknown flow
- Contours

**EarthTech**  
A tyco International Ltd. Company

**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 25 50 100 Feet  
1 inch equals 50 feet



# SITE 5 and 6



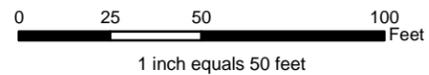
### Legend

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



### AERIAL PHOTO VIEW

BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits

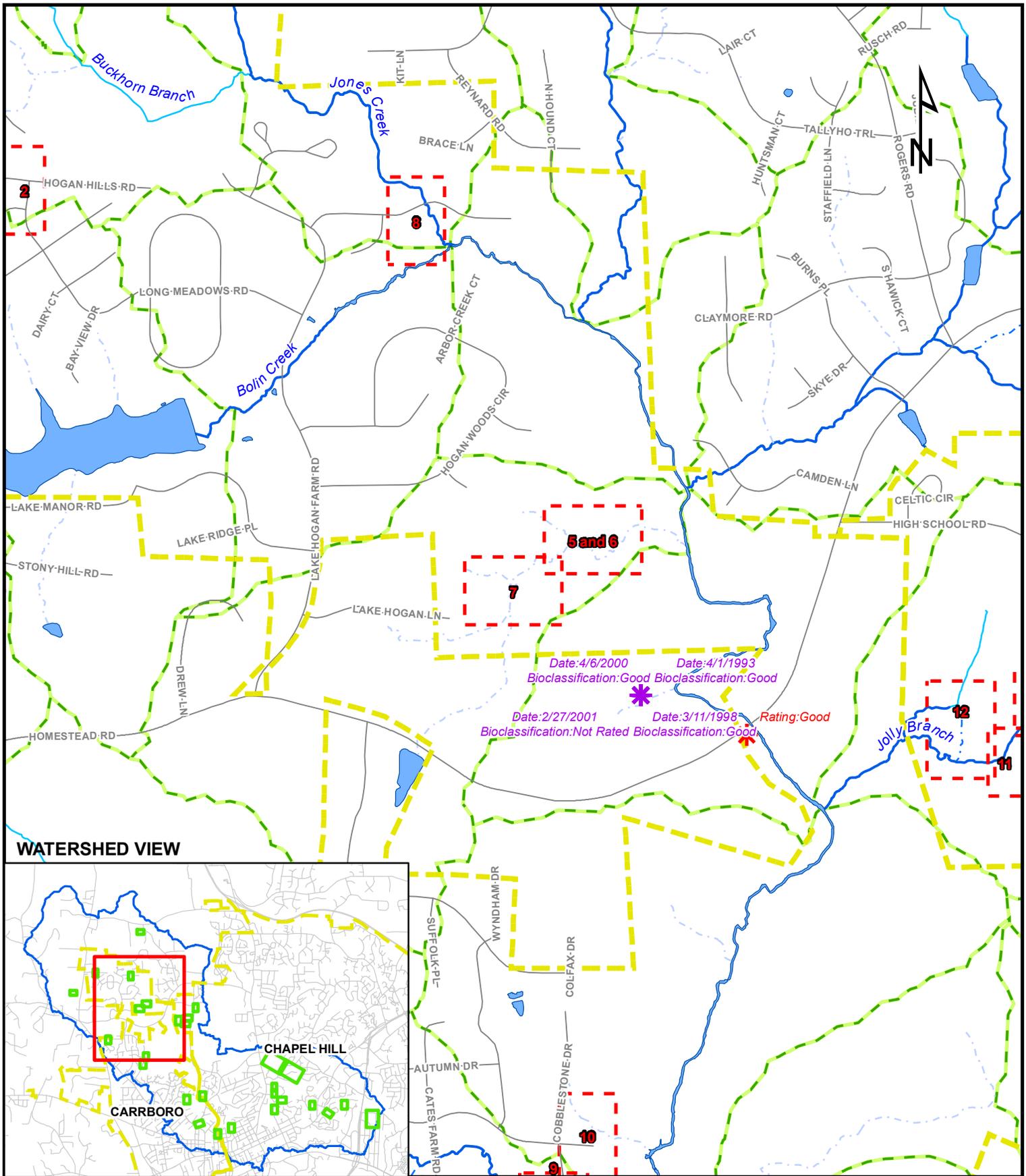


**SITE 7**

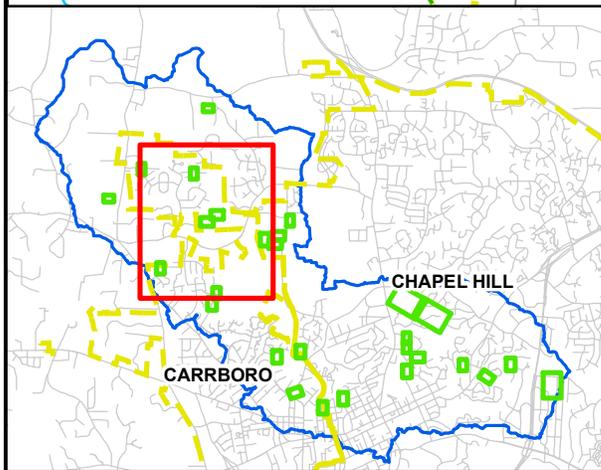
Index Sheet No.: 11  
Raw Data Name: None



Estimated Construction Cost: \$100,000



**WATERSHED VIEW**



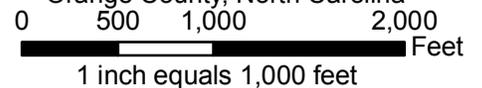
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 7  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 7	2.4	0.7	29.6%

**Location**

Site 7 is located west of S. Cammelia Drive and private alley in the subdivision of Winmore, which is located off of Homestead Rd. At the time of this report, the subdivision was still under construction.

**Problem Description**

The stormwater system coming from several acres of the Winmore subdivision is discharged at a location that is very near an un-named perennial stream. The pipe system outlet had a small pre-formed scour type sediment basin and the plans call for a rip-rap apron at the completion of construction. During the site visit, Earth Tech observed the effects of concentrated flow on the perennial stream and the flood plain. Rill erosion has begun and a head cut up from the stream to the outlet will likely be the end result of the erosive forces of the concentrated flows. Also, from a water quality point of view, the approximately 10' of distance between the BMP and the stream channel is not a sufficient filter strip. This BMP will very likely cause significant degradation to the water quality of the receiving waters due to the anticipated sediment inputs from future channel instability and direct inputs of nutrients.

**Proposed Solution**

The terrain of this site limits the options for retrofitting the existing BMP. A linear bio-retention area is proposed a solution to dissipative energy, reduce velocities by distributing flow over a significantly larger area, and utilizing a much larger area of biological treatment of nutrients by using the bioretention area itself and increased area of filter strip that results. This project would be a hybrid of a bioretention area with storage and a level spreader.

A secondary, although very significant benefit of this BMP retrofit would be the possibility of augmenting base flow via the stored stormwater volume. It may be desirable to add a series of “weeps” to the design which would be made of several collector pipes or seepage layer fill material with a vegetated geo-grid to prevent erosion due to the seep. An example of the later method would be the use of a pervious drain layer on a typical dam embankment design. The idea is to insure that you regain available storage volume in the BMP by allowing a delayed release of the volume over an extended period, up to 2 weeks, while intentionally adding base flow to the channel between rainfall events.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 7.1**

SITE 7	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	9.92	1.57	292.55
STORM WATER WETLAND TREATMENT	20.00%	17.50%	42.50%
NET REDUCTION	1.98	0.27	124.33
FUTURE CONDITION	7.94	1.29	168.21

**Constraints**

The primary constraint of this site is the boundary of the roadway on one side and the stream on the other. Access to the site is excellent and the terrain is suitable for equipment. Due to the confinement of the site, there will be modifications to the floodplain of the small stream and this will create some environmental concerns that must be considered and managed. In addition, a utilities easement is adjacent to the site, and thus a MOU or MOA may be required to be executed with the utilities entity to implement the project.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 7.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

**Table 7.2**

Site 7 Construction Cost

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bioretention Area	6933.0	CF	12.62	\$87,494
<b>Total</b>				<b>\$87,494</b>

Mobilization (5%)	1.00	LS	\$4,375
Contingencies (10%)	1.00	LS	\$8,749

Total + Mobilization and Contingencies			<b>\$100,619</b>
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**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	\$5,031
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**SITE 7**

CONSTRUCT BERM  
TIE TO EXISTING GRADE

CONSTRUCT BIORETENTION AREA  
WITH UNDERGROUND STORAGE  
IN FLOODPLAIN

EXISTING PIPE (TEMPORARY)

PRIVATE ALLEY

W. WINMORE AVE.

N. CAMMELIA ST.

E. WINMORE AVE.

S. CAMMELIA ST.

**Legend**

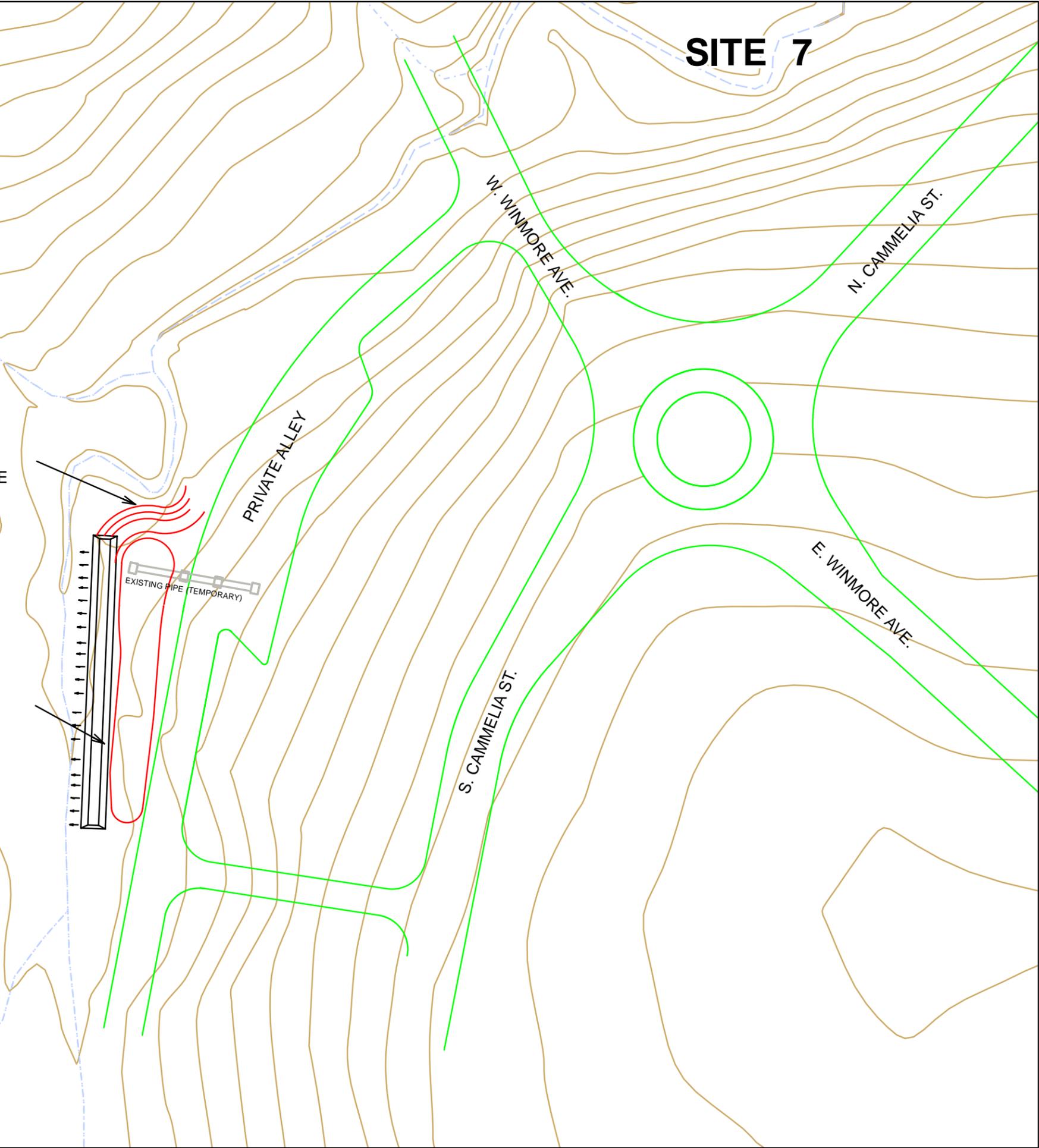
- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- · - · - Stream, unknown flow
- Contours




**EarthTech**  
A tyco International Ltd. Company

**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 25 50 100 Feet  
1 inch equals 50 feet





**SITE 7**

CONSTRUCT BERM  
TIE TO EXISTING GRADE

CONSTRUCT BIORETENTION AREA  
WITH UNDERGROUND STORAGE  
IN FLOODPLAIN

EXISTING PIPE (TEMPORARY)

PRIVATE ALLEY

W. WINMORE AVE.

N. CAMMELIA ST.

E. WINMORE AVE.

S. CAMMELIA ST.

- Legend**
- Stormwater Lines
  - Perennial Stream
  - Intermittent Stream
  - Ephemeral Stream
  - Stream, unknown flow



**AERIAL PHOTO VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits

0 25 50 100 Feet  
 1 inch equals 50 feet

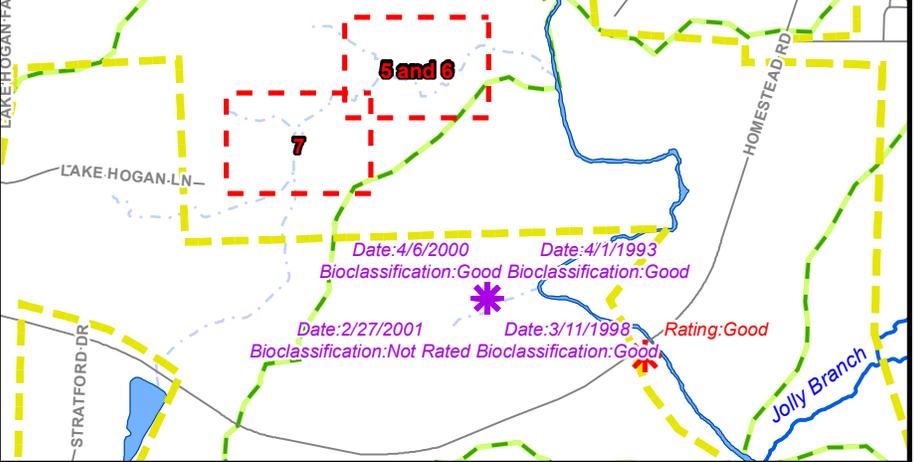
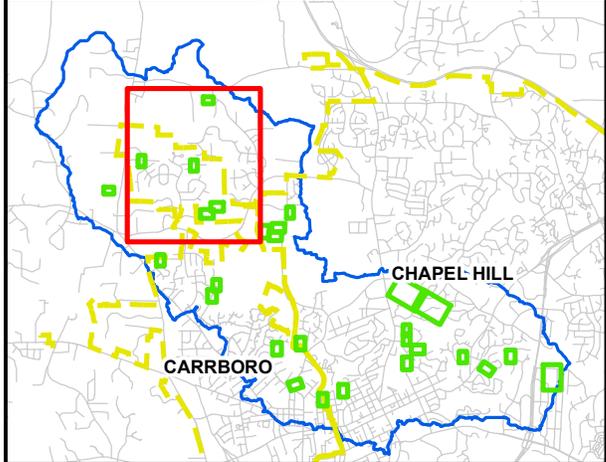
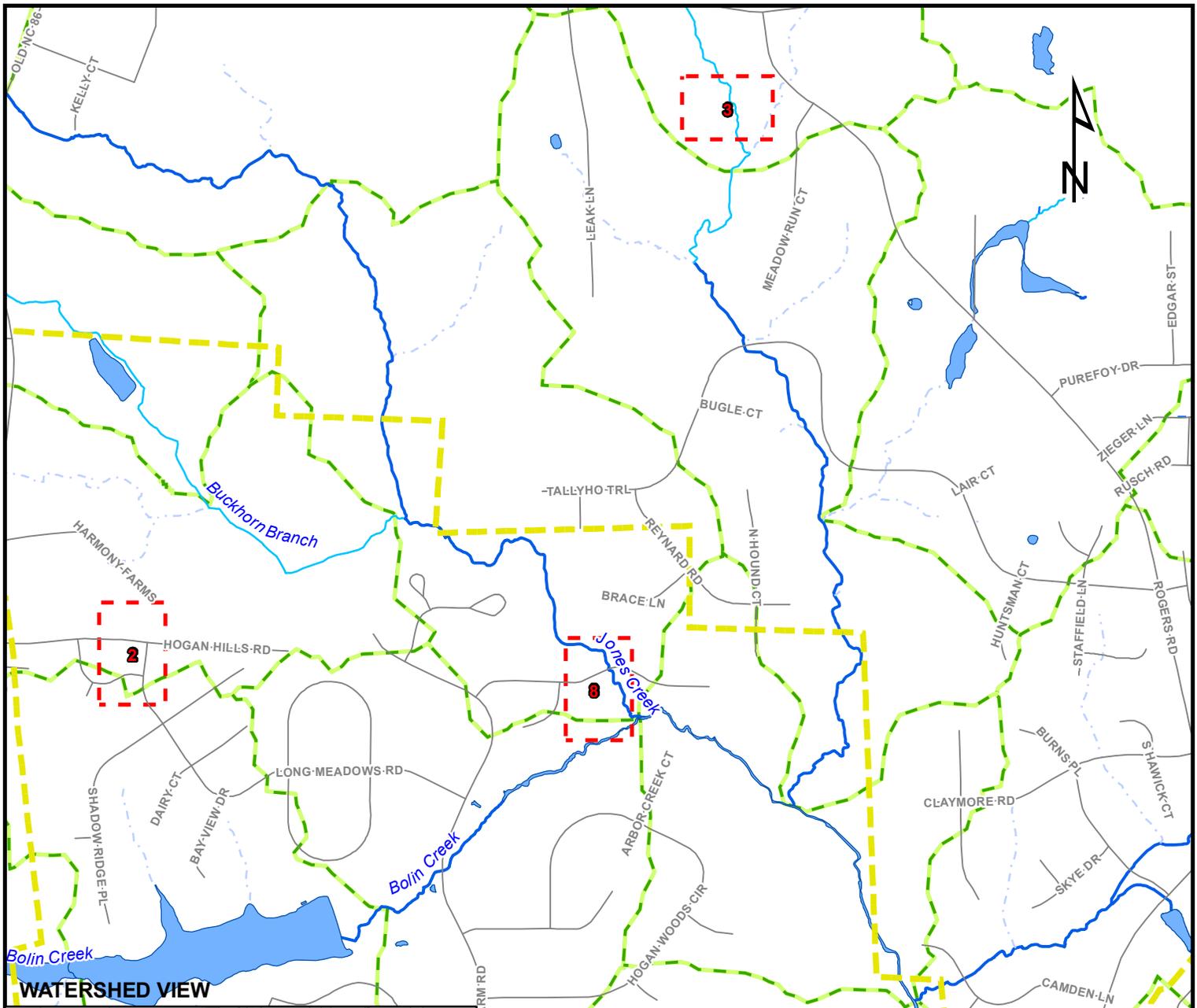
## **SITE 8**

Index Sheet No.: 11  
Raw Data Name: IJ 19

### **Retrofit of Existing Sediment Basin**



Estimated Construction Cost: \$19,000



**Legend**

Ambient Monitoring	Orange County Roads
Benthic Monitoring	Subwatersheds
Fish Sampling	Perennial Stream
Municipal Boundary	Intermittent Stream
	Ephemeral Stream
	Stream, unknown flow




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**SITE 8 VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 8	7.4	1.7	23.0%

**Location**

Site 8 is located near the intersection of Turtleback Crossing Drive and Painted Turtle Lane, in the Lake Hogan Farms subdivision.

**Problem Description**

The continuing development of the Lake Hogan Farms subdivision was observed to be impacting the surrounding stream systems, including Jones Creek and Bolin Creek. A number of small sediment basins, likely built during construction of the subdivision, are still in existence in various parts of the subdivision. These provide an opportunity for stormwater BMP retrofits for water quality treatment and the attenuation of peak flows, which should help to alleviate the stress on the surrounding streams.

At present, the BMP at Site 8 only serves as an energy dissipater with some water quantity management. The recessed boulder basin or energy dissipater is a good example of how a discharge outlet must typically be recessed to have an adequate effect of retaining the high velocity flows within a prescribed area. This BMP distributes its flow over a small area of about 20 feet, which then collects as a concentrated flow before entering the channel due to the natural terrain. Earth Tech observed signs of erosion due to this concentrated flow and further deterioration of the streambank of Jones Creek is expected to occur over time. No water quality treatment is presently achieved beyond what would occur due to some diffused flow through vegetation immediately after overflowing the crest of the basin.

**Proposed Solution**

The treatment at Site 8 should consist of retrofitting the existing basin into a stormwater wetland. This can be done by expanding the volume of the basin and digging out areas within the basin to serve as permanent pools. The wetland should have a constructed forebay to trap sediment and dissipate energy before reaching the remainder of the wetland. Areas of shallow land or low marsh benches can also be constructed to provide a diversity of habitat necessary for maximum pollutant removal. An outlet structure should be constructed consisting of an overflow weir that will discharge into a level spreader. The level spreader is important to ensure that flow spreads out diffusely into the surrounding floodplain, rather than concentrating into areas of scour. The entire site should be planted with native vegetation. A detailed site survey may reveal that the floodplain needs to be graded in order to maintain the diffused flow that will converge with Jones Creek. This project will also benefit from future water quality treatment by the use of the vegetated filter strip between the level spreader and Jones Creek, provided the site is adequate to maintain the shallow, diffused flow.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

Potential pollution removal rates using this method have been estimated and are shown in **Table 8.1**.

**Table 8.1**

SITE 8	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	12.47	1.26	169.43
STORM WATER WETLAND TREATMENT REMOVAL %	40.00%	35.00%	85.00%
NET REDUCTION	4.99	0.44	144.02
FUTURE CONDITION	7.48	0.82	25.42

**Constraints**

An agreement may have to be worked out with the surrounding landowners to provide drainage and access easements, which are required for stormwater wetlands (NCDWQ, 2007). As with other projects, working in the riparian zone will require care and consideration of water quality effects of the construction project.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 8.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

**Table 8.2**

**Site 8 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	8365.0	CF	Equation Derived	\$16,536
<b>Total</b>				<b>\$16,536</b>

Mobilization (5%)	1.0	LS	\$827
Contingencies (10%)	1.0	LS	\$1,654

Total + Mobilization and Contingencies **\$19,017**

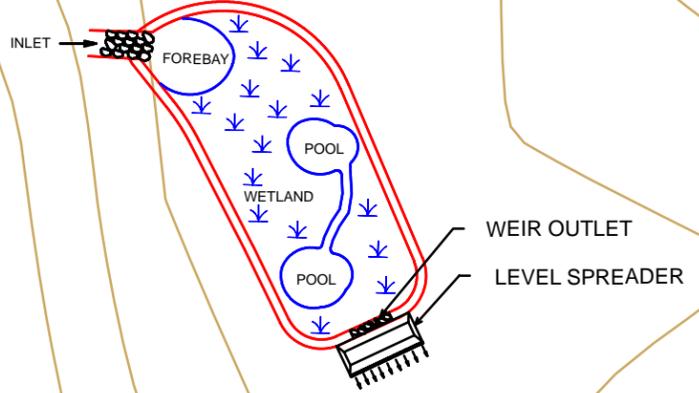
**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	<b>\$951</b>
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**SITE 8**



**TURTLEBACK CROSSING DR**



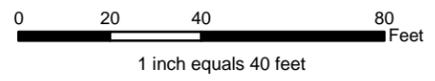
Jones Creek

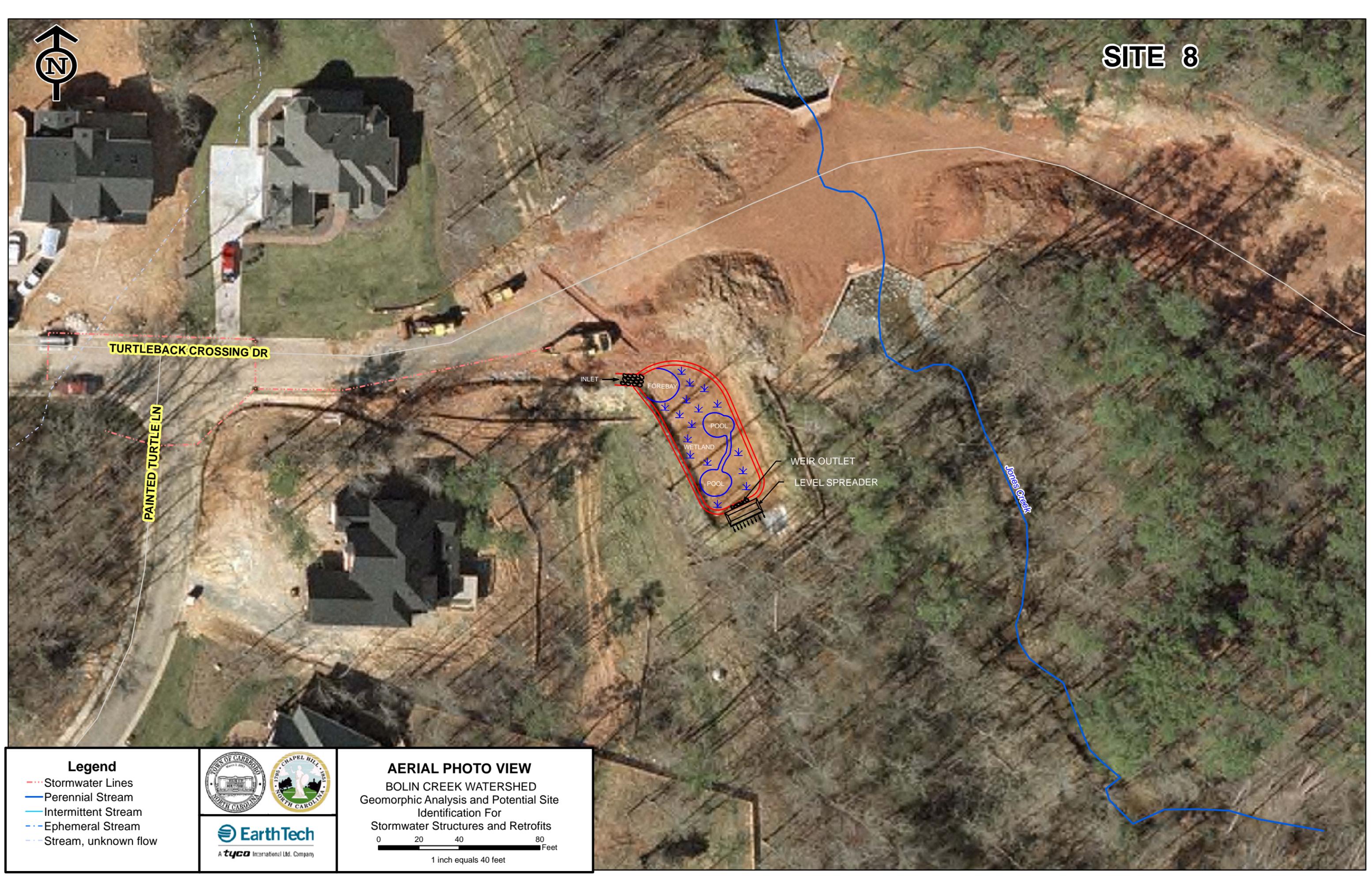
**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits





TURTLEBACK CROSSING DR

PAINTED TURTLE LN

INLET

FOREBAY

POOL

WETLAND

POOL

WEIR OUTLET

LEVEL SPREADER

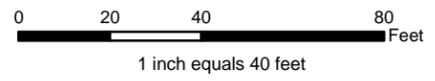
James Creek

**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits



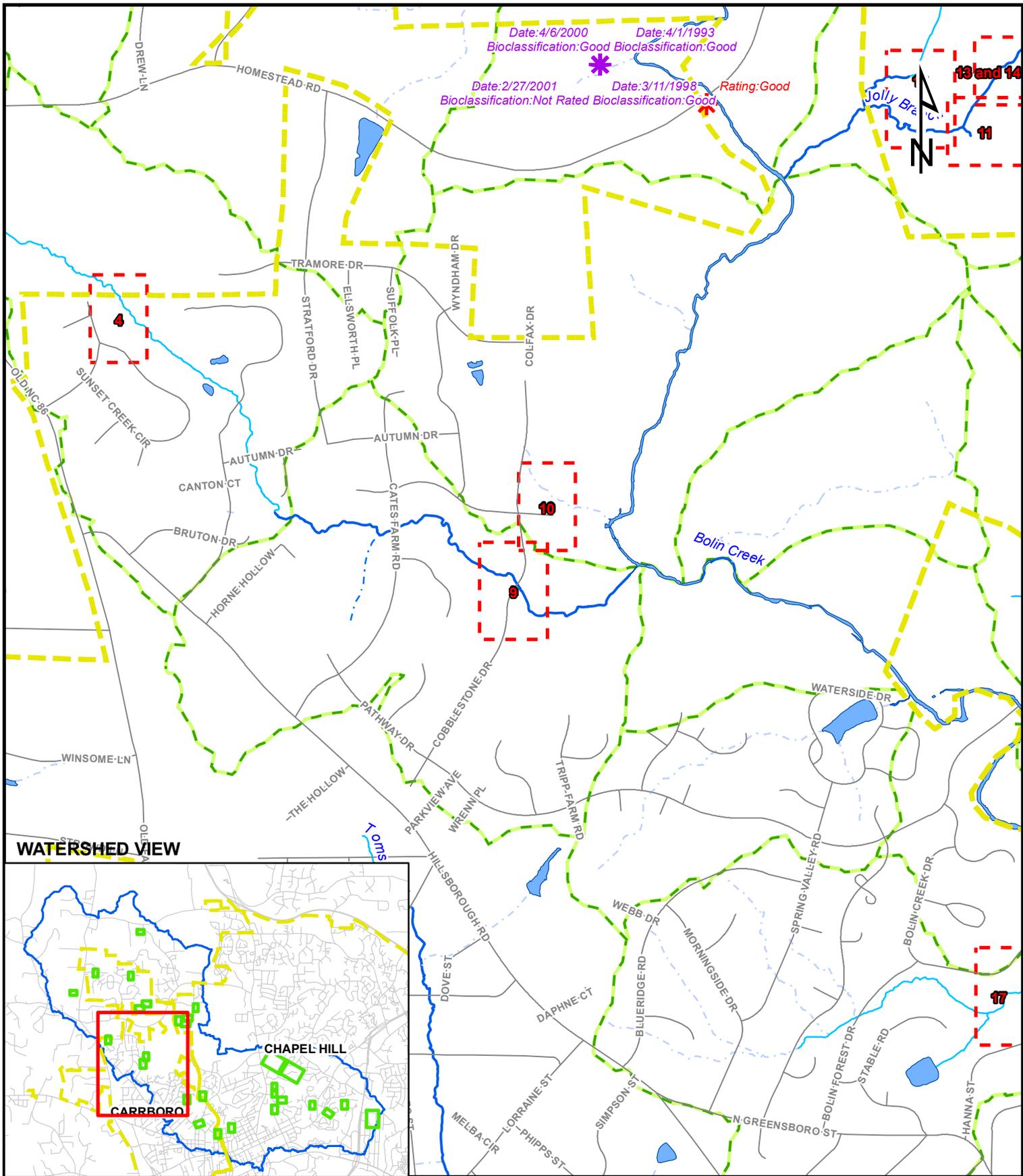
## **SITE 9**

### **Bank Stabilization and Flow Attenuation**

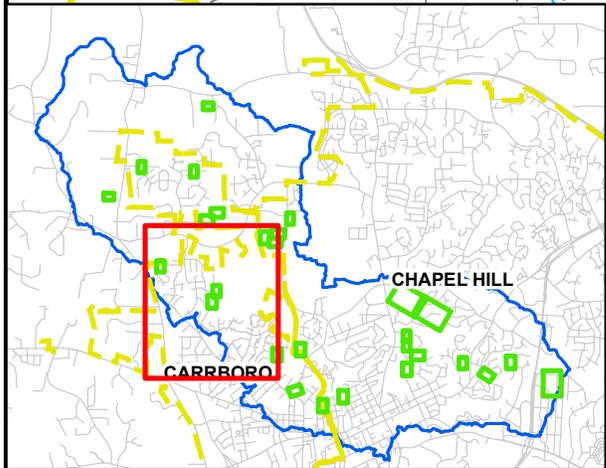
Index Sheet No.: 14  
Raw Data Name: TA 5, TA 6 and TA 7



Estimated Construction Cost: \$18,200



**WATERSHED VIEW**



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 9 VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

### **Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 9	290.8	42.8	14.7%

### **Location**

Site 9 is located on the west and east sides of Cobblestone Drive where the road passes over a tributary to Bolin Creek.

### **Problem Description**

Site 9 consists of an approximately 70 feet long stretch of an unnamed tributary to Bolin Creek which is experiencing extreme bank erosion on both banks as it approaches a road crossing. The erosion is likely due to combination of effects to channel stability that are created from the road crossing, a lack of a vegetated riparian buffer that would otherwise provide root stabilization on the banks, and increased peak flows from the high impervious surface of the contributing drainage area. Downstream of the road crossing, an additional area of extreme bank erosion is present on the outside of a meander bend.

The extreme bank erosion has been estimated to be contributing approximately 95 tons of sediment per year, or approximately 1.4 tons per year per foot of channel. Concomitant nutrient export has also been calculated and is listed in **Table 9.1**. In addition, the lateral movement of the stream cross section is causing adjacent landowners to lose more of their property every year. Therefore, the severity of the problem at this site warrants immediate action.

### **Proposed Solution**

As with other bank stabilization/restoration projects, this site could benefit mainly from a change in the stream cross-section that provides the following:

- a bankfull bench that gives the stream access to a small floodplain which reduces the depth of flow near the bank and thus significantly reduces near bank stress during above-bankfull events
- reduced bank slopes, at a maximum of 2:1
- vegetated banks with woody plants that will provide stabilization through rooting mass

By modifying the cross-section of the stream in this way for the length of the extreme eroding banks, the sediment export rates of this site could potentially be reduced to 0.2 tons per year, with a corresponding reduction in nutrient export. Calculated sediment and nutrient reductions are shown in **Table 9.1**.

In addition to the change in cross-section of the stream, a wide, abandoned floodplain area adjacent to the stream on the downstream side of the road crossing provides a good location for an offline stormwater wetland or wet detention pond. A weir or other diversionary device could be placed in the stream upstream of the wetland, and allow for a certain percentage of stormflow to be diverted into the wetland while not interfering with the continual baseflow of the stream. The primary benefit of this would be

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

reduction of peak flow during storm events, which could possibly reduce near bank stress on eroding banks downstream. A secondary benefit would be the possibility to augment baseflow by storing some of the runoff volume in the basin, which can be intentionally or passively discharged into the stream over longer periods of time.

**Table 9.1**

Pre-Treatment	
Estimated Total Sediment Export	95.1 tons/year
Erosion per length of Channel	1.4 tons/yr/ft
Pounds of Nitrogen	190.2 lbs/year
Pounds of Phosphorus	95.1 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.2 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	0.4 lbs/year
Pounds of Phosphorus	0.2 lbs/year

**Constraints**

The primary constraint at this site is land acquisition and landowner cooperation, as it is located in a residential area with privately owned land on either side of the stream. Stormwater easements should be checked to see if work can be performed within the easements, primarily in laying back banks and revegetating the riparian area. In addition, a utilities easement is adjacent to the site, and thus a MOU or MOA may be required to be executed with the utilities entity to implement the project.

**Alternatives**

No alternatives are proposed for this site.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Cost-Estimate Breakdown**

**Table 9.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

**Table 9.2**  
Site 9 Construction Cost

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	62.0	CY	15.00	\$930
Stormwater Wetland	2534.0	CF	Equation Derived	\$7,159
Site Preparation and Planting	0.1	AC	7500.00	\$750
Rip Rap Class B	10.0	Tons	45.00	\$450
Filter Fabric	30.0	SY	5.00	\$150
Silt Fence	200.0	LF	3.75	\$750
Construction Safety Fence	260.0	LF	2.50	\$650
Construction Entrance	2.0	Ea	2500.00	\$5,000
			<b>Total</b>	<b>\$15,839</b>
Mobilization (5%)	1.0	LS		\$792
Contingencies (10%)	1.0	LS		\$1,584
			<b>Total + Mobilization and Contingencies</b>	<b>\$18,215</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		<b>\$911</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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EXISTING 4-10 FT ERODING BANKS

BUILD BANKFULL BENCH AND LAY BACK BANKS

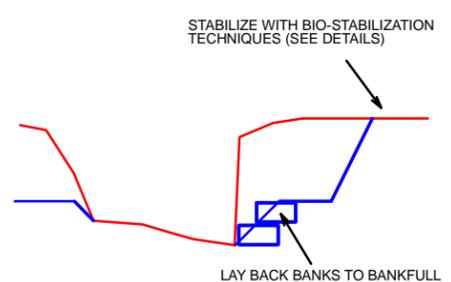
REVEGETATE BUFFER

INSTALL FLOW DIVERSION

CONSTRUCT OFFLINE STORMWATER WETLAND FOR FLOW ATTENUATION

**COBBLESTONE DR**

**CONCEPTUAL CROSS SECTION**



STABILIZE WITH BIO-STABILIZATION TECHNIQUES (SEE DETAILS)

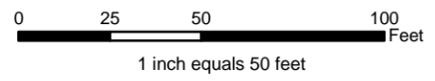
LAY BACK BANKS TO BANKFULL

NOT TO SCALE

- Legend**
- Stormwater Lines
  - Impervious Surfaces
  - Perennial Stream
  - Intermittent Stream
  - Ephemeral Stream
  - Stream, unknown flow
  - Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 9**

EXISTING 4-10 FT ERODING BANKS

BUILD BANKFULL BENCH AND LAY BACK BANKS

REVEGETATE BUFFER

INSTALL FLOW DIVERSION

**COBBLESTONE DR**

CONSTRUCT OFFLINE STORMWATER WETLAND FOR FLOW ATTENUATION

**CONCEPTUAL CROSS SECTION**



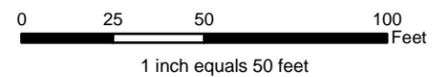
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- - - Stream, unknown flow



**AERIAL PHOTO VIEW**

**BOLIN CREEK WATERSHED**  
Geomorphic Analysis and Potential Site Identification For  
Stormwater Structures and Retrofits



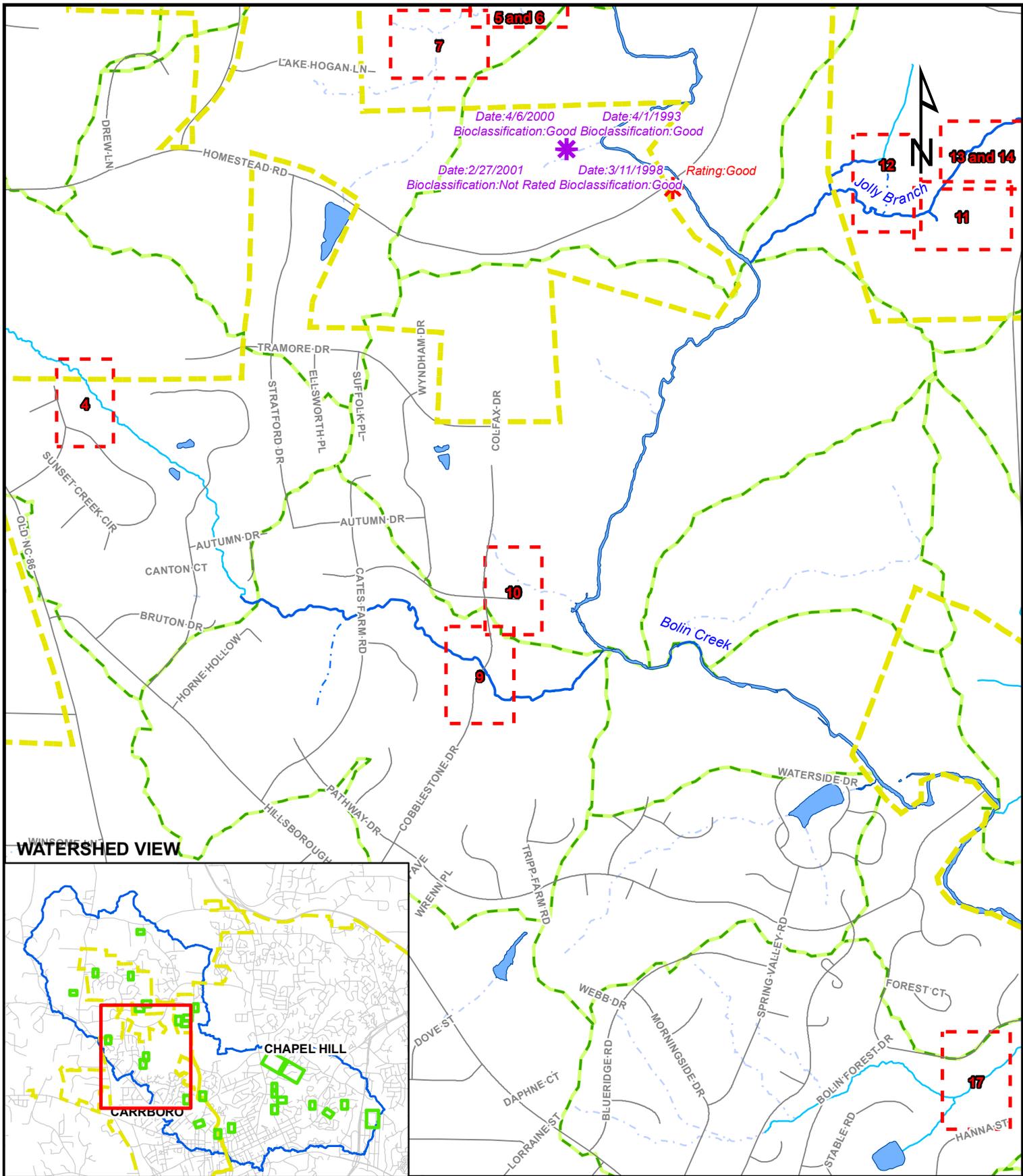
## **SITE 10**

### **Construction of Stormwater Wetland on Ephemeral Channel**

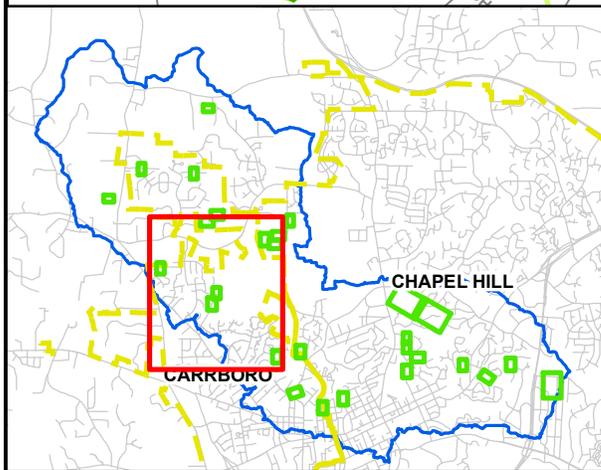
Index Sheet No.: 15  
Raw Data Name: TA 12



Estimated Construction Cost: \$48,300



**WATERSHED VIEW**



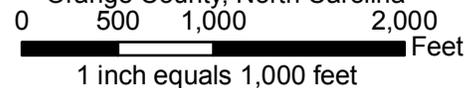
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 10  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 10	36.0	7.7	21.3%

**Location**

Site 10 is located to the east of Rockgarden Rd and Cobblestone Dr., behind several houses and adjacent to a sewer easement. To get to the site from downtown Carrboro, take Greensboro St. until it joins with Hillsborough Rd., and proceed north for a half mile before turning right on Cobbleston Dr. At the intersection with Rockgarden Rd. turn right into a dead end road. The site is downhill and to the north of the dead end.

**Problem Description**

Site 10 consists of an ephemeral stream (drainage area approximately 36 acres) that flows diffusely through a flat wooded area behind the yards of two houses, and then becomes concentrated where the slope of the valley begins to steepen. The stream flows directly into Bolin Creek after only a short distance downhill. Where the flow concentrates, a discernible head cut has formed, and is advancing upstream. The head cut is most likely caused by an increased amount of flow in the watershed due to the increase in impervious area, and the lowering of bed elevations of Bolin Creek, which is causing a corresponding drop in the bed of the tributary stream. Currently, the contributing drainage area of the stream has no water quality or water quantity treatment.

**Proposed Solution**

The topographically flat area present at Site 10 provides a good location to construct a stormwater wetland or bio-retention area at minimal cost. Due to the ephemeral nature of the drainage feature and large area available, a stormwater wetland is advised. A large enough area is present that the wetland could treat the calculated water quality treatment volume (WQv) for the contributing drainage area. A bio-retention area could be constructed, if a smaller surface area were used than what is proposed, otherwise the cost of the bioretention area, which is typically much higher than that of a comparably sized stormwater wetland, would be prohibitively expensive.

Potential pollution removal rates using this method have been estimated and are shown in **Table 10.1**.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 10.1**

SITE 15-01	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	13.07	1.32	178.06
STORMWATER WETLAND TREATMENT REMOVAL %	37.00%	35.00%	85.00%
NET REDUCTION	4.84	0.46	151.35
FUTURE CONDITION	8.24	0.86	26.71

The stream that flows through Site 10 is labeled as “unknown flow” by both the Carrboro and Chapel Hill stream data, and therefore would need to be verified as ephemeral before construction of an in-line stormwater wetland. Earth Tech based our ephemeral classification purely on field experience and experience with DWQ stream classification forms.

The current nutrient export rates, and potential benefit of a stormwater wetland here have been calculated based on land use, drainage area and percent imperviousness of the drainage area, and are displayed in **Table 10.1**:

**Constraints**

The biggest constraint at this site could potentially be landowner cooperation and land acquisition. The access easement could be obtained to the current dead end of Rockgarden Rd, which is uphill of the project site. In addition, an existing sewer line runs parallel to the project site, indicating that a drainage easement may exist at the site. .

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 10.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

**Table 10.2**

SITE 10				
Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	31652.0	CF	Equation Derived	\$42,031
<b>Total</b>				<b>\$42,031</b>
Mobilization (5%)	1.0	LS		\$2,102
Contingencies (10%)	1.0	LS		\$4,203
<b>Total + Mobilization and Contingencies</b>				<b>\$48,336</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		\$2,417



STORMWATER WETLAND AREA

LEVEL SPREADER

**ROCKGARDEN RD**

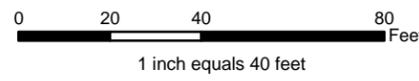
**COBBLESTONE DR**

**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits





**SITE 10**

STORMWATER WETLAND AREA

LEVEL SPREADER

ROCKGARDEN RD

COBBLESTONE DR

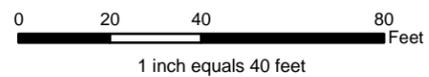
**Legend**

- - - Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- - - Stream, unknown flow



**AERIAL PHOTO VIEW**

BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

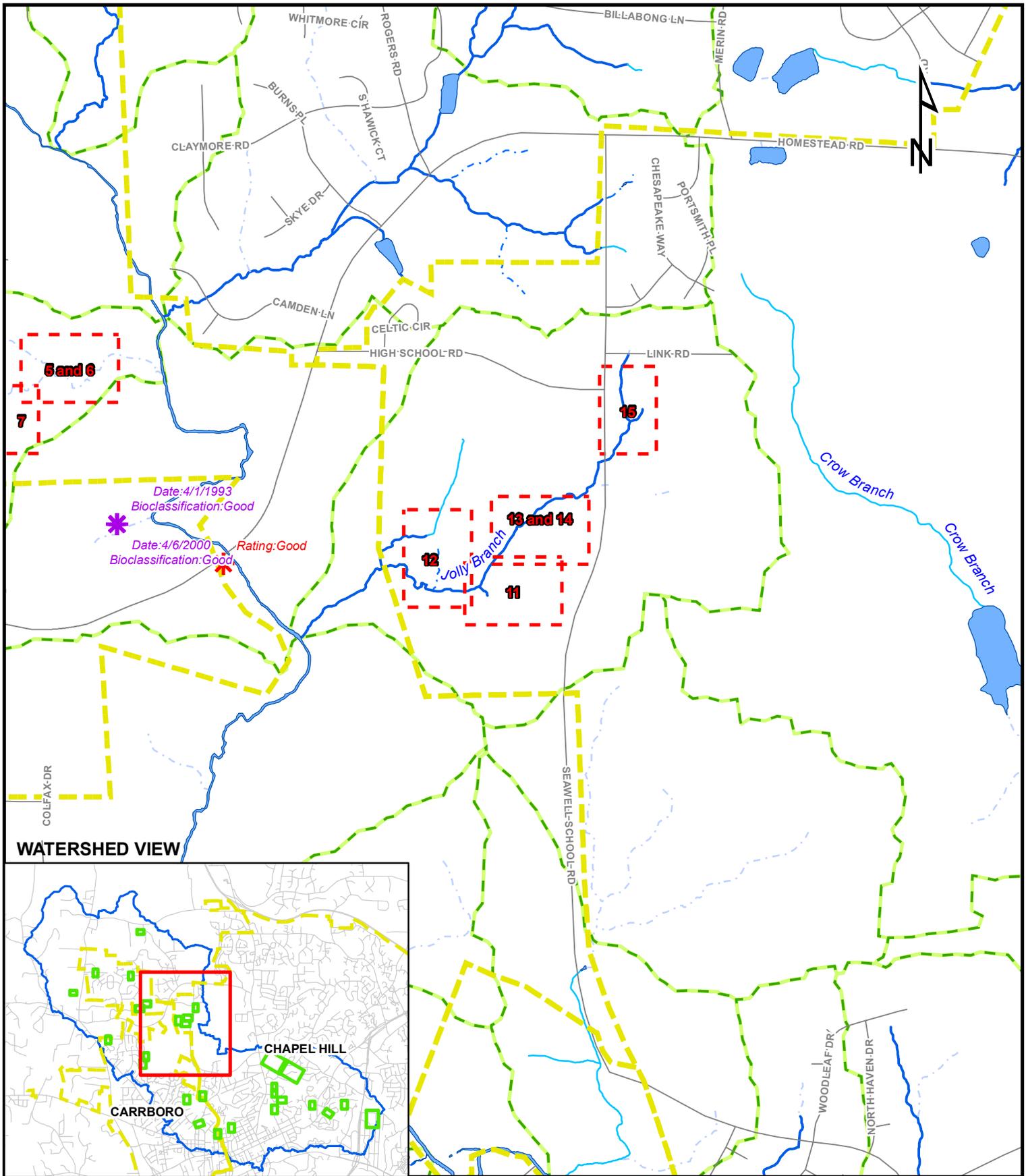


**SITE 11**  
**BMP retrofits at Smith Middle School**

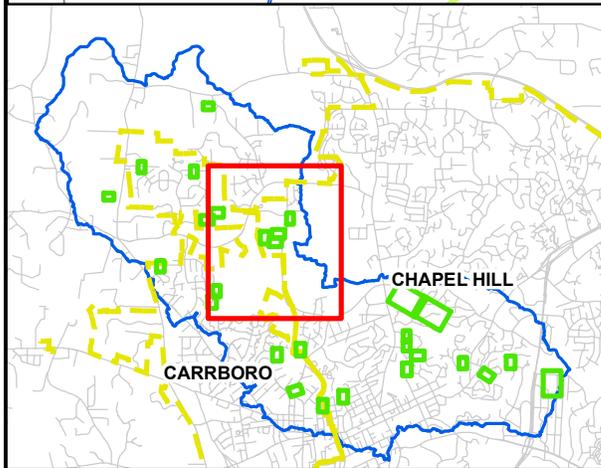
Index Sheet No.: 16  
Raw Data Name: IJ 34



Estimated Construction Cost: \$30,000-\$110,000



**WATERSHED VIEW**



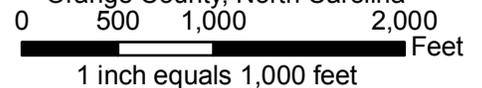
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 11  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 16-01	10.8	4.1	38.0%

**Location**

Site 11 is just north of the soccer field and track at Smith Middle School, which is located off Seawell School Road.

**Problem Description**

At Smith Middle School, it appears that most of the stormwater that collects on the schools rooftops and parking lots is routed to an outlet pipe at the northwestern corner of the school site. This outlet pipe, which is approximately 36” in diameter, currently has no water quality treatment in the form of retention or detention downstream of it. Instead, the pipe discharges stormwater into a pre-formed scour hole, then into a concentrated channel that flows into the nearby perennial stream, Jolly Branch. Thus, the pollutants collecting on-site flow into Jolly Branch with no treatment. Additionally, field observations indicate that the concentrated flows that leave the small pre-formed scour hole is causing erosion and will continue to degrade the floodplain and stream channel over time.

Sites 11 through 15 are in close proximity to each other, and could therefore be integrated amongst themselves as a single package. In addition, other similar opportunities for the work proposed here are present throughout the three surrounding campuses, as well as other parts of the Jolly Branch watershed.

**Proposed Solution**

Site 11 offers a good location for stormwater BMP retrofits, with the added benefit of public exposure and educational opportunities for students of the surrounding schools. The primary location for a Stormwater BMP is at the outlet pipe on the northwestern corner of the school property. Here, the pre-formed scour hole that was constructed can be expanded, and dug out to create a wet detention pond (wet pond). The wet detention pond will contain a permanent pool that will allow aquatic vegetation to thrive in the structure year-round. The floodplain has sufficient room to allow for this retrofit. The pond should have a boulder basin underneath the outlet pipe to provide energy dissipation.

The outlet structure of the wet detention pond should consist of a riser pipe, and then a level spreader just downhill of the pond. It is important that the level-spreader be used, so as to prevent flow from concentrating into an incised channel before reaching Jolly Branch. The floodplain along the channel provides ample room to install a level spreader parallel with the channel.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

Any tree removal that is necessary can provide an opportunity to educate the students of neighboring schools about forest secession and how gap communities can dramatically increase diversity.

Pollutant reduction rates as a result of stormwater treatment are shown in **Table 11.1**.

**Table 11.1**

SITE 11	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	10.97	1.22	284.48
WET DETENTION TREATMENT	25.00%	40.00%	85.00%
NET REDUCTION	2.74	0.49	241.81
FUTURE CONDITION	8.23	0.73	42.67

### **Constraints**

The recommended treatment may require removal of a few trees in order to excavate the necessary volume for the wet detention pond.

The site is located on public land, therefore an acquisition should not prove to be a constraint.

### **Alternatives**

In addition to the treatment mentioned above, several additional treatments could be implemented at this site to further capture and treat stormwater.

Alternative 1: consists of the treatment outlined above, with the construction of a wet detention pond with an energy dissipater basin and level spreader.

Alternative 2: consists of the treatment of Alternative 1, with the addition of the construction of an underground filtration area into which the stormwater system of the school is re-routed. This filtration area could be built beneath the existing soccer field, and would contain an aggregate material that would allow the stormwater to infiltrate into the surrounding soil. An overflow pipe would be built at a certain elevation within this area to allow any volume above the water quality treatment volume to discharge into the pipe outlet and wet detention pond constructed in Alternative 1. Construction of this system would also require a flow-splitting device to be placed before stormwater reaches the primary outlet.

Several drop inlets are located in the lawn areas around Smith Middle School, and each of these has the potential to harbor a small bio-retention area. In this way, the runoff of the rooftop would be treated immediately before entering the stormwater system of the school.

### **Cost-Estimate Breakdown**

**Tables 11.2 and 11.3** show a conceptual itemized cost estimate for both alternatives at Site 11. These costs represent construction and maintenance costs only. The cost for the bioretention areas are derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007). In the same study, the cost of an underground

*Bolin Creek Watershed*  
*Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

infiltration area, similar to that proposed at this site, was stated to be similar to that of the cost of a bioretention area, therefore these two costs are the same. The cost for the wet detention pond is derived from an equation developed by Brown and Schueler (1997).

**Table 11.2**  
**SITE 11 Alternative 1**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Wet Detention Pond	3762.0	CF	Equation Derived	\$26,368
<b>Total</b>				<b>\$26,368</b>

Mobilization (5%)	1.0	LS	\$1,318
Contingencies (10%)	1.0	LS	\$2,637

Total + **Mobilization and Contingencies**      **\$30,323**

**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	<b>\$1,516</b>
--	-----	------	----------------

**Table 11.3**  
**SITE 11 Alternative 2**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Wet Detention Pond	3762.0	CF	Equation Derived	\$26,368
Bioretention Areas (x4)	3040.0	CF	12.62	\$38,365
Underground Storage Area	2500.0	CF	12.62	\$31,550
<b>Total</b>				<b>\$96,283</b>

Mobilization (5%)	1.0	LS	\$4,814
Contingencies (10%)	1.0	LS	\$9,628

Total + **Mobilization and Contingencies**      **\$110,725**

**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	<b>\$5,536</b>
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SMITH MIDDLE SCHOOL

**SITE 11**

Jolly Branch

ALTERNATIVE 2:  
BIORETENTION AREAS  
AT EACH DROP INLET

EXISTING PIPE OUTLET

OVERFLOW CONNECTION TO OUTLET

COLLECTS FROM BIORETENTION AREAS

ALTERNATIVE 2:

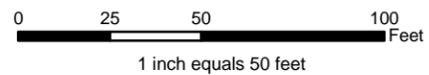
EXISTING SOCCER FIELD

**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





Jolly Branch

NORTH MIDDLE

SITE 11



ALTERNATIVE 2:  
BIORETENTION AREAS  
AT EACH DROP INLET



EXISTING PIPE OUTLET

OVERFLOW CONNECTION TO OUTLET

COLLECTS FROM BIORETENTION AREAS

ALTERNATIVE 2:

EXISTING SOCCER FIELD

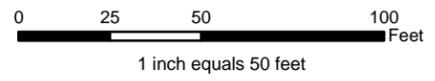
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

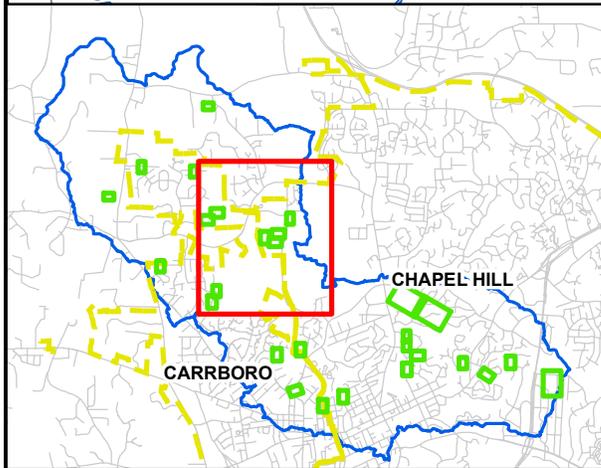
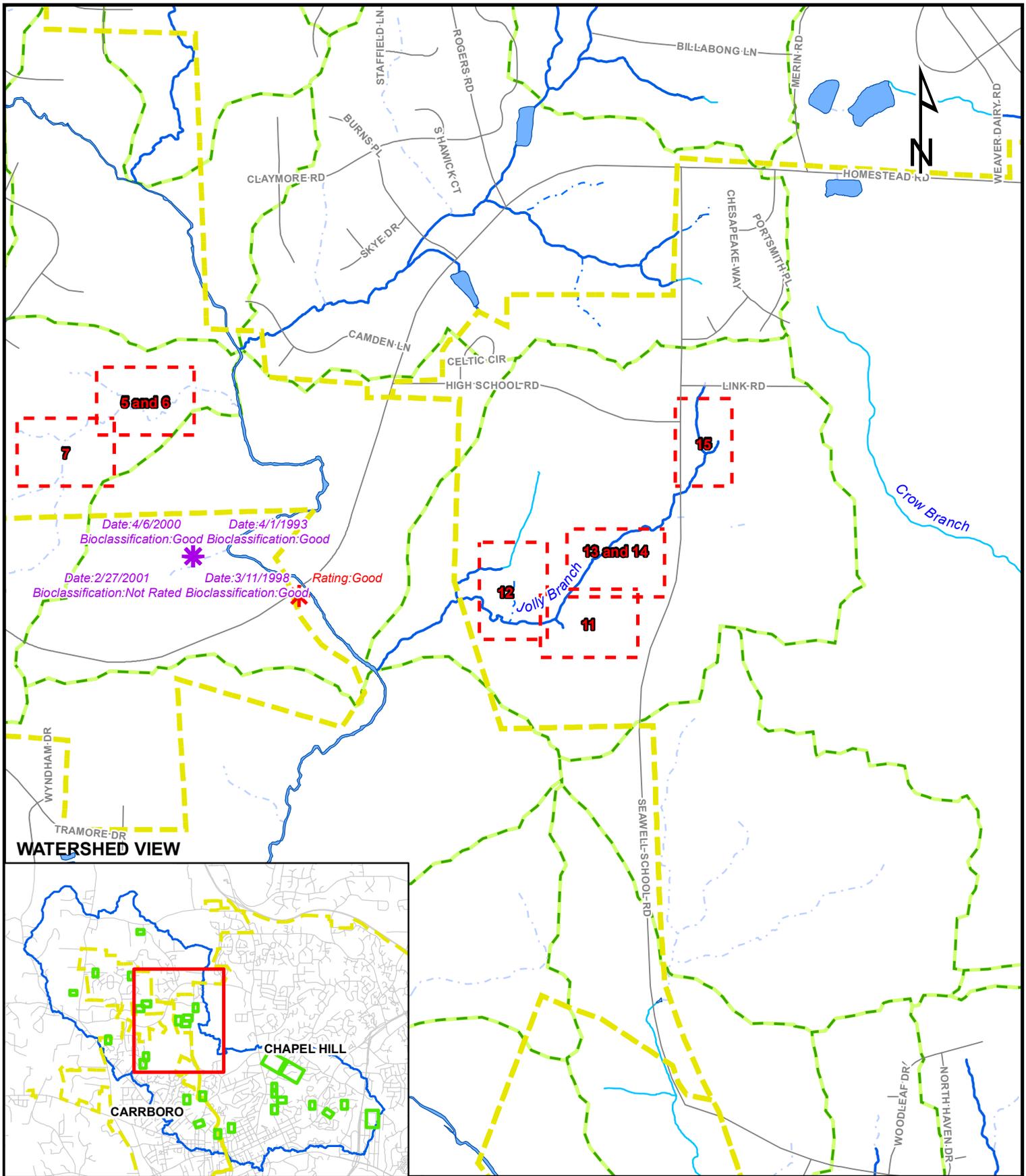
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



## **SITE 12**

Index Sheet No.: 16  
Raw Data Name: IJ 24

Estimated Construction Cost: \$69,300



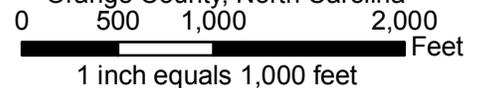
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 12  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 12	10.8	4.1	38.0%

**Location**

Site 12 is located on the western side of the football stadium and track at Chapel Hill High School. Chapel Hill High School is located at the intersections of Seawell School Rd. and High School. Rd.

**Problem Description**

Site 12 consists of a corrugated metal pipe outlet and ditch draining part of the football stadium facility at Chapel Hill High School. The football field is likely fertilized on a regular basis. The ditch discharges the stormwater from this field into Jolly Branch, a perennial stream, without any water quality treatment. Several spots of geomorphic instability, in the form of eroding banks and scour lines in the floodplain, were noted in Jolly Branch where these stormwater inputs reach a confluence.

Sites 11 through 15 are in close proximity to each other, and could therefore be integrated amongst themselves as a single package. In addition, other similar opportunities for the work proposed here are present throughout the three surrounding campuses, as well as other parts of the Jolly Branch watershed.

**Proposed Solution**

Site 12 provides a good location for a bio-grade step (see Details). Constructing this BMP in this location would provide needed treatment of the stormwater produced by the contributing drainage area and reduce velocities of the flows reaching Jolly Branch. The bio-grade step allows for a linear shaped, grade-control BMP solution that will prevent future head cutting of the drainage ditch, while using minimum area.

The storage of some of the runoff volume will potentially augment baseflow to the stream and reduce the runoff volume that reaches the stream for the duration of the rain event. This attenuation of peak flows and chance to augment base flow is another tangible benefit of the linear bioretention.

Pollutant reduction rates as a result of stormwater treatment are shown in **Table 12.1**.

**Table 12.1**

SITE 12	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	7.35	0.82	190.56
BIORETENTION TREATMENT REMOVAL %	37.00%	45.00%	85.00%
NET REDUCTION	2.72	0.37	161.97
FUTURE CONDITION	4.63	0.45	28.58

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Constraints**

The primary constraints at Site 12 are the existing trees, that would need to be removed to provide room for construction of the bio-grade step. However, the bio-grade step uses minimum surface area, and could probably be constructed with the least impact to the surrounding forest in comparison to other BMP options.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

Tables 12.2 shows a conceptual itemized cost estimate for Site 12. These costs represent construction and maintenance costs only. The cost for the bio-grade step is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

**Table 12.2**  
SITE 12

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Biograde Step	4779.0	CF	12.62	\$60,311
			<b>Total</b>	<b>\$60,311</b>
Mobilization (5%)	1.0	LS		\$3,016
Contingencies (10%)	1.0	LS		\$6,031
			<b>Total + Mobilization and Contingencies</b>	<b>\$69,358</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		<b>\$3,468</b>



# SITE 12



CHAPEL HILL HIGH SCHOOL  
FOOTBALL FIELD AND TRACK

EXISTING PIPE OUTLET  
DRAINS FOOTBALL FIELD

BIO-GRADE STEPS

LEVEL SPREADER

ALTERNATIVE 1:  
SMALL WET POND WITH LEVEL SPREADER

Jolly Branch

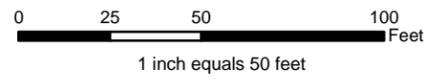
### Legend

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- - - Stream, unknown flow



### AERIAL PHOTO VIEW

BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

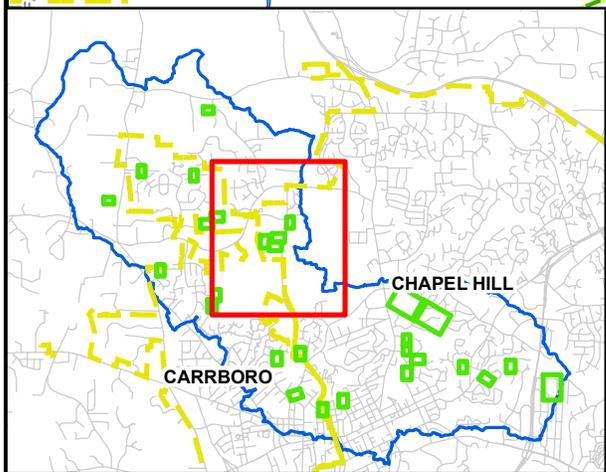
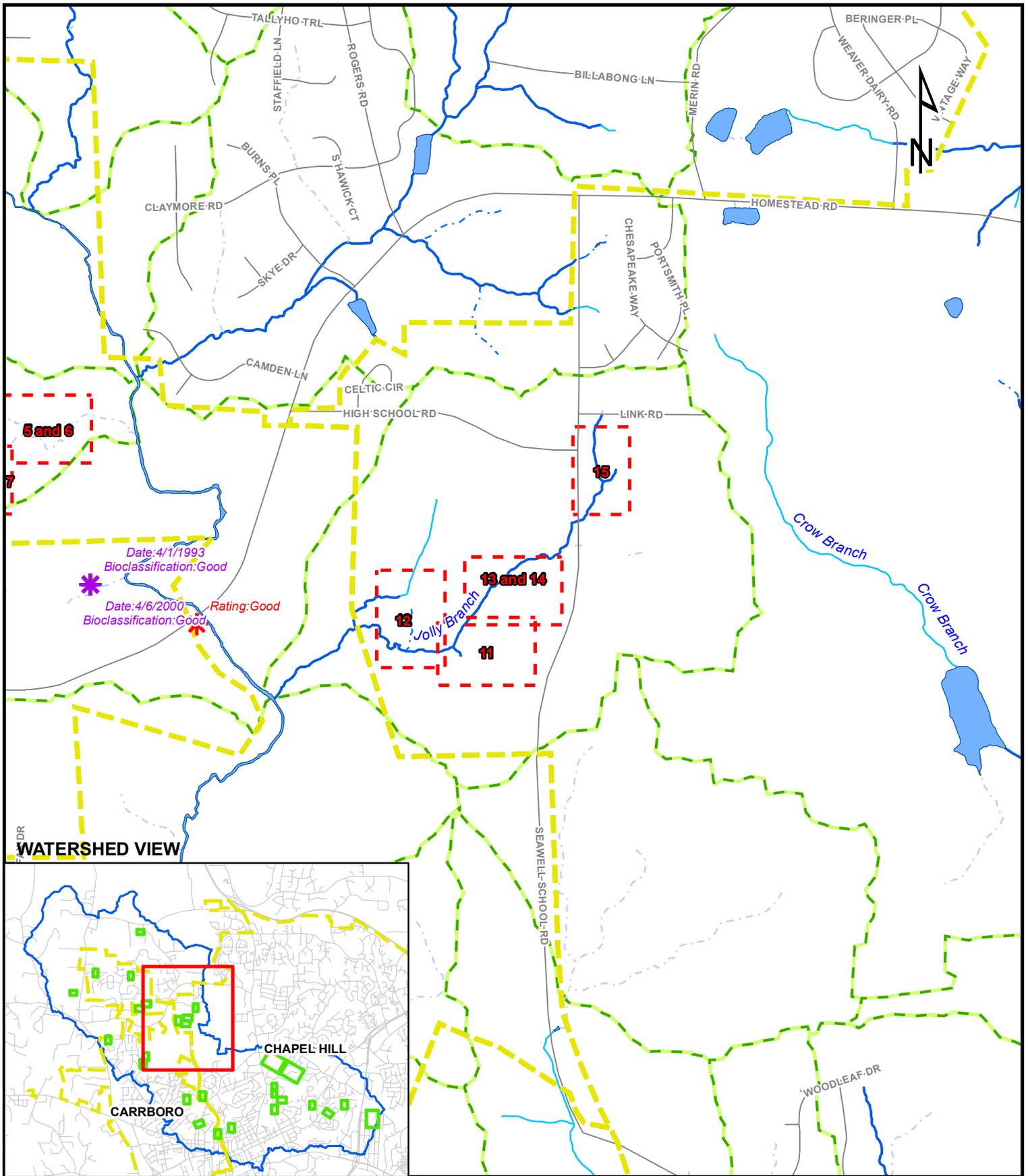


## **SITE 13**

Index Sheet No.: 16  
Raw Data Name: IJ 32



Estimated Construction Cost: \$25,700



**Legend**

Ambient Monitoring	Orange County Roads
Benthic Monitoring	Subwatersheds
Fish Sampling	Perennial Stream
Municipal Boundary	Intermittent Stream
	Ephemeral Stream
	Stream, unknown flow




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**SITE 13 and 14  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 13	1.6	0.02	1.2%

**Location**

Project 16-03 is located just south of the practice football field at Chapel Hill High School, along a ditch that flows into the perennial stream Jolly Branch. A paved path crosses over the ditch just upstream of the site.

**Problem Description**

Project 16-03 consists of what was observed to be an ephemeral tributary to Jolly Branch that is currently incised and contains a headcut working upstream towards a paved path. The tributary has been channelized into a ditch, and has a concrete pipe outlet providing stormwater input. The contributing drainage area of this pipe appears to consist of part of the football field at Chapel Hill High School, part of the practice football field, and a portion of the student parking lot. These impervious surfaces are likely contributing pollutants, as well as the nutrients from the fertilization of the football fields, into the ephemeral tributary and into Jolly Branch. The confined ephemeral drainage feature does not have a floodplain or enough surface area to prevent erosion, so bank erosion will continue.

Sites 11 through 15 are in close proximity to each other, and could therefore be integrated amongst themselves as a single package. In addition, other similar opportunities for the work proposed here are present throughout the three surrounding campuses, as well as other parts of the Jolly Branch watershed.

**Proposed Solution**

Water quality treatment and quantity treatment at Site 13 could be provided by the construction of a small bio-retention area in-line with the tributary. A bio-retention area is preferred over another structural BMP here because of the lack of available space for construction, and the relatively small drainage area. The tributary on which the bio-retention area should be located was observed to be ephemeral, however further verification will be needed to ensure that an in-line BMP can be placed along it. Runoff volume will be stored in underground storage, reducing peak runoff rates and potentially augmenting baseflow.

An under-drain should be used with the bio-retention area, as the in-situ soils are most likely too impermeable to allow infiltration into the surrounding soils. This under drain or pervious drain layer will allow each successive cell to discharge to the next over extended periods of time.

Pollutant reduction rates as a result of stormwater treatment are shown in **Table 13.1**.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 13.1**

SITE 13	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	27.44	1.70	673.47
BIO-RETENTION TREATMENT	37.00%	45.00%	85.00%
NET REDUCTION	10.15	0.76	572.45
FUTURE CONDITION	17.29	0.93	101.02

**Constraints**

Site 13 is located in a wooded area, and therefore tree removal will be required.

**Alternatives**

No alternatives are proposed for this site.

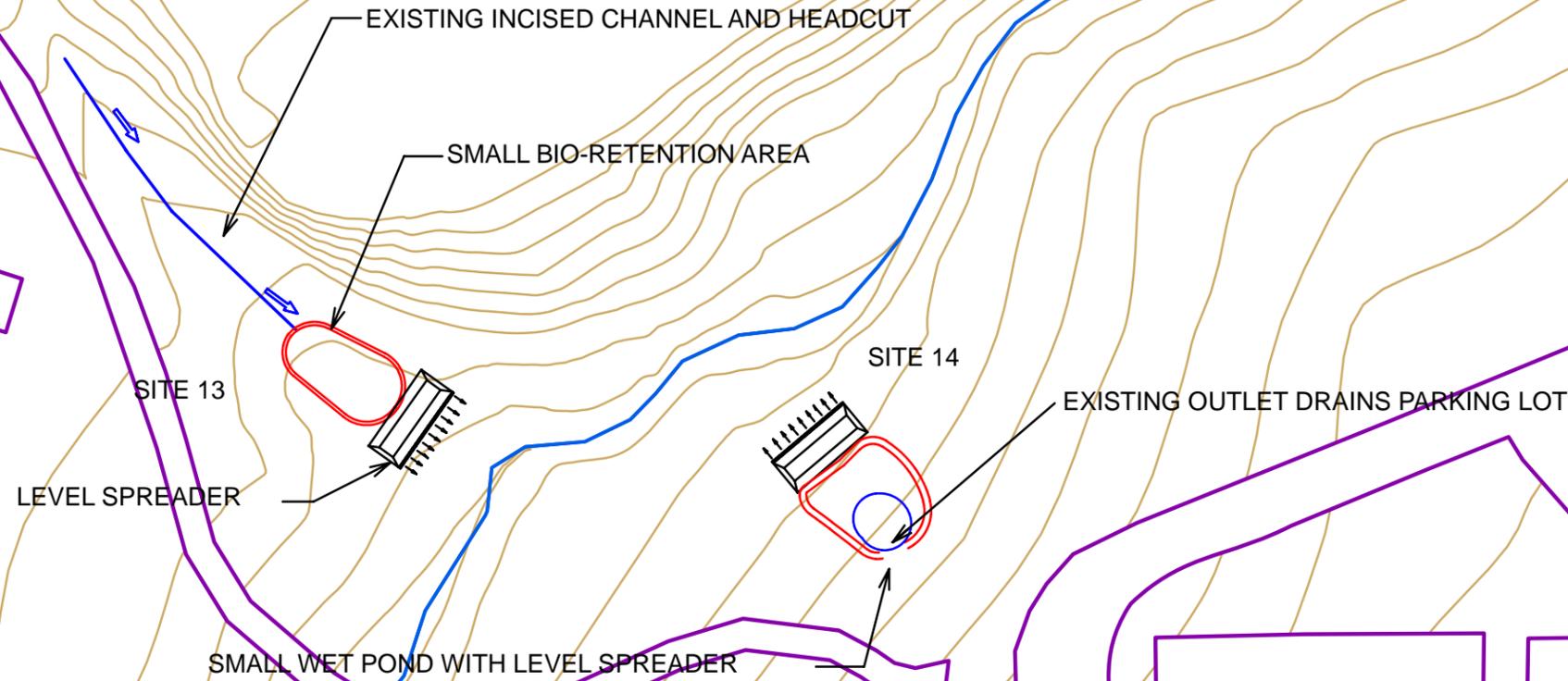
**Cost-Estimate Breakdown**

**Table 13.2** shows a conceptual itemized cost estimate for Site 13. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

**Table 13.2**  
SITE 13

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-Retention Area	1770.00	CF	12.62	\$22,337
		<b>Total</b>		<b>\$22,337</b>
Mobilization (5%)	1.0	LS		\$1,117
Contingencies (10%)	1.0	LS		\$2,234
		<b>Total + Mobilization and Contingencies</b>		<b>\$25,688</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		\$1,284

# SITE 13 and 14



SMITH MIDDLE SCHOOL

### Legend

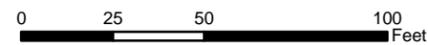
- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



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### CONCEPTUAL PLAN VIEW

BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



1 inch equals 50 feet



# SITE 13 and 14

EXISTING INCISED CHANNEL AND HEADCUT

SMALL BIO-RETENTION AREA

SITE 13

LEVEL SPREADER

SMALL WET POND WITH LEVEL SPREADER

SITE 14

EXISTING OUTLET DRAINS PARKING LOT

**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow




**EarthTech**  
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**AERIAL PHOTO VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 25 50 100 Feet

1 inch equals 50 feet

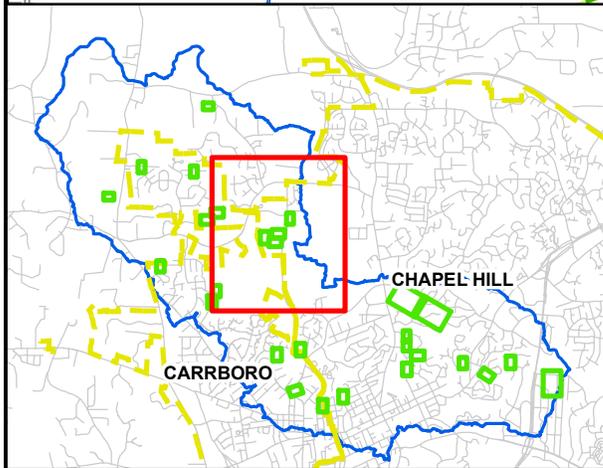
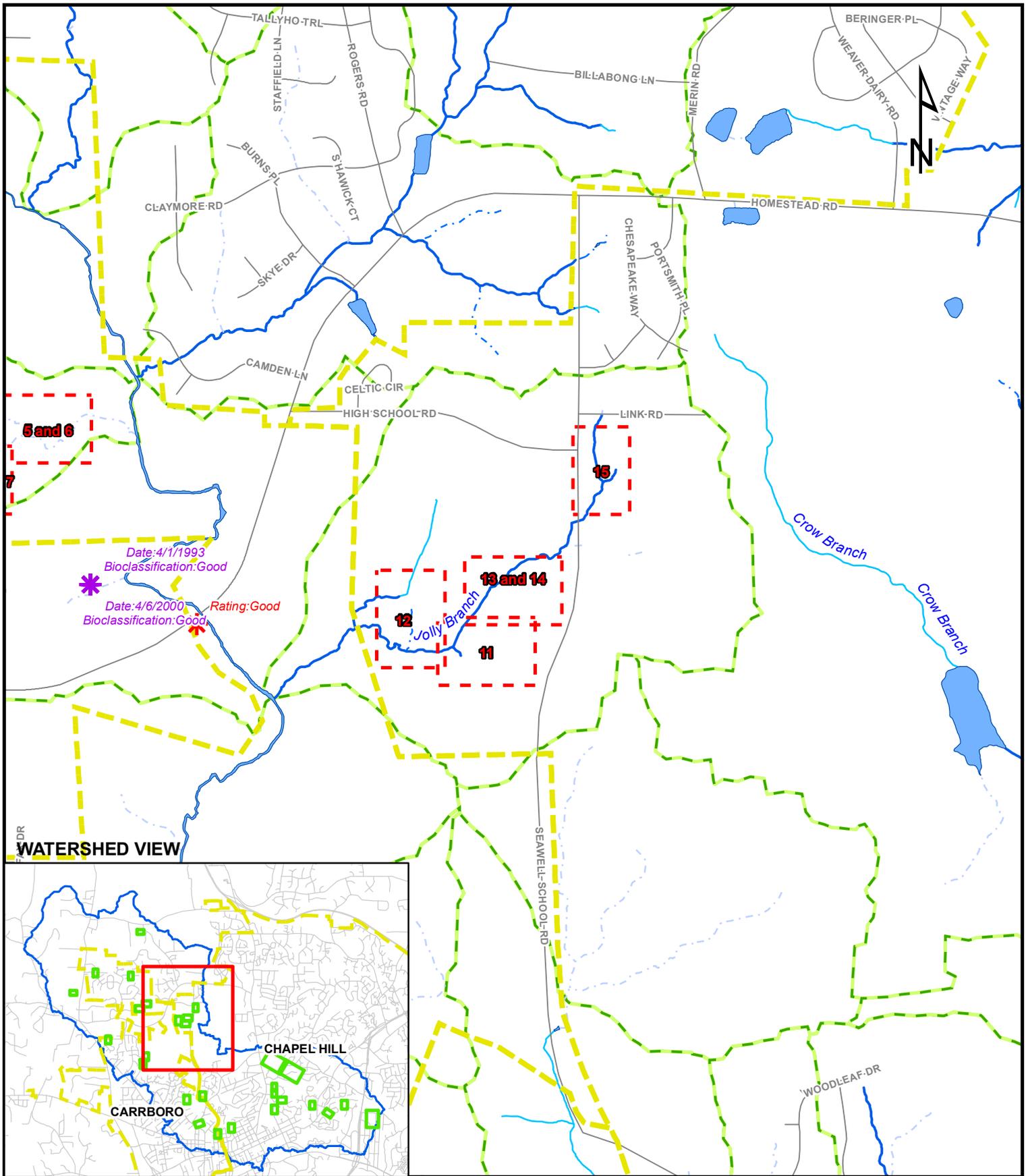


## **SITE 14**

Index Sheet No.: 16  
Raw Data Name: None



Estimated Construction Cost: \$25,600



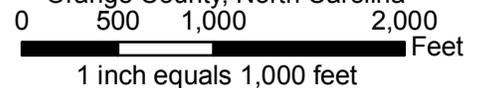
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 13 and 14  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 14	2.9	1.5	53.1%

**Location**

Site 14 is located north of a parking lot of Smith Middle School, off of Seawell School Rd.

**Problem Description**

Site 14 is situated at the outlet pipe that discharges the storm flow of one of the parking lots of Smith Middle School. Currently, no water quality treatment is provided for the parking lot runoff before it reaches the receiving stream, Jolly Branch. This direct discharge to the stream has caused channel incision and does not provide water quality or quantity treatment of any form. Channel instability will continue due to this direct discharge of stormwater into the receiving channel, Jolly Branch.

Sites 11 through 15 are in close proximity to each other, and could therefore be integrated amongst themselves as a single package. In addition, other similar opportunities for the work proposed here are present throughout the three surrounding campuses, as well as other parts of the Jolly Branch watershed.

**Proposed Solution**

The outlet pipe at Site 14 provides a good location to intercept the runoff produced by the parking lot and provide treatment for pollutants. Because of the small drainage area and limited space available for construction, a bio-retention area with underground storage is the preferred stormwater BMP here. The underground storage will serve to reduce the peak flows of the runoff from the impervious area and can be designed with a drain layer to augment baseflow to Jolly Branch while regaining needed storage volume for the next rain event. For this particular bio-retention area, the concept of providing a drain for the underground storage is an important one. Without intentional release of the stored rainfall, the BMP would lose some of its benefits during frequent rainfall events. It is suggested that this project be designed with a drain layer or under-drain that will drain the stored volume of rainfall within 3-5 days.

**Table 14.1** shows a conceptual itemized cost estimate for both alternatives at Site 14.

**Table 14.1**

SITE 14	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	14.77	1.64	382.97
BIO-RETENTION TREATMENT	37.00%	45.00%	85.00%
NET REDUCTION	5.47	0.74	325.53
FUTURE CONDITION	9.31	0.90	57.45

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Constraints**

Some mature trees are present around the site, thus tree removal will be required.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 14.2** shows a conceptual itemized cost estimate for Site 14. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

**Table 14.2**

**SITE 14 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-Retention Area	1770.00	CF	12.62	\$22,337
			<b>Total</b>	<b>\$22,337</b>

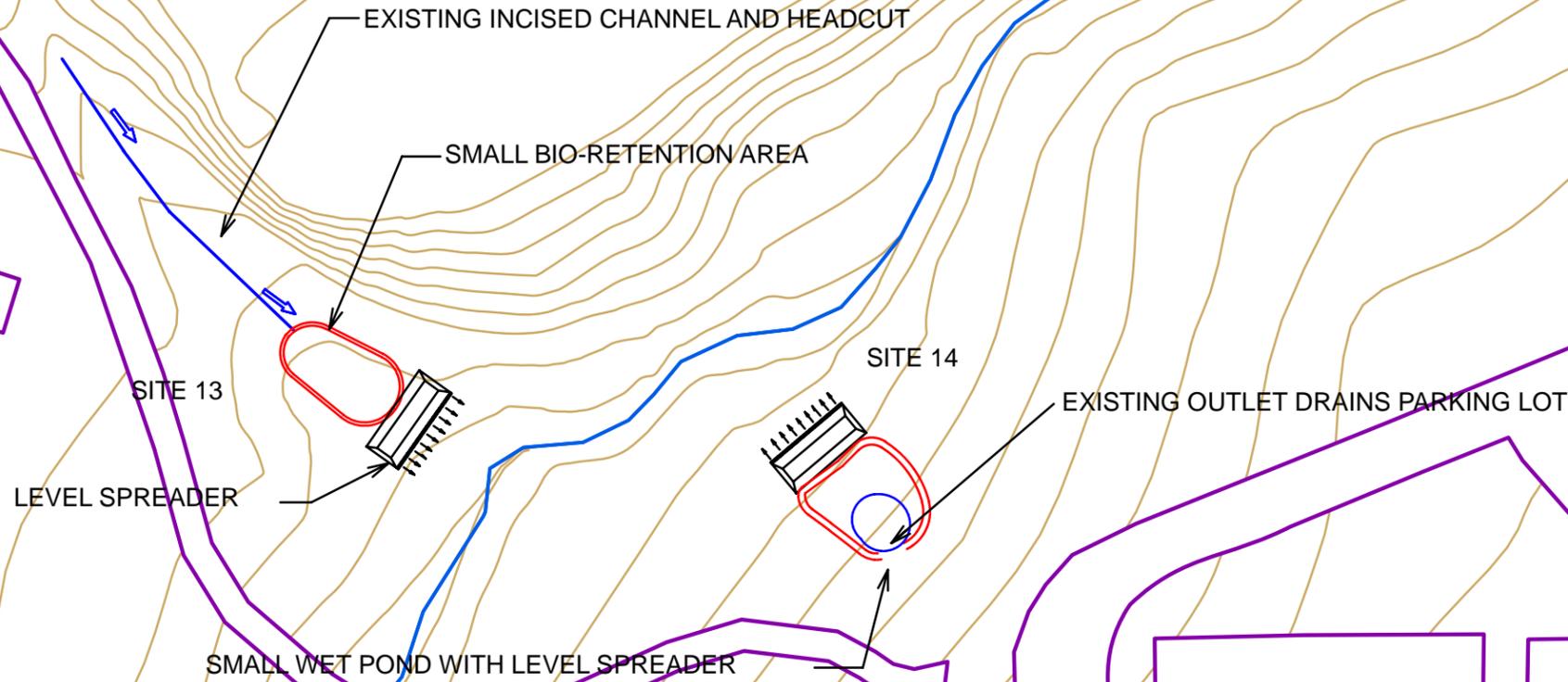
Mobilization (5%)	1.0	LS	\$1,117
Contingencies (10%)	1.0	LS	\$2,234

Total + Mobilization and Contingencies	<b>\$25,688</b>
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**Maintenance Costs**

Maintenance (5% of base construction cost)	1.0	Year	<b>\$1,284</b>
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# SITE 13 and 14



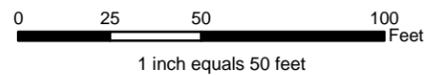
SMITH MIDDLE SCHOOL

### Legend

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



### CONCEPTUAL PLAN VIEW BOLIN CREEK WATERSHED Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits





# SITE 13 and 14

EXISTING INCISED CHANNEL AND HEADCUT

SMALL BIO-RETENTION AREA

SITE 13

LEVEL SPREADER

SMALL WET POND WITH LEVEL SPREADER

SITE 14

EXISTING OUTLET DRAINS PARKING LOT

**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow

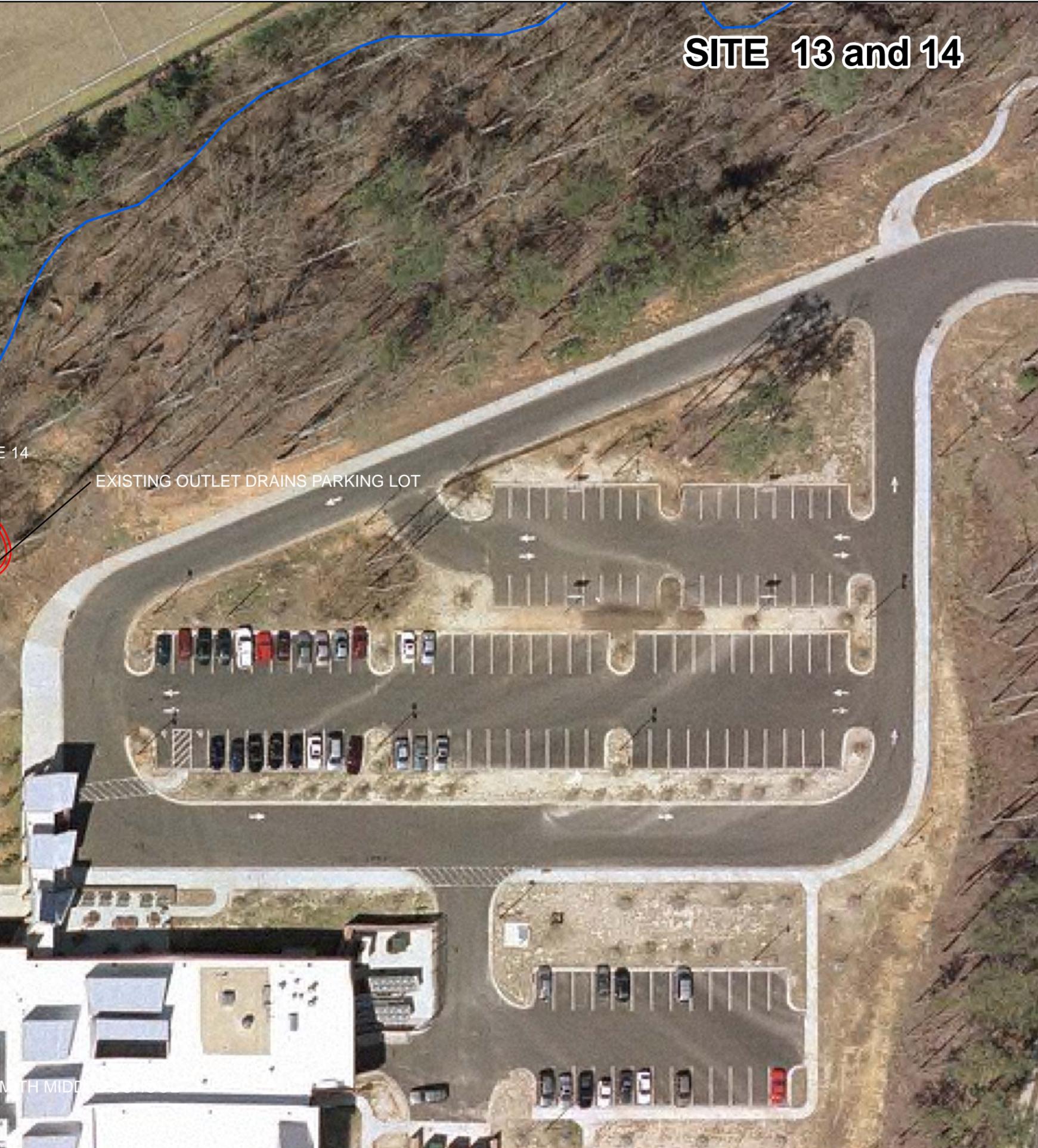



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**AERIAL PHOTO VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 25 50 100 Feet

1 inch equals 50 feet



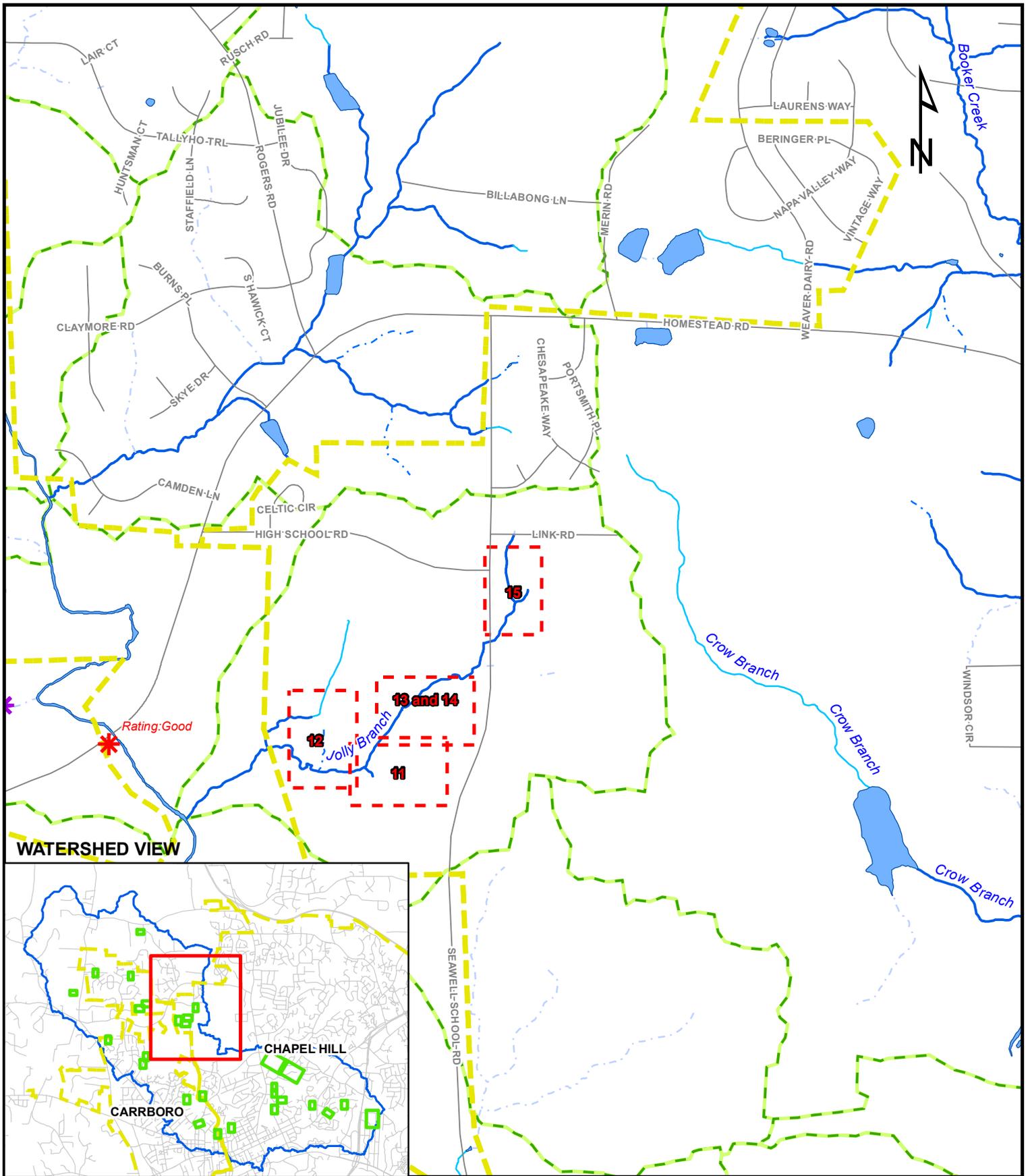
## **SITE 15**

### **Retrofit of Existing Sediment Basin**

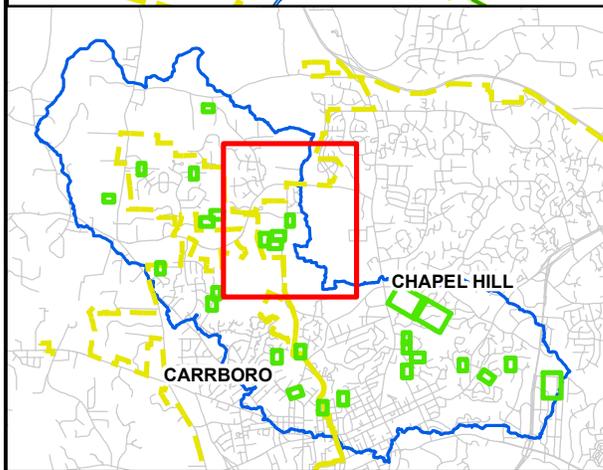
Index Sheet No.: 17  
Raw Data Name: IJ 26



Estimated Construction Cost: \$27,300



**WATERSHED VIEW**



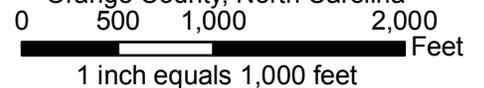
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 15  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 15	11.7	1.7	14.7%

**Location**

Site 15 is located south of a gravel driveway, at its intersection with Seawell School Road. Chapel Hill High School and Smith Middle School are across the street from the site.

**Problem Description**

Site 15 consists of an existing sediment basin at the outlet of a culvert passing under a gravel driveway. The basin was likely constructed along with the driveway and the church to which the driveway leads to collect sediment from runoff during construction. The basin has filled in, and consists only of a remnant rip rap berm and a large flat area of silt and clay at an elevation equal to the berm. Stormwater from the culvert currently passes over the basin without any retention or detention, and then concentrates into a scoured drainage channel just downhill of the basin. The drainage channel deepens into a headcut just before reaching a perennial stream, Jolly Branch, approximately one hundred feet from the basin. Due to these existing conditions, there is no water quality treatment, sediment is exported from the actively eroding channel, and a headcut is advancing towards the basin, threatening to create an even deeper gully.

Sites 11 through 15 are in close proximity to each other, and could therefore be integrated amongst themselves as a single package. In addition, other similar opportunities for the work proposed here are present throughout the three surrounding campuses, as well as other parts of the Jolly Branch watershed.

**Proposed Solution**

The existing basin of Site 15 is a prime candidate for a BMP retrofit in the form of a stormwater wetland to provide water quality treatment and peak flow attenuation. The retrofit could be facilitated by expanding the surface area of the current sediment basin, and digging out the accumulated sediment to create areas of shallow land, shallow water and deep pools. The site is a desirable one for a stormwater BMP retrofit in that the amount of earthwork will be minimal. In addition to the construction of a stormwater wetland, the existing erosive channel and headcut should also be stabilized. This can be done by creating a level spreader below the outlet of the wetland, which would cause stormwater to overflow diffusely through the floodplain and into the stream without concentrating the convergence at one location.

Benefits of the project would include the following:

- Attenuation of peak flows and relief of the main channel of Jolly Branch to keep it stable

*Bolin Creek Watershed*  
*Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

- Water quality treatment of the contributing drainage area.
- Reduction of peak flow
- Possible baseflow augmentation from the water stored in the wetland

The current nutrient export rates, and potential benefit of a stormwater wetland here have been calculated based on land use, drainage area and percent imperviousness of the drainage area, and are displayed in **Table 15.1**:

**Table 15.1**

SITE 15	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	2.99	0.19	87.54
STORM WATER WETLAND TREATMENT REMOVAL %	37.00%	35.00%	85.00%
NET REDUCTION	1.11	0.07	74.41
FUTURE CONDITION	1.88	0.12	13.13

**Constraints**

Site 15 is heavily wooded, and care would therefore have to be taken to protect the larger trees on the site during construction. During field visits, it was observed that a large, dead maple is still standing just downhill of the sediment basin. This could be removed and provide a significant amount of the surface area for the expansion of the basin into a stormwater wetland.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 15.2** shows a conceptual itemized cost estimate. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

*Bolin Creek Watershed  
 Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 15.2**

**SITE 15 Construction Cost**

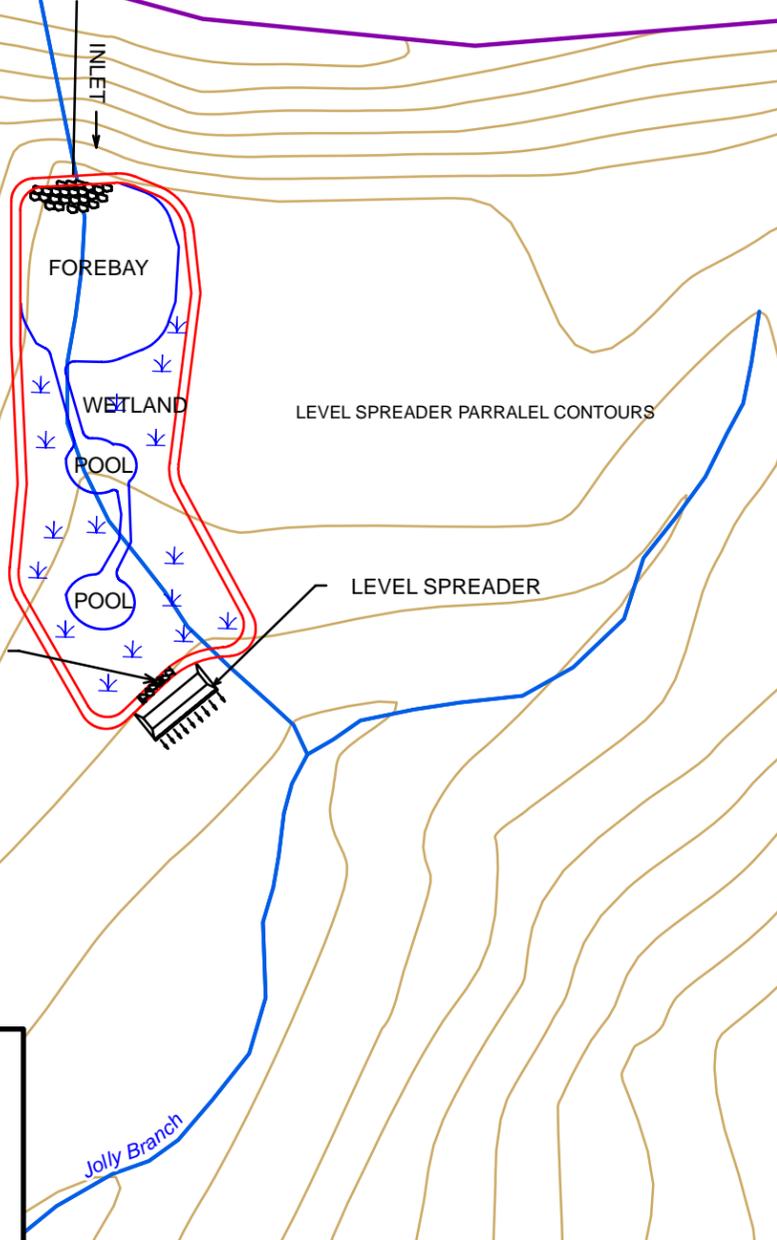
Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	13986.0	CF	Equation Derived	\$23,709
<b>Total</b>				<b>\$23,709</b>
Mobilization (5%)	1.0	LS		\$1,185
Contingencies (10%)	1.0	LS		\$2,371
Total + Mobilization and Contingencies				<b>\$27,266</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		<b>\$1,363</b>

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HIGH SCHOOL RD

SEAWELL SCHOOL RD



FOREBAY

WETLAND

POOL

POOL

LEVEL SPREADER PARRALEL CONTOURS

LEVEL SPREADER

WEIR OUTLET

Jolly Branch

**Legend**

- - - Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- - - Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 15**

**HIGH SCHOOL RD**

**SEAWELL SCHOOL RD**

*Jolly Branch*

INLET

FOREBAY

WETLAND

POOL

POOL

WEIR OUTLET

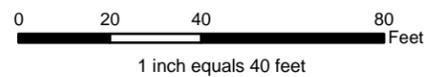
LEVEL SPREADER PARRALEL CONTOURS

LEVEL SPREADER

- Legend**
- Stormwater Lines
  - Perennial Stream
  - Intermittent Stream
  - - - Ephemeral Stream
  - - - Stream, unknown flow



**AERIAL PHOTO VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits



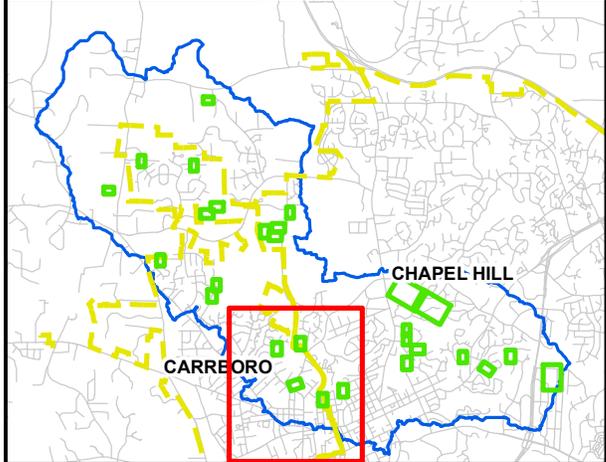
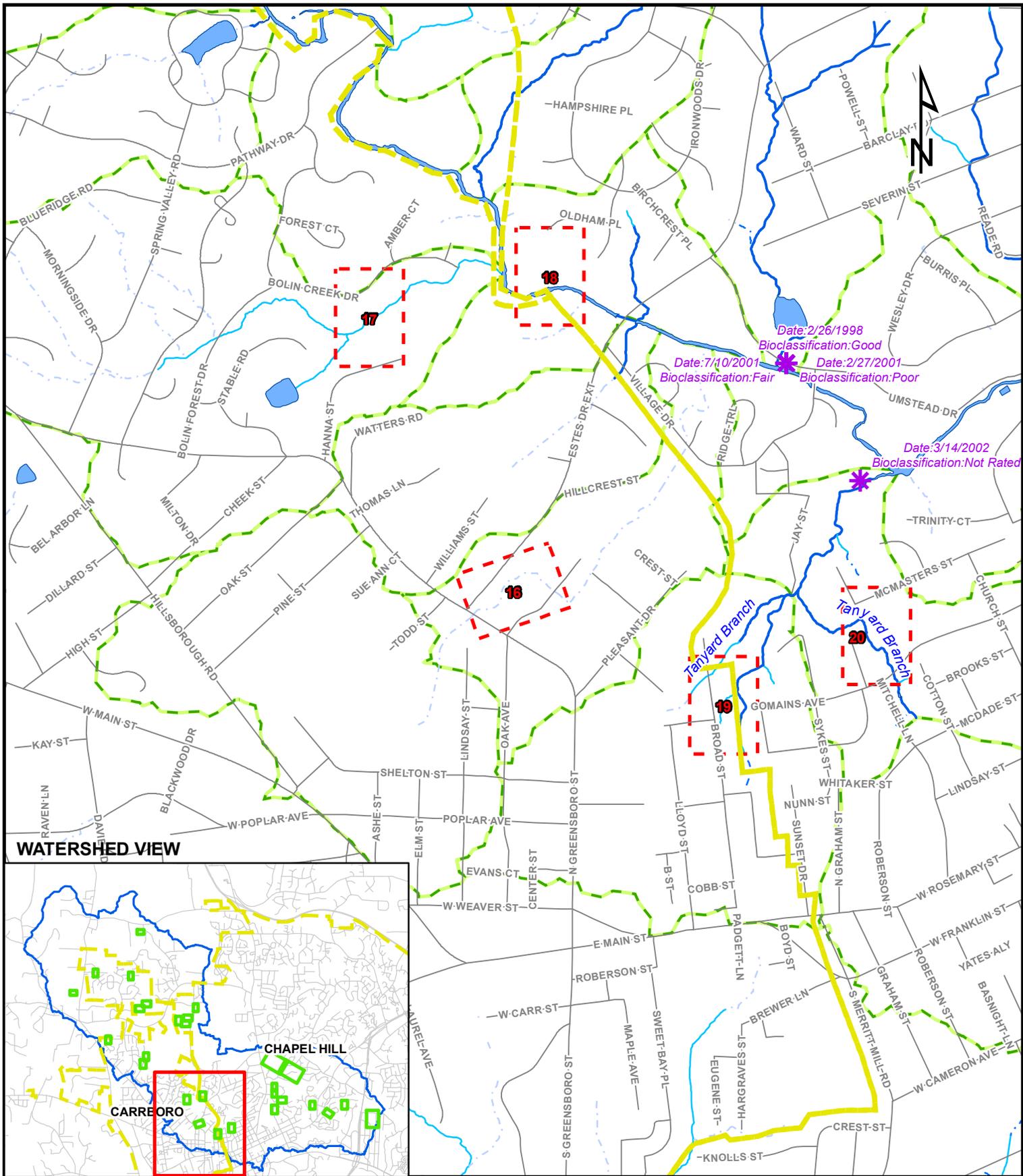
## **SITE 16**

### **Stabilize Erosion at Apartment Complex and Provide Water Quality Treatment.**

Index Sheet No.: 19  
Raw Data Name: BD 47



Estimated Construction Cost: \$56,500 - \$86,300



**Legend**

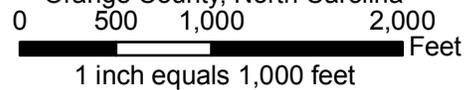
- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



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**SITE 16  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 16	129.0	29.6	23.0%

**Location**

Site 16 is located just east of the intersection of Estes Drive Extension with N. Greensboro Street and is surrounded by an apartment complex.

**Problem Description**

Site 16 consists of approximately 500 feet of an incised, actively eroding stream, and small tributary that converges with the stream after passing through a culvert under Estes Drive Extension. Both the Carrboro and Chapel Hill stream datasets list the flow type as “Unknown”. However, based on the drainage area of 0.2 square miles and the position in the landscape, the stream appears to be perennial, though further verification is needed. The stream is surrounded on both sides by the landscaping and hardscapes of an apartment complex. A wooden footbridge passes over the stream near the midpoint of the problematic reach.

The chief problems at site 16 are active mass wasting banks, and considerable sediment export from the eroding stream banks. Using the BANCS model, it is estimated that approximately 200 tons of sediment are being exported from the site each year. Concomitant nutrient export has also been calculated and is listed in **Table 16.1**.

**Table 16.1**

Pre-Treatment	
Estimated Total Sediment Export	200.4 tons/year
Erosion per length of Channel	13.4 tons/yr/ft
Pounds of Nitrogen	400.9 lbs/year
Pounds of Phosphorus	200.4 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.7 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	1.4 lbs/year
Pounds of Phosphorus	0.7 lbs/year

### **Proposed Solution**

As with other bank stabilization/restoration projects, this site could benefit primarily from a change in the stream cross-section that provides the following:

- a bankfull bench that gives the stream a floodplain to access, thus significantly reducing shear stress and near bank velocities during above-bankfull events
- reduced slopes on the bank, at a maximum of 2:1, thus reducing potential for bank erosion
- vegetated banks with woody plants that will provide stabilization through rooting depth

By modifying the cross-section of the stream in this way for the length of the extreme eroding banks, the sediment export rates of this site could potentially be reduced to 0.7tons per year, with a corresponding reduction in nutrient export rates. Calculated sediment and nutrient reductions are shown in **Table 16.1**. The confinement of this site may force the designer to use relatively steep banks and no restored bankfull bench. However, laying back banks or using other alternative methods such as crib walls would be an improvement over the un-checked erosion that is occurring at present.

### **Constraints**

Due to the highly urbanized location of this site, the chief constraint to this project would be the ability to acquire enough of a permanent drainage easement to implement the suggested treatment. Sloping back banks at a 2:1 ratio, yet keeping the existing depth of the stream at approximately 3.5 feet, would require moving back the banks laterally approximately 7 feet. In addition, landowners may not be amenable to construction equipment in close proximity to their apartment units.

### **Alternatives**

Two alternative treatments could be implemented at this site, depending on size constraints and landowner cooperation.

In Alternative 1, the banks would be sloped back, a bankfull bench would be established and both would be vegetated. Brush matting on the banks will provide the necessary change in boundary conditions of the banks to resist the erosive force of peak flows. On the small tributary leading into the main stream channel, a step-pool should be built to stop the active headcut where the two channels meet.

In Alternative 2, the treatments recommended in Alternative 1 would be implemented, with the added water quality treatment of a bioretention area. The bioretention area should be constructed inline with the tributary and receive the flow of its contributing drainage area.

*Bolin Creek Watershed  
Geomorphologic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Cost-Estimate Breakdown**

Tables 16.2 and 16.3 show a conceptual itemized cost estimate for both alternatives. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

**Table 16.2**  
SITE 16 ALTERNATIVE 1

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	1800.00	CY	15.00	\$27,000
Bank stabilization with Brush Matting	630.00	SY	15.00	\$9,450
Site Preparation and Planting	0.13	Ac	7500.00	\$975
Silt Fence	750.00	LF	3.75	\$2,813
Boulders	25.00	Tons	200.00	\$5,000
Construction Safety Fence	550.00	LF	2.50	\$1,375
Construction Entrance	1.00	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$49,113</b>
Mobilization (5%)	1.00	LS		\$2,456
Contingencies (10%)	1.00	LS		\$4,911
<b>Total + Mobilization and Contingencies</b>				<b>\$56,479</b>

**Table 16.3**  
SITE 16 ALTERNATIVE 2

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	1800.00	CY	15.00	\$27,000
Bank stabilization with Brush Matting	630.00	SY	15.00	\$9,450
Site Preparation and Planting	0.13	Ac	7500.00	\$975
Silt Fence	750.00	LF	3.75	\$2,813
Boulders	25.00	Tons	200.00	\$5,000
Construction Safety Fence	550.00	LF	2.50	\$1,375
Construction Entrance	1.00	Ea	2500.00	\$2,500
Bio-Retention Area with Underdrain	2061.00	CF	12.62	\$26,010
<b>Total</b>				<b>\$75,122</b>
Mobilization (5%)	1.00	LS		\$3,756
Contingencies (10%)	1.00	LS		\$7,512
<b>Total + Mobilization and Contingencies</b>				<b>\$86,391</b>

**Maintenance Costs**

Maintenance (5% of base construction cos of BMP)	1.0	Year		<b>\$1,300</b>
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ESTES DR EXT

N GREENSBORO ST

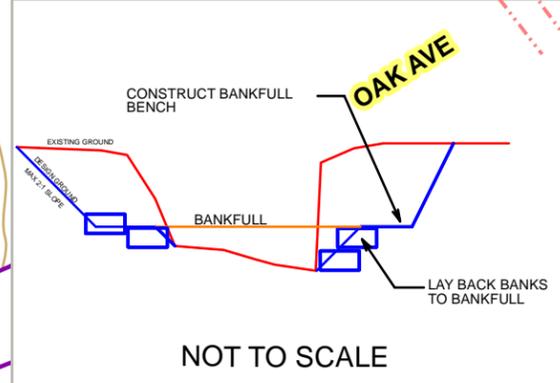
ALTERNATIVE 2: CONSTRUCT SMALL BIO-RETENTION AREA

ALTERNATIVE 1: USE STEP POOL TO GRADE DOWN TO BED OF RECEIVING STREAM

STABILIZE BOTH BANKS WITH BRUSH MATTING

STABILIZE BOTH BANKS WITH BRUSH MATTING AND LAY BACK BANKS WITH BANKFULL BENCH

CONCEPTUAL CROSS SECTION

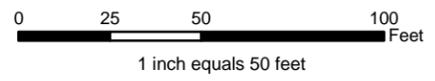


STABILIZATION AREAS

- Legend**
- Stormwater Lines
  - Impervious Surfaces
  - Perennial Stream
  - Intermittent Stream
  - Ephemeral Stream
  - Stream, unknown flow
  - Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 16**

**ESTES DR EXT**

**INGRENSBORO ST**

ALTERNATIVE 2: CONSTRUCT SMALL BIO-RETENTION AREA

ALTERNATIVE 1: USE STEP POOL TO GRADE DOWN TO BED OF RECEIVING STREAM

STABILIZE BOTH BANKS WITH BRUSH MATTING

STABILIZE BOTH BANKS WITH BRUSH MATTING AND LAY BACK BANKS WITH BANKFULL BENCH

CONCEPTUAL CROSS SECTION

**OAK AVE**

CONSTRUCT BANKFULL BENCH

BANKFULL

LAY BACK BANKS TO BANKFULL

NOT TO SCALE

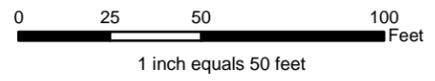
STABILIZATION AREAS

**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- · - Stream, unknown flow



**AERIAL PHOTO VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits



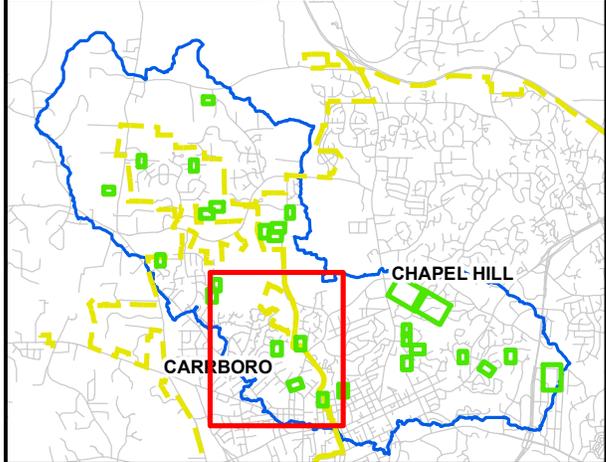
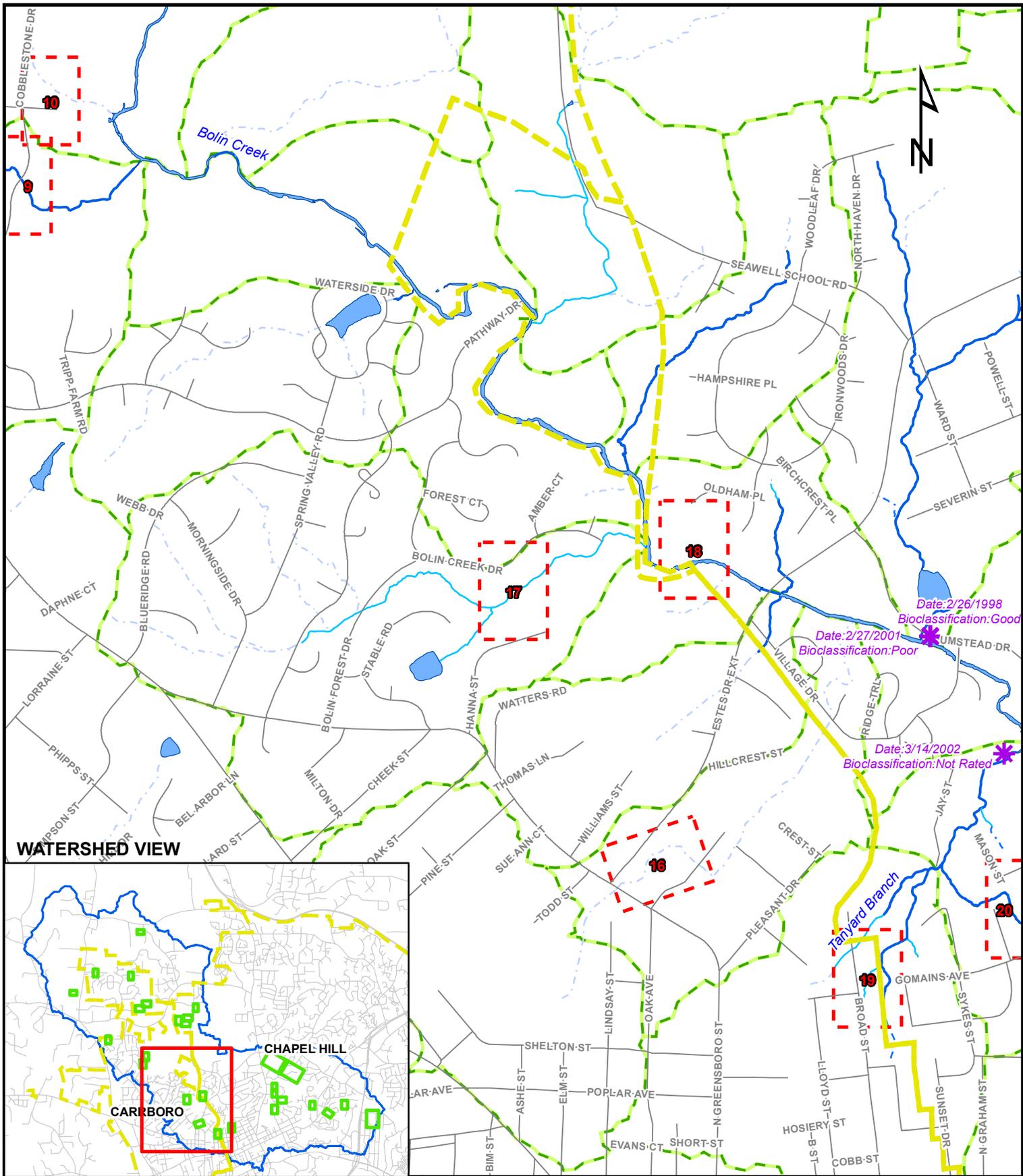
## **SITE 17**

### **Offline Bioretention Area and Sediment Reduction Below New Development.**

Index Sheet No.: 20  
Raw Data Name: BD 11



Estimated Construction Cost: \$66,700



**Legend**

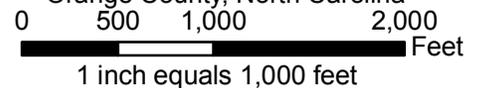
- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



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**SITE 17  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 17	156.0	36.4	23.3%

**Location**

Site 17 is located downhill and to the south of Bolin Creek Drive, and downhill and to the north of Hannah Street. A sewer easement runs along the stream where treatment is proposed.

**Problem Description**

Site 17 consists of an incised channel and actively eroding bank, as well as a relatively flat area in the floodplain of the stream in which an offline bioretention area could be constructed. Water quality treatment is lacking in most of this watershed, thus a flat area such as that present at Site 17 affords an opportunity for diversion of flow and pollutant treatment.

An actively eroding bank at Site 17 is causing export of sediment and loss of bank. Using the BANCS model, it is estimated that approximately 60.8 tons of sediment are being exported from the site each year. Concomitant nutrient export has also been calculated and is listed in **Table 17.1**.

**Table 17.1**

Pre-Treatment	
Estimated Total Sediment Export	60.8 tons/year
Erosion per length of Channel	1 tons/yr/ft
Pounds of Nitrogen	121.6 lbs/year
Pounds of Phosphorus	60.8 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.2 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	0.3 lbs/year
Pounds of Phosphorus	0.2 lbs/year

**Proposed Solution**

As with other bank stabilization/restoration projects, this site could benefit primarily from a change in the stream cross-section that provides the following:

- a bankfull bench that gives the stream a floodplain to access, thus significantly reducing near bank stress during above-bankfull events

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

- reduced slopes on the bank, at a maximum of 2:1, thus reducing potential for bank erosion
- vegetated banks with woody plants that will provide stabilization through rooting depth

By modifying the cross-section of the stream in this way for the length of the extreme eroding banks, the sediment export rates of this site could potentially be reduced to 0.2 tons per year, with a corresponding reduction in nutrient export rates. Calculated sediment and nutrient reductions are shown in **Table 17.1**.

An offline bioretention area could also be built in the existing floodplain of the stream. A topographically flat area there could provide the needed surface area for providing pollutant removal for a percentage of the flow, with the added benefit of attenuation of peak flows and reduction of near bank stress against the outside meander that is currently eroding. Additionally, the storage of runoff volume in the bioretention area may supplement for some of the loss of baseflow that was observed in this channel. Side channel storage can generally be assumed to reduce channel stresses of the downstream system.

**Constraints**

Constraints consist of space needed for the construction of the bioretention area, and avoiding impacts to the existing sewer line.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 17.2** shows a conceptual itemized cost estimate for Site 17. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007). The contingency fee for this site has been increased due to the difficulty of access and proximity to a sewer easement.

**Table 17.2**

**SITE 17 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-Retention Area	4401.00	CY	12.62	\$55,541
<b>Total</b>				<b>\$55,541</b>
Mobilization (5%)	1.00	LS		\$2,777
Contingencies (15%)	1.00	LS		\$8,331
<b>Total + Mobilization and Contingencies</b>				<b>\$66,649</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		\$2,777

**SITE 17**



**BOLIN CREEK DR**

REALIGNED STREAM

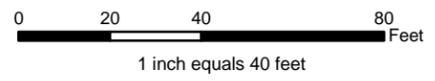
BIORETENTION AREA

**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





BOLIN CREEK DR

SITE 17

REALIGNED STREAM

BIORETENTION AREA

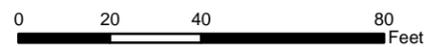
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



1 inch equals 40 feet

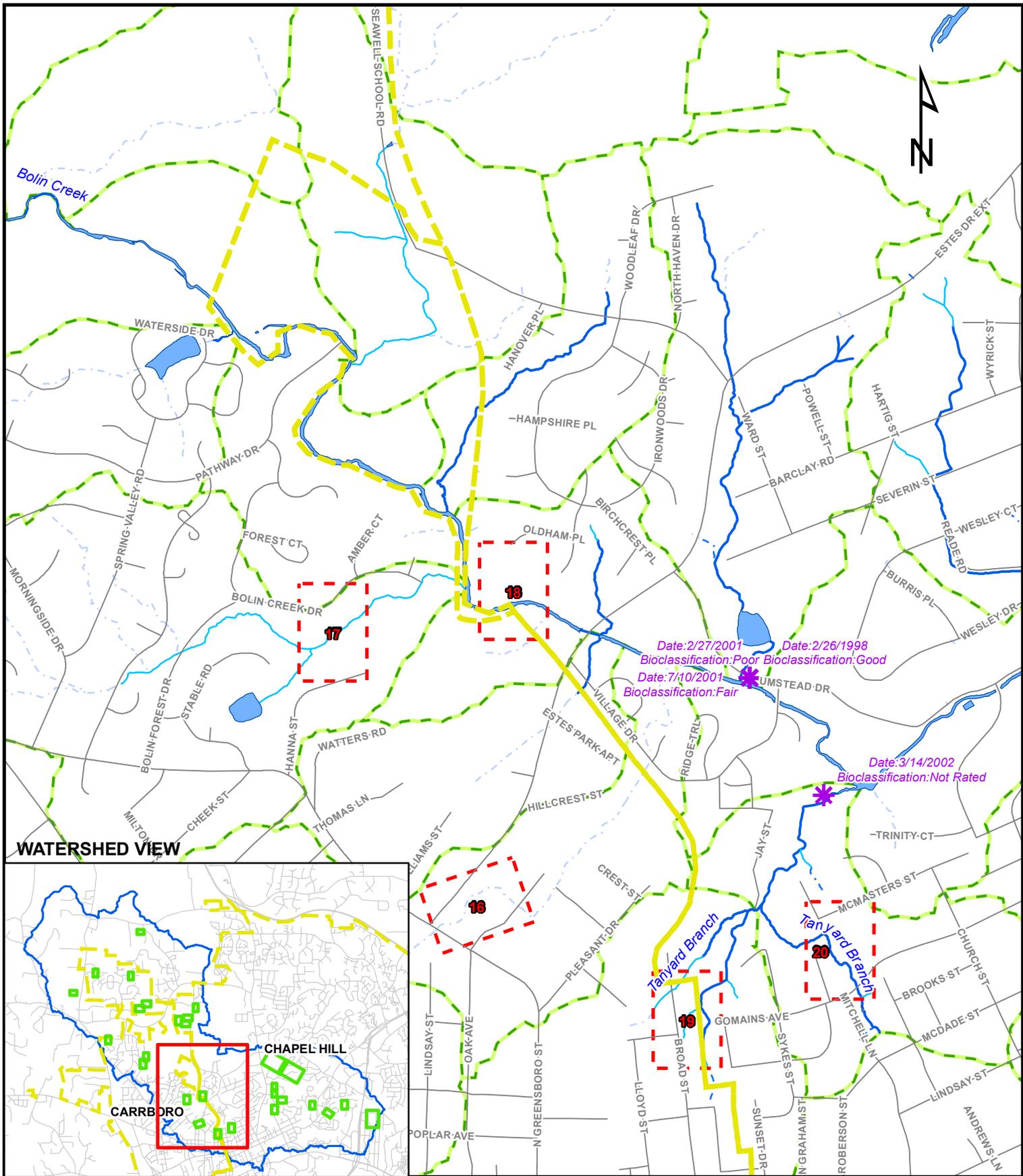
## **SITE 18**

### **Restoration of Erosive Gulley Beneath Railroad Trestle, and Treatment of Pollutants From Subdivision**

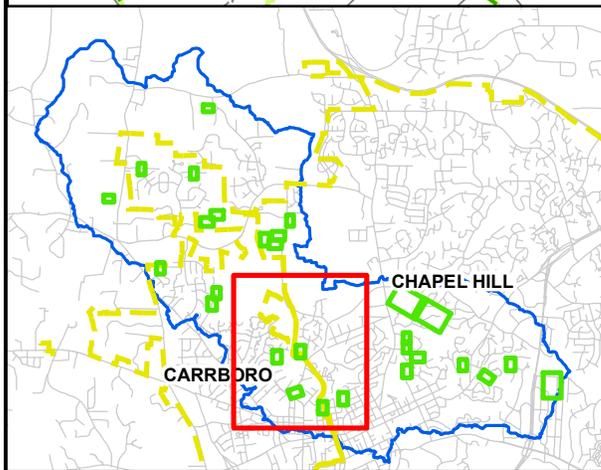
Index Sheet No.: 20  
Raw Data Name: TA 19



Estimated Construction Cost: \$17,400



**WATERSHED VIEW**



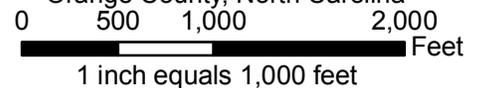
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 18  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



### **Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 18	4.7	0.8	16.0%

### **Location**

Site 18 is located beneath a railroad trestle approximately 500 feet to the west of Estes Drive Extension. The railroad trestle crosses over Bolin Creek, and the site is located on the left bank, looking downstream. Access to the site can be obtained by traveling along an existing sewer easement and footpath that follows the stream.

### **Problem Description**

Site 18 consists of two actively eroding headcuts on an exposed hillslope adjacent to a railroad trestle. Upslope of the gulley is a subdivision and what appears to be an ephemeral stream discharging from the storm system of the neighborhood, which consists of a curb and gutter drainage system. The runoff that accumulates on the relatively high percentage of impervious surface concentrates in the gulley just before reaching Bolin Creek, causing severe scour and mass wasting, and contributing sediment to the watershed, as well as any pollutants that may be contained in the runoff from the subdivision. There is also an indication that impacts from recreational use of this site could be adding to the problem of the erosive banks by causing bank failure in between rainfall events.

Potential pollutant loads and reduction have been calculated based on impervious area and land use, and are shown in **Table 18.2**.

### **Proposed Solution**

Site 18 poses a unique situation for stormwater treatment; a steep slope and limited space between the area of the headcuts, the footers of the railroad trestle and Bolin Creek. A solution for treatment at this site is to construct a “bio-grade step”, which is a series of small bio-retention cells filled with a filter media, such as a mixture of sand, fines and organic mater (see Appendix A-Details). Ideally, this media will have a filtration rate of 1.0 to 2.0 inches per hour, to optimize pollution removal (Schueler, et. al., 2007). Each cell is connected to the other by the use of a drainage or seepage layer, thus allowing stormwater to filter through each cell without the expense of an underdrain. An underdrain is also an option if it is preferred. Each cell would have a given amount of volume to fill while infiltrating before cresting the berm and overflowing into the next cell downstream. Below the bio-grade step, a preformed scour hole (see Appendix A-Details), should be built to dissipate any overflow before reaching Bolin Creek. There is not enough room to dissipate energy via a level spreader.

This treatment option will provide a linear, grade-control solution to reduce erosive velocities of the stream, while also treating stormwater runoff for pollutants. A substantial amount of storage volume, with respect to drainage area, can help to reduce

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

the total runoff that Bolin Creek receives. This may also augment baseflow to Bolin Creek by delaying the release of the stored runoff volume. It is important to note that this bio-grade step should drain completely over a period of 5-7 days in order to insure that there is available storage volume for runoff from the next rain event. Thus, the design of the weeps or drainage layers is an important factor for the continual success of this project.

The depth of each cell can vary depending on choice of planting materials. Trees, with a deeper rooting structure, will require deeper soils, while herbaceous plants and shrubs can have soil as shallow as 1.5 feet (Schuler et. al, 2007). Potential pollution removal rates using this method have been estimated and are shown in **Table 18.2**.

**Table 18.2**

SITE 18	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	8.24	0.81	121.55
BIORETENTION TREATMENT REMOVAL %	35.00%	45.00%	85.00%
NET REDUCTION	2.89	0.36	103.32
FUTURE CONDITION	5.36	0.45	18.23

**Constraints**

The nearest right of way to this site is Estes Drive Extension, nearly 500 feet downstream. What appears to be an existing sewer easement, as evidenced by manholes, runs parallel with Bolin Creek and a maintenance path runs from Estes Drive Extension to the site. Thus, a drainage easement and access easement may already exist.

Other constraints consist of the avoidance of the railroad trestle, gaining permission to do work around it, and the difficult terrain.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

**Table 18.3** shows a conceptual itemized cost estimate for Site 18. These costs represent construction and maintenance costs only. The cost for the bio-grade step is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

*Bolin Creek Watershed  
 Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 18.3**  
**Site 18 Construction Cost**

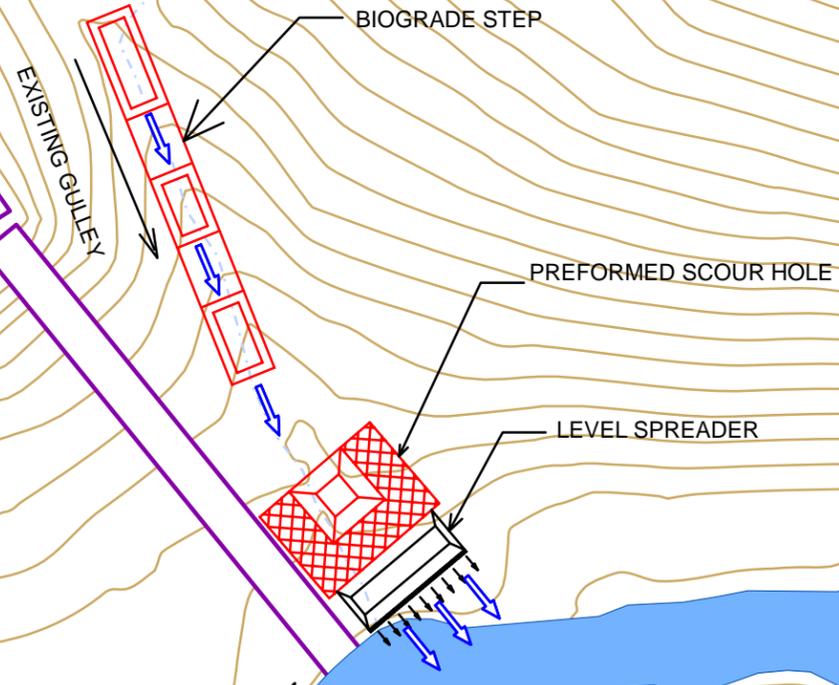
Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Biograde Step	1200.0	CF	12.62	\$15,144
<b>Total</b>				<b>\$15,144</b>
Mobilization (5%)	1.00	LS		\$757
Contingencies (10%)	1.00	LS		\$1,514
Total + Mobilization and Contingencies				<b>\$17,416</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost)	1.0	Year		<b>\$871</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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**SITE 18**



**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours

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**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 20 40 80 Feet  
1 inch equals 40 feet



**SITE 18**



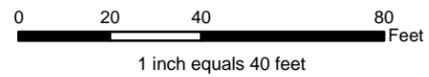
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits



## **SITE 19**

### **Stream Restoration/Bank Stabilization in Park**

Index Sheet No.: 23  
Raw Data Name: TA 29-31



Estimated Construction Cost: \$10,300-\$15,500



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 19	149.5	31.5	21.0%

**Location**

Site 19 is located in a public park off of Broad Street and approximately 0.25 miles north of Rosemary Street/E. Main Street.

**Problem Description**

Site 19 consists approximate 165 feet of an incised reach of Tanyard Branch, with actively eroding, vertical banks and lack of a riparian buffer. Upstream of the site, the stream is completely piped, and emerges from a culvert after passing under Broad Street, where it then flows through a town-owned park. The eroding streambanks are likely the result of what was observed to be repeated mowing up to the stream ( mechanical stresses on the channel) and a lack of riparian buffer to resist the high shear stress coming from the concentrated flow discharge of the upstream pipe network. The eroding stream banks are causing export of sediment and associated nutrients. A preliminary investigation of streambank erosion potential using the BANCS model indicates that approximately 29 tons of sediment is being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 19.1**.

**Table 19.1**

Pre-Treatment	
Estimated Total Sediment Export	28.3 tons/year
Erosion per length of Channel	2.4 tons/yr/ft
Pounds of Nitrogen	56.6 lbs/year
Pounds of Phosphorus	28.3 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.5 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	1 lbs/year
Pounds of Phosphorus	0.5 lbs/year

**Proposed Solution**

As with other bank stabilization/restoration projects, this site could benefit primarily from a change in the stream cross-section that provides the following:

*Bolin Creek Watershed*  
*Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

- a bankfull bench that gives the stream a floodplain to access, thus significantly reducing near bank stress during above-bankfull events
- reduced slopes on the bank, at a maximum of 2:1, thus reducing potential for bank erosion
- vegetated banks with woody plants that will provide stabilization through rooting mass

In areas of fill soils, additional toe or bank protection using methods such as Bio-D or blocks or soil layering techniques may be necessary (see Appendix A- Details.)

Changes to the profile (riffle-pool sequence) could also be implemented at this site to restore in-stream habitat, but at a greater project cost (see Alternatives). The preferred alternative is one in which the banks are laid back and the streambank erosion reduced to the maximum extent possible. Calculated sediment and nutrient reductions as a result of this treatment are shown in **Table 19.1**.

In addition to the changes in stream cross-section, the banks of the stream should be planted with deep rooting plants that will provide banks stabilization through their rooting mass. As this site is located in an urban park, the needs of safety, aesthetics and functionality need to be met with a choice of plant species. While trees are preferred in the stabilization of stream banks, low-growing grasses and perennials may be more appropriate to a park setting. If low growing grasses pose a problem due to public concerns of thick brush, the select trees may provide stability with maintenance to the herb layer.

### **Constraints**

Land acquisition is not a constraint here, as the stream travels through land owned by the Town of Chapel Hill.

Limited space available in the park may constrain the width of the buffer. Public relations and perception of re-vegetation may hinder the improvements to this site.

### **Alternatives**

There are three alternatives at this site that could be implemented, based on available funds.

Alternative 1: Rather than laying back banks and incurring the expense of earthwork, brush matting (see Details) could be laid on all banks, providing a certain degree of resistance of erosive flows and reducing bank erosion. The riparian buffer area could then be re-vegetated with low-growing plants, as mentioned above.

Alternative 2: To reduce bank erosion rates to the greatest extent, lay back the stream banks at a maximum 2:1 slope and construct a bankfull bench. Then re-vegetate the riparian buffer with low-growing plants.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

Alternative 3: In addition to the treatment of Alternative 2, modify the profile of the stream, constructing pools at each meander bend of the existing channel. This will lead to further dissipation of energy, while improving in-stream habitat.

**Cost-Estimate Breakdown**

Tables 19.2, 19.3 and 19.4 show a conceptual itemized cost estimate for all three alternatives. These costs represent construction costs only.

**Table 19.2**  
SITE 18 ALTERNATIVE 1

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Construction Safety Fence	700.00	LF	2.50	\$1,750
Site Preparation and Planting	0.13	Ac	7500.00	\$975
Brush Matting	75.00	LF	50.00	\$3,750
Construction Entrance	1.00	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$8,975</b>
Mobilization (5%)	1.00	LS		\$449
Contingencies (10%)	1.00	LS		\$898
<b>Total + Mobilization and Contingencies</b>				<b>\$10,321</b>

**Table 19.3**  
SITE 18 ALTERNATIVE 2

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	250.00	CY	15.00	\$3,750
Site Preparation and Planting	0.13	Ac	7500.00	\$975
Silt Fence	600.00	LF	3.75	\$2,250
Bio -D Blocks for Bank Stabilization	75.00	LF	20.00	\$1,500
Construction Safety Fence	700.00	LF	2.50	\$1,750
Construction Entrance	1.00	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$12,725</b>
Mobilization (5%)	1.00	LS		\$636
Contingencies (10%)	1.00	LS		\$1,273
<b>Total + Mobilization and Contingencies</b>				<b>\$14,634</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

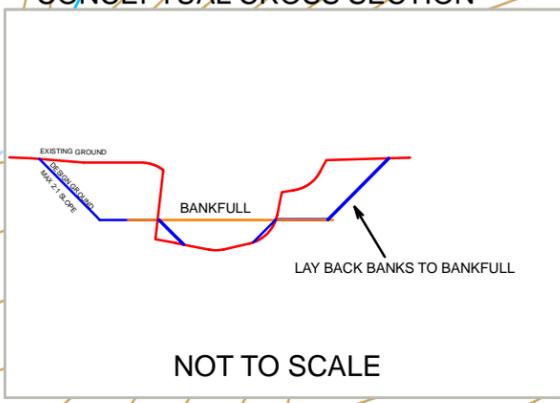
**Table 19.4**  
**SITE 18 ALTERNATIVE 3**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	300.00	CY	15.00	\$4,500
Site Preparation and Planting	0.13	Ac	7500.00	\$975
Silt Fence	600.00	LF	3.75	\$2,250
Bio -D Blocks for Bank Stabilization	75.00	LF	20.00	\$1,500
Construction Safety Fence	700.00	LF	2.50	\$1,750
Construction Entrance	1.00	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$13,475</b>
Mobilization (5%)	1.00	LS		\$674
Contingencies (10%)	1.00	LS		\$1,348
<b>Total + Mobilization and Contingencies</b>				<b>\$15,496</b>



Tanyard Branch

CONCEPTUAL CROSS SECTION



ALTERNATIVE 2:  
LAY BACK BANKS WITH BANKFULL BENCH  
AND VEGETATE WITH LOW GROWING GRASS

ALTERNATIVE 1:  
LAY BRUSH MATTING ON BOTH BANKS  
AND REVEGETATE WITH LOW-GROWING GRASS

ALTERNATIVE 3:  
LAY BACK BANKS AND MODIFY  
PROFILE AND GEOMETRY

ALTERNATIVE 2 AND 3:  
ADD DISSIPATION POOL AT HEAD OF PROJECT

GOMAINS AVE

HILL ST

BROAD ST

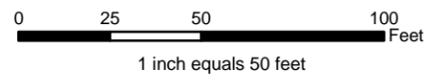
BYNUM ST

Legend

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 19**

Tanyard Branch

BROAD ST

GOMAINS AVE

BYNUM ST

HILL ST

**CONCEPTUAL CROSS SECTION**



ALTERNATIVE 2:  
LAY BACK BANKS WITH BANKFULL BENCH  
AND VEGETATE WITH LOW GROWING GRASS

ALTERNATIVE 1:  
LAY BRUSH MATTING ON BOTH BANKS  
AND REVEGETATE WITH LOW-GROWING GRASS

ALTERNATIVE 3:  
LAY BACK BANKS AND MODIFY  
PROFILE AND GEOMETRY

ALTERNATIVE 2 AND 3:  
ADD DISSIPATION POOL AT HEAD OF PROJECT

- Legend**
- Stormwater Lines
  - Perennial Stream
  - Intermittent Stream
  - Ephemeral Stream
  - Stream, unknown flow



**AERIAL PHOTO VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits

0 25 50 100 Feet  
 1 inch equals 50 feet

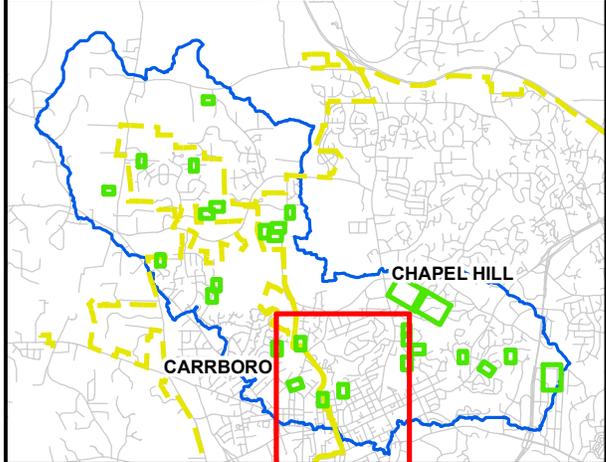
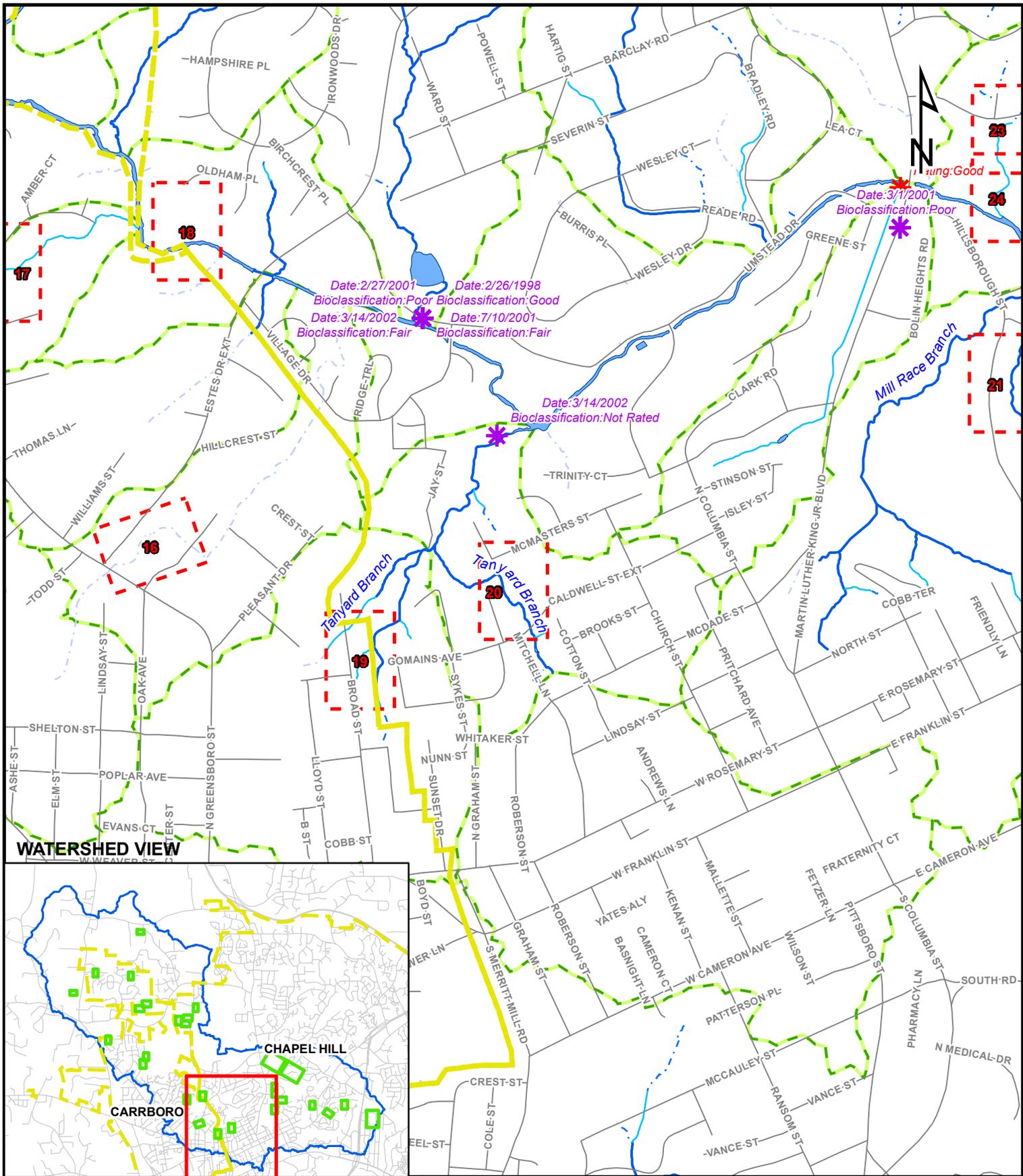
## **SITE 20**

### **Stream Restoration/Bank Stabilization on Incised Reach of Tanyard Branch**

Index Sheet No.: 24  
Raw Data Name: TA 24-01



Estimated Construction Cost: \$49,500



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow

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**SITE 20 VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 20	205.9	102.9	50.0%

**Location**

Site 20 is located north of Caldwell Street Extension, approximately 0.5 miles north of Rosemary Street in downtown Chapel Hill.

**Problem Description**

Site 20 consists approximately 500 feet of an incised stream channel, Tanyard Branch, with actively eroding, vertical banks and lack of riparian buffer. The stream flows through an urban residential area, and a large culvert before reaching the project site. The eroding streambanks are likely the result of a combination of the upstream road crossing, increased peak flows due to the high percentage of impervious area in the contributing watershed, and lack of riparian vegetation to hold the banks. The mass wasting stream banks are causing export of sediment and associated nutrients. A preliminary investigation of streambank erosion potential using the BANCs model show that approximately 1902 tons of sediment are being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 20.1**.

**Table 20.1**

Pre-Treatment	
Estimated Total Sediment Export	1901.9 tons/year
Erosion per length of Channel	3.7 tons/yr/ft
Pounds of Nitrogen	3803.8 lbs/year
Pounds of Phosphorus	1901.9 lbs/year
Post-Treatment	
Estimated Total Sediment Export	2 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	3.9 lbs/year
Pounds of Phosphorus	2 lbs/year

**Proposed Solution**

Bank stabilization is the preferred solution to this problem with the addition of re-vegetation after construction is complete. This relatively short stretch of channel is not long enough to restore completely, but reducing near-bank stress could eliminate the majority of the sediment contributions from this reach. Laying back the banks as much as possible, establishing an interior floodplain or bankfull bench and possibly even

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

placing a vane in this section would accomplish the goal of reducing stresses. Brush mattresses may be used to quickly stabilize the modified banks.

As this channel is overly wide, a bankfull bench would and modification to channel cross section geometry would promote channel stability. Revegetation is critical for this site.

**Constraints**

This site will require a certain degree of either site acquisition or agreement of adjacent landowners to implement the project. The sloping back of banks will place the current stream banks further from the stream channel than they are currently, requiring that a certain amount of land be appropriated for this use. According to Orange County Parcel data, one bank of the proposed reach is owned by the Town of Chapel Hill and Orange County. The other bank, however, is under private ownership, and the landowner would need to be contacted to provide permission for any work done.

**Alternatives**

There are no proposed alternatives at this site.

**Cost-Estimate Breakdown**

Table 20.2 shows a conceptual itemized cost estimate for Site 20. These costs represent construction costs only.

**Table 20.2**

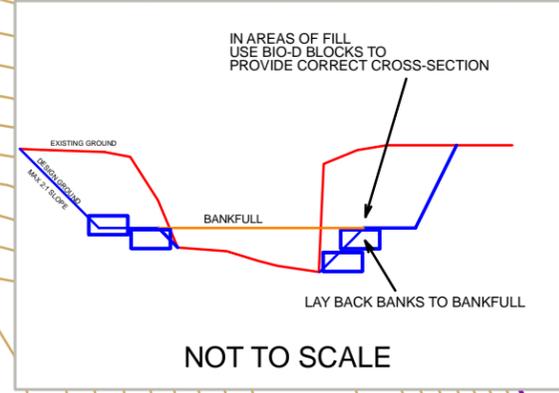
**SITE 20 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	1900.00	CY	15.00	\$28,500
Site Preparation and Planting	0.47	AC	7500.00	\$3,525
Bio-D Blocks for Bank Stabilization	100.00	LF	20.00	\$2,000
Silt Fence	1000.00	LF	3.75	\$3,750
Construction Safety Fence	1100.00	LF	2.50	\$2,750
Construction Entrance	1.00	Ea	2500.00	\$2,500
Root Wads	8.00	Ea	395.00	\$3,160
			<b>Total</b>	<b>\$43,025</b>
Mobilization (5%)	1.00	LS		\$2,151
Contingencies (10%)	1.00	LS		\$4,303
			<b>Total + Mobilization and Contingencies</b>	<b>\$49,479</b>



**SITE 20**

**CONCEPTUAL CROSS SECTION**



Tanyard Branch

EDWARDS ST

CALDWELL ST EXT

COTTON ST

STABILIZE BANKS WITH BANKFULL BENCH

INSTALL ROOT WADS FOR BANK PROTECTION

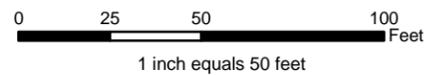
REVEGETATE BANKS

**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



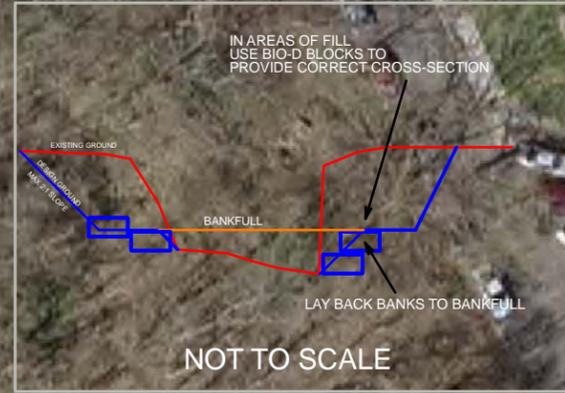
**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 20**

**CONCEPTUAL CROSS SECTION**



Tonyard Branch

STABILIZE BANKS WITH BANKFULL BENCH

INSTALL ROOT WADS FOR BANK PROTECTION

REVEGETATE BANKS

EDWARDS ST

CALDWELL ST EXT

COTTON ST

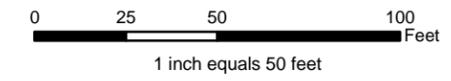
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



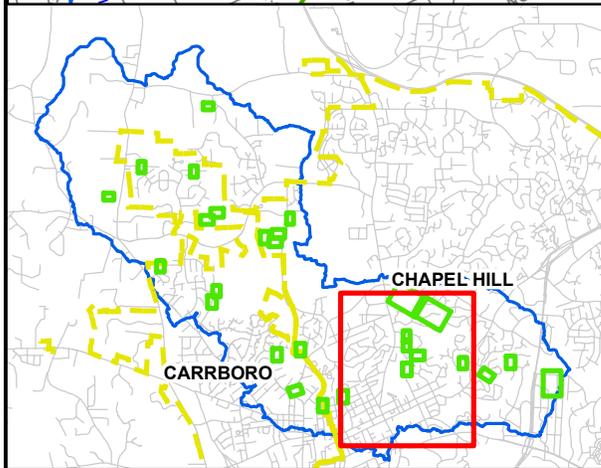
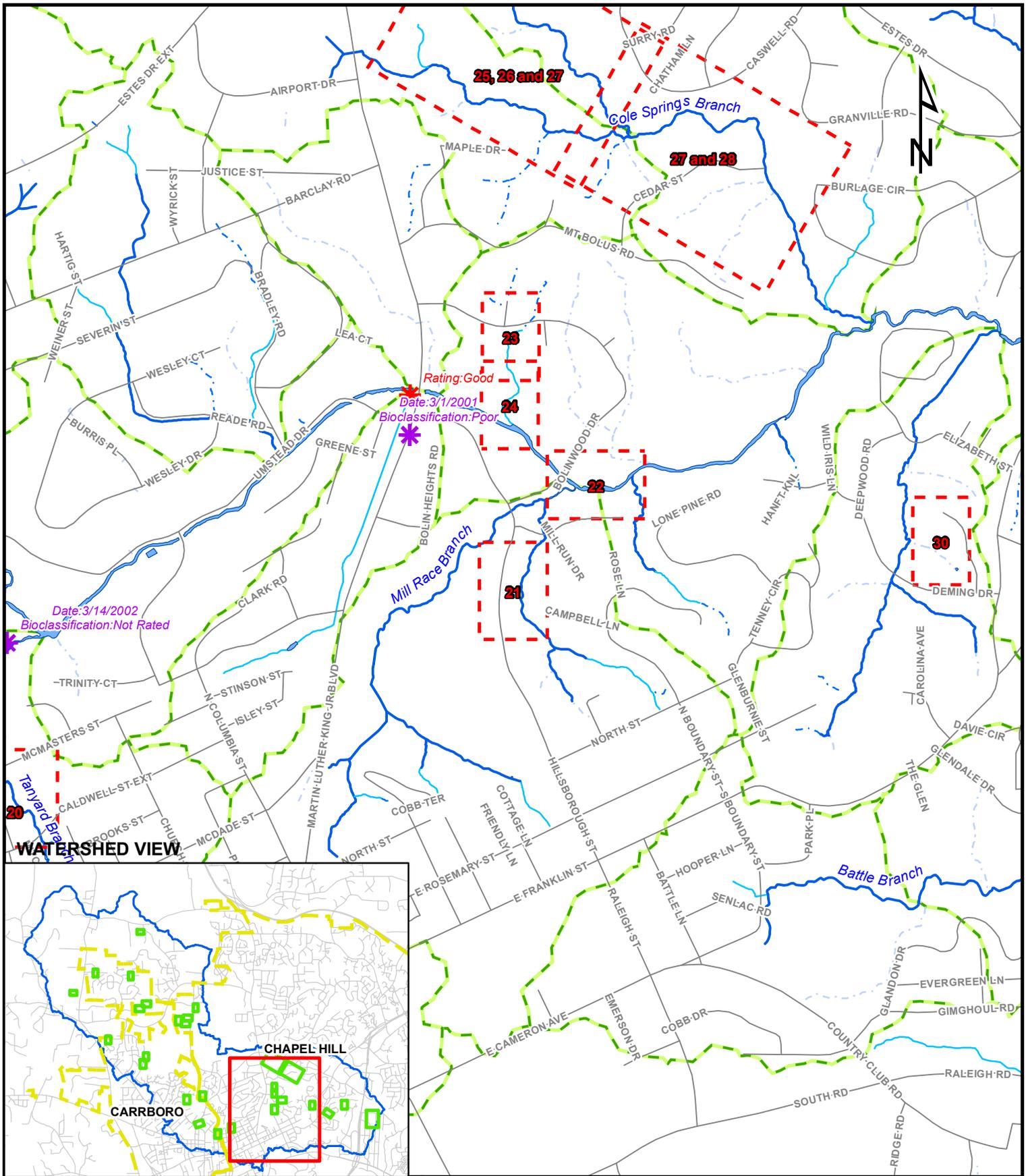
## **SITE 21**

### **Restoration of Stormwater Outfall and Gulley off of Hillsborough St.**

Index Sheet No.: 25  
Raw Data Name: IJ 43



Estimated Construction Cost: \$52,000



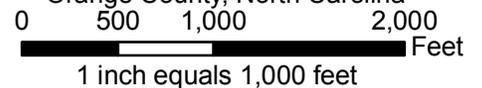
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 21  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 21	3.4	1.9	54.8%

**Location**

Site 21 is located off of Hillsborough Street, approximately 0.3 miles north of the intersection of Hillsborough St. and Rosemary St.

**Problem Description**

Site 21 consists of a deep, actively eroding gulley on a hillside below a stormwater pipe outlet from Hillsborough Street.

Stormwater runoff from Hillsborough Street and surrounding houses collects into a curb and gutter system along the street, and then is discharged at several outlets as the street runs downhill from the downtown area of Chapel Hill towards Bolin Creek. One of these outlets discharges at the top of a steep hill, with a drop of approximately 30 feet over a distance of approximately 100 feet. At the base of the hill is a tributary to Bolin Creek. There is no energy dissipation structure at this outlet, and thus the stormwater has concentrated as it flows downhill towards the stream, forming a massive gulley that is approximately 8 feet deep. The sides of this gulley are actively eroding, and likely contributing a large amount of sediment to the watershed each year.

Using the BANCS model, it is estimated that approximately 700 tons of sediment are being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 21.1**. In addition, pollutant loads have been calculated based on impervious area and land use, and are shown in **Table 21.1**.

**Table 21.1**

Pre-Treatment	
Estimated Total Sediment Export	701 tons/year
Erosion per length of Channel	7.7 tons/yr/ft
Pounds of Nitrogen	1402.1 lbs/year
Pounds of Phosphorus	701 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.1 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	0.2 lbs/year
Pounds of Phosphorus	0.1 lbs/year

**Proposed Solution**

The target of treatment at this site is reduction of sediment caused by erosion, and thus the best solution is to restore the gully into an “A” type-channel, which is stream type that would typically be found on a very steep slope (Rosgen, 1996). An “A” channel typically consists of large boulders and a run-pool sequence, with the direction and path of flow controlled by the location of rocks and boulders. These channels are typically very stable and are not a source of sediment export.

Constructing an “A” channel at this site would preclude the need to fill the existing gully, as the channel could be constructed entirely within the gully. At the bottom of the channel, a wet detention pond should be constructed with an energy dissipation pool. The water will potentially infiltrate through the bottom of the pond, providing base-flow augmentation to the perennial stream below, and overflow control will be provided by two level spreaders situated parallel to the stream channel. The level spreaders provide a distribution of flows that enter the stream. In addition to providing reduction in sediment export, the wet detention basin will serve to treat the pollutants in the stormwater runoff from Hillsborough St. An estimate of the reduction of sediment as a result of this practice has been calculated and is shown in **Table 21.2**. Pollutant reduction rates as a result of stormwater treatment are shown in **Table 21.2**.

**Table 21.2**

Site 21	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	16.82	2.66	357.95
WET DETENTION TREATMENT	25.00%	40.00%	85.00%
NET REDUCTION	4.21	1.06	304.26
FUTURE CONDITION	12.62	1.60	53.69

**Constraints**

The chief constraint of Site 21 is the difficulty of working in the existing gully. Because of the steep side slopes and depth of the gully, gaining access with equipment may be difficult.

**Alternatives**

Two alternatives are proposed for this site:

**Alternative 1:** Construct an “A” channel in the existing gully, using large boulders and stone to define the channel. Construct a wet detention basin at the bottom of the hillslope, containing a permanent pool where the channel meets the basin, to provide energy dissipation. The depth of the basin should be higher in elevation than the bed of the stream, so that groundwater will discharge from the basin and recharge the stream. The bottom of the basin should consist of a porous soil media to allow infiltration through the soil. The overflow structure will be two level spreaders situated parallel to the stream.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Alternative 2:** Construct a concrete-lined channel with friction blocks, rather than an “A” channel, and the wet detention basin and level spreaders described above.

**Cost-Estimate Breakdown**

**Tables 21.3 and 21.4** show a conceptual itemized cost estimate for the two alternatives of Site 21. These costs represent construction costs only. The cost for the wet detention pond is derived from an equation developed by Brown and Schueler (1997). The contingency fee for this site has been increased due to the difficulty of access.

**Table 21.3**  
SITE 21 Alternative 1

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	40.00	CY	15.00	\$600
Wet Detention Pond	3518.0	CF	Equation Derived	\$25,408
Site Preparation and Planting	0.10	Ac	7500.00	\$750
Rip Rap Class B	5.00	Tons	45.00	\$225
Filter Fabric	15.00	SY	5.00	\$75
Boulders	25.00	Tons	200.00	\$5,000
Silt Fence	100.00	LF	3.75	\$375
Level Spreader	2.0	EA	3000.00	\$6,000
Construction Safety Fence	300.00	LF	2.50	\$750
Construction Entrance	1.00	Ea	2500.00	\$2,500
			<b>Total</b>	<b>\$41,683</b>
Mobilization (5%)	1.00	LS		\$2,084
Contingencies (20%)	1.00	LS		\$8,337
			Total + Mobilization and Contingencies	<b>\$52,104</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		<b>\$1,270</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 21.4**  
**SITE 21 Alternative 2**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	40.00	CY	15.00	\$600
Wet Detention Pond	3518.0	CF	Equation Derived	\$25,408
Site Preparation and Planting	0.10	Ac	7500.00	\$750
Rip Rap Class B	5.00	Tons	45.00	\$225
Filter Fabric	15.00	SY	5.00	\$75
Silt Fence	100.00	LF	3.75	\$375
Level Spreader	2.0	EA	3000.00	\$6,000
Concrete Lined Channel with Friction Blocks	5.00	CY	500.00	\$2,500
Construction Safety Fence	300.00	LF	2.50	\$750
Construction Entrance	1.00	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$39,183</b>

Mobilization (5%)	1.00	LS	\$1,959
Contingencies (20%)	1.00	LS	\$7,837

Total + Mobilization and Contingencies **\$48,979**

**Maintenance Costs**

Maintenance (5% of base construction cost of BMP)	1.0	Year	<b>\$1,270</b>
---	-----	------	----------------



ALTERNATIVE 2:  
CONSTRUCT CONCRETE FLUME WITH  
FRICTION BLOCKS

USE LARGE BOULDERS TO  
DEFINE CHANNEL

**HILLSBOROUGH ST**

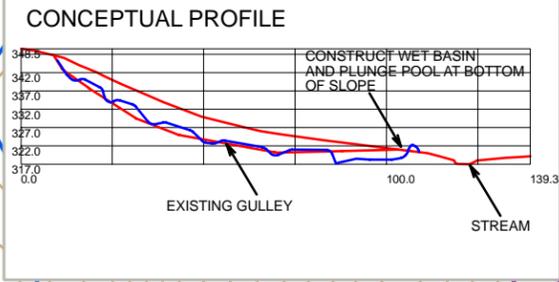
EXISTING  
OUTLET

WET POND

LEVEL SPREADER

ALTERNATIVE 1: RECONSTRUCT EXISTING  
GULLEY INTO "A" CHANNEL

LEVEL SPREADER



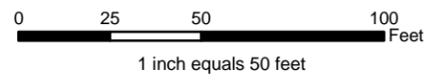
**CAMPBELL LN**

**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits





**SITE 21**

ALTERNATIVE 2:  
CONSTRUCT CONCRETE FLUME WITH  
FRICTION BLOCKS

USE LARGE BOULDERS TO  
DEFINE CHANNEL

**HILLSBOROUGH ST**

EXISTING  
OUTLET

ALTERNATIVE 1: RECONSTRUCT EXISTING  
GULLEY INTO "A" CHANNEL

WET POND

LEVEL SPREADER

LEVEL SPREADER

CONCEPTUAL PROFILE



**CAMPBELL LN**

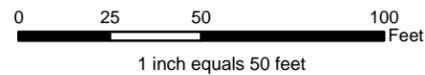
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

**BOLIN CREEK WATERSHED**  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



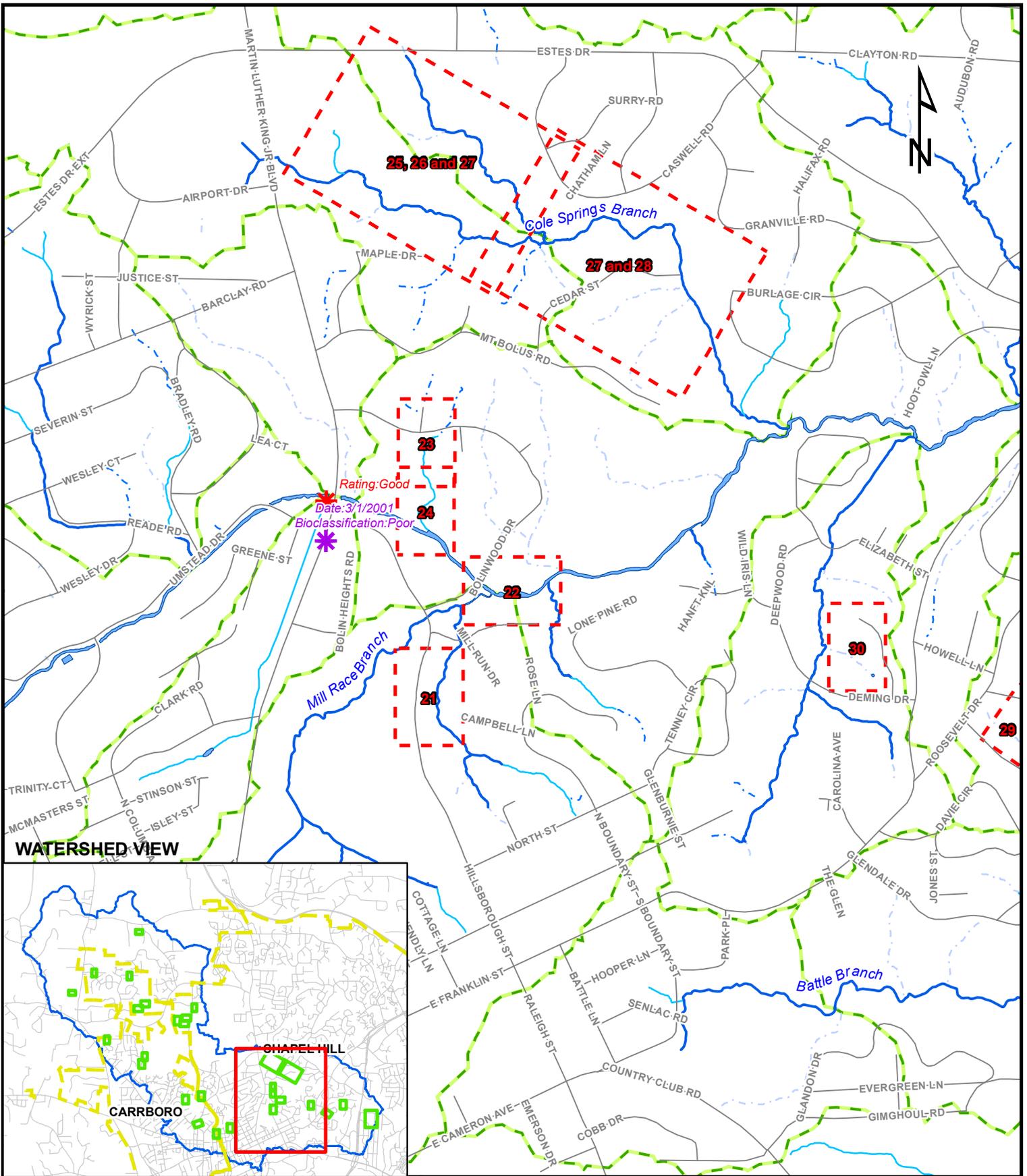
## **SITE 22**

### **Stabilization of Bank Erosion on Bolin Creek**

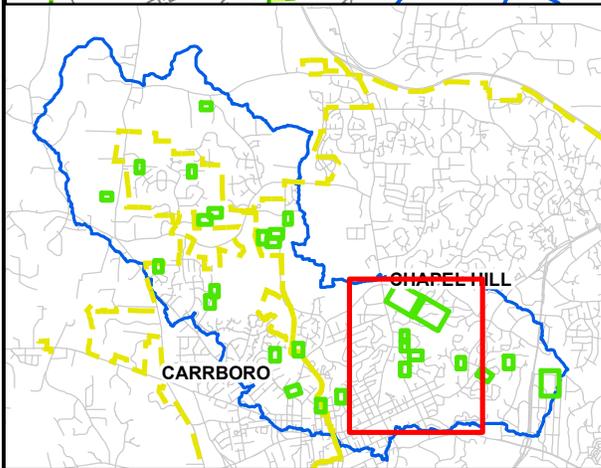
Index Sheet No.: 25  
Raw Data Name: IJ 53



Estimated Construction Cost: \$72,500



**WATERSHED VIEW**



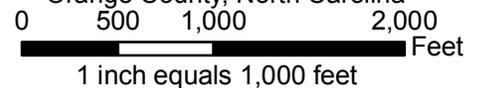
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 22  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 22	6050.0	780.5	12.9%

**Location**

Site 22 is located on Bolin Creek, just to the east of Bolinwood Drive. The site can be accessed by a greenway trail running parallel to Bolin Creek.

**Problem Description**

Site 22 consists of a massive, actively eroding bank along Bolin Creek. The bank is approximately 18 feet high at its highest point, and extends downstream for approximately 200 feet. The bank is the result of the stream flowing against the hillside at the edge of the streams valley, where it was probably moved during construction of the sewer line that runs parallel to Bolin Creek. Orange County tax parcel data shows that the properties which abut this bank have lost a significant amount their land to the erosion.

Using the BANCS model, it is estimated that approximately 1900 tons of sediment are being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 22.1**.

**Table 22.1**

Pre-Treatment	
Estimated Total Sediment Export	1889.3 tons/year
Erosion per length of Channel	8.7 tons/yr/ft
Pounds of Nitrogen	3778.7 lbs/year
Pounds of Phosphorus	1889.3 lbs/year
Post-Treatment	
Estimated Total Sediment Export	1.8 tons/year
Erosion per length of Channel	0.008 tons/yr/ft
Pounds of Nitrogen	3.7 lbs/year
Pounds of Phosphorus	1.8 lbs/year

**Proposed Solution**

Site 22 needs stabilization of the hillside that has been eroded by the flow of Bolin Creek. If the erosion continues, tons of sediment will continue to be exported each year, and the adjacent landowners will continue to lose more of their property. Stabilization of the hillside will require a fill slope to be placed against the existing eroded bank at a slope of 2:1 or less. Doing this will also require relocation of the existing stream channel (see

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

Plan View). The existing stream channel should then be filled, which will provide a floodplain for the new channel. The entire site should then be planted with native vegetation. Structures such as root wads and cross vanes can be used to temporarily protect the newly constructed banks while the vegetation becomes established. These types of projects have a very high rate of success when the constructed project has the proper bankfull height, thus providing flood plain access. This project is a very high priority and also has a high chance for success.

**Constraints**

While an existing drainage easement may exist at the site, as evidenced by the sewer line running parallel to the stream, Orange County Tax Parcel data shows the land surrounding Bolin Creek is privately owned. Thus permission may need to be obtained to perform the recommended treatment at the site. It is assumed the landowners will be cooperative with efforts to keep them from continuing to loose their property

The greenway and sewer lines run parallel to Bolin Creek at Site 22, therefore the relocation of the stream channel should be adjusted to maintain an adequate distance from these two features. Based on preliminary Proposed Solution, however, there is sufficient room to construct a fill slope and new channel without impacting the sewer line or greenway trail.

A floodway analysis and submission of a conditional letter of map revision (CLOMR) will likely be needed to determine if there will be any increase or decrease in flood elevations as a result of relocating Bolin Creek.

**Alternatives**

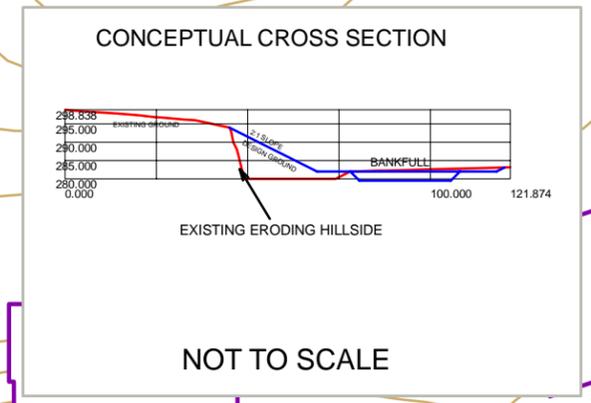
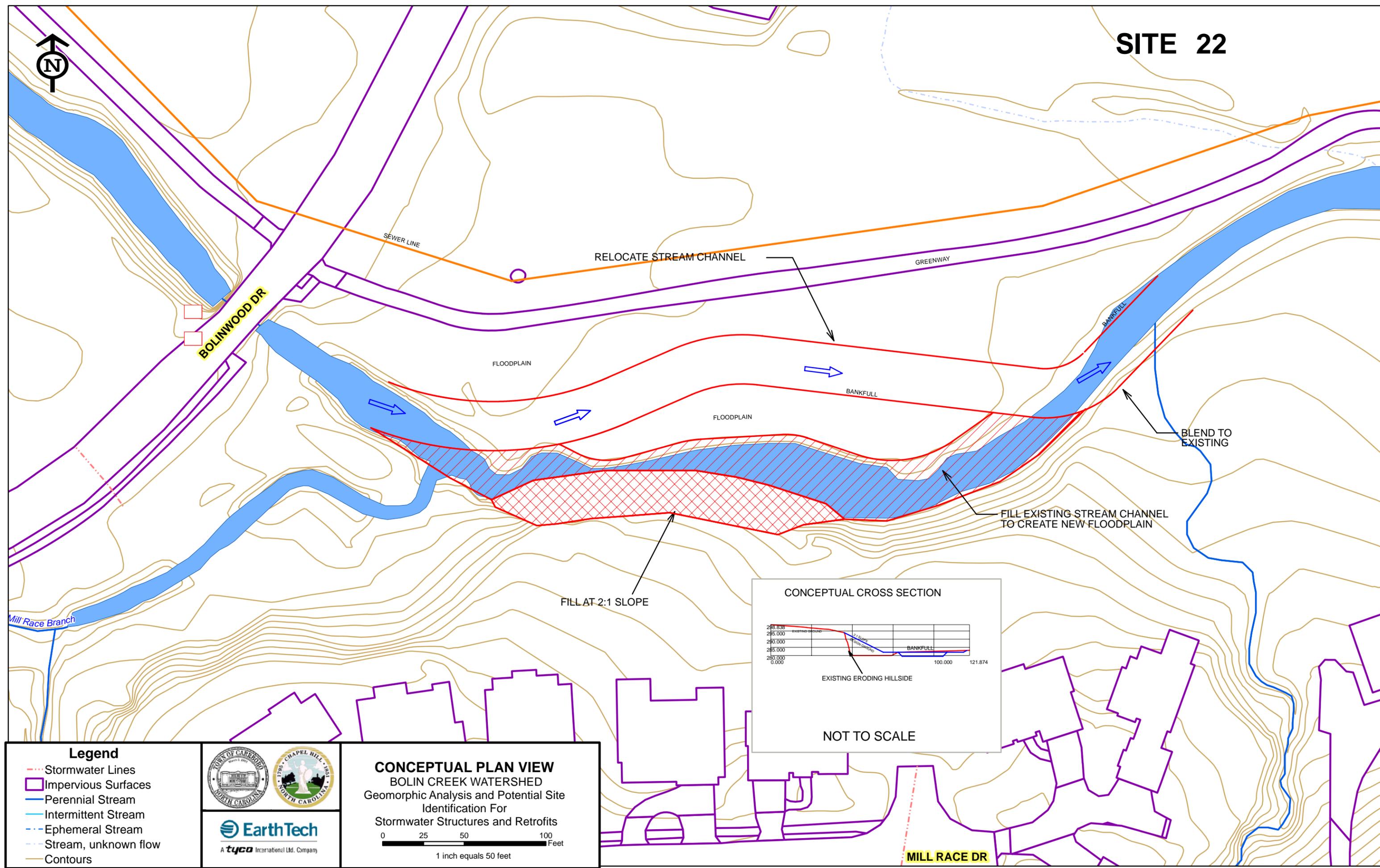
There are no alternatives proposed for this site.

**Cost-Estimate Breakdown**

**Table 22.2** shows a conceptual itemized cost estimate for Site 22. These costs represent construction costs only.

**Table 22.2**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	2500.00	CY	15.00	\$37,500
Plantings	0.80	Ac	7500.00	\$6,000
Root Wads	8.00	Ea	395.00	\$3,160
Cross Vane	2.00	Ea	5000.00	\$10,000
Silt Fence	575.00	LF	3.75	\$2,156
Construction Safety Fence	700.00	LF	2.50	\$1,750
Construction Entrance	1.00	Ea	2500.00	\$2,500
			<b>Total</b>	<b>\$63,066</b>
Mobilization (5%)	1.00	LS		\$3,153
Contingencies (10%)	1.00	LS		\$6,307
			<b>Total + Mobilization and Contingencies</b>	<b>\$72,526</b>



**Legend**

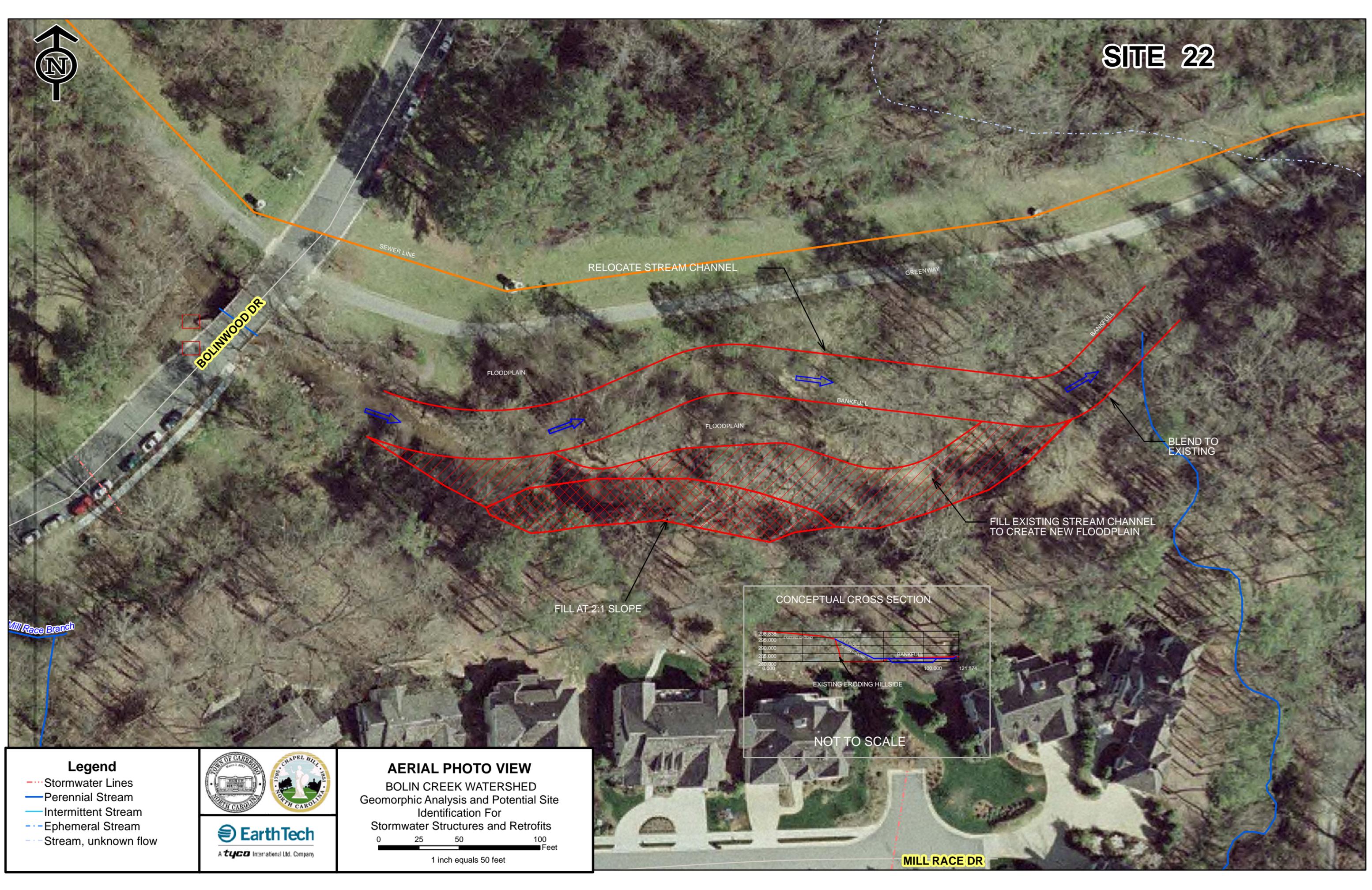
- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours

**EarthTech**  
A tyco International Ltd. Company

**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits

0 25 50 100 Feet  
1 inch equals 50 feet

**MILL RACE DR**



**BOLINWOOD DR**

SEWER LINE

RELOCATE STREAM CHANNEL

GREENWAY

FLOODPLAIN

FLOODPLAIN

BANKFULL

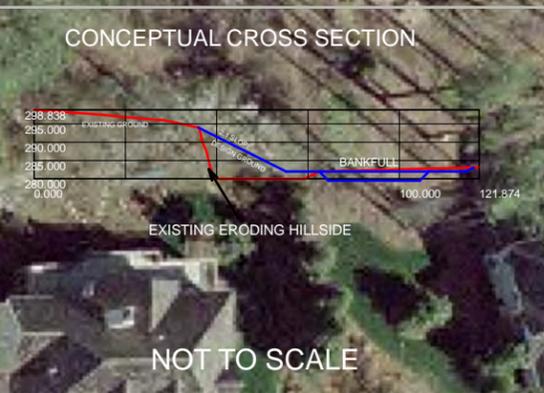
BANKFULL

BLEND TO EXISTING

FILL EXISTING STREAM CHANNEL TO CREATE NEW FLOODPLAIN

FILL AT 2:1 SLOPE

CONCEPTUAL CROSS SECTION



NOT TO SCALE

- Legend**
- Stormwater Lines
  - Perennial Stream
  - Intermittent Stream
  - - - Ephemeral Stream
  - - - Stream, unknown flow



**AERIAL PHOTO VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits

0 25 50 100 Feet  
 1 inch equals 50 feet

**MILL RACE DR**

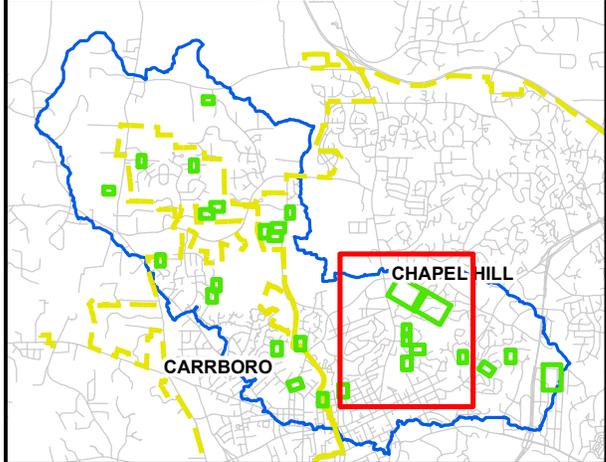
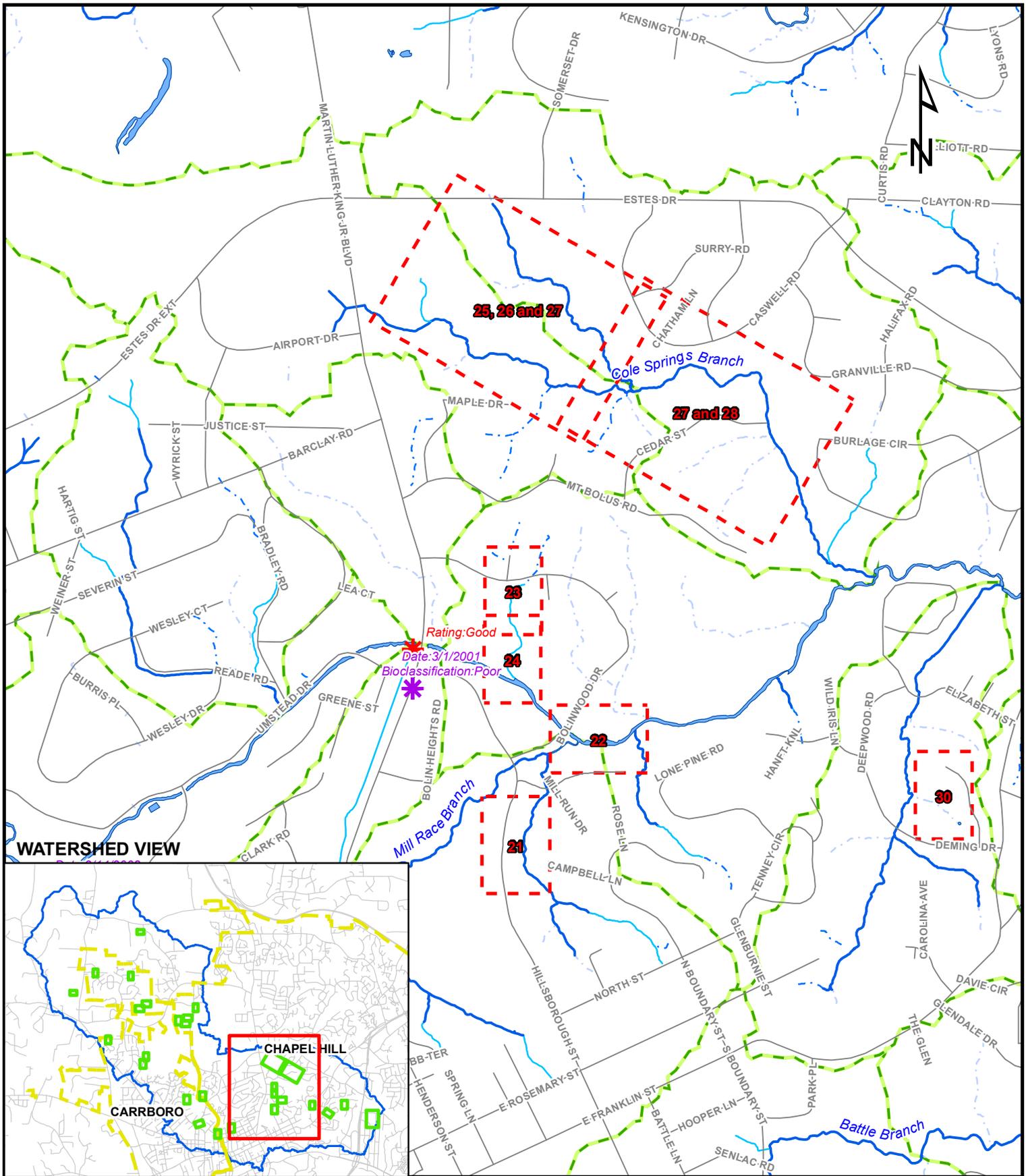
## **SITE 23**

### **Retrofit of Existing Sediment Basin in Residential Area off Bolinwood Drive**

Index Sheet No.: 25  
Raw Data Name: BD 57



Estimated Construction Cost: \$32,000



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow




**EarthTech**  
A tyco International Ltd. Company

**SITE 23  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

### **Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 23	14.5	2.6	18.1%

### **Location**

Site 23 is located just south of Bolinwood Drive, near its intersection with Mullin Ct. The site is approximately 700 feet to the east of the intersection of Bolinwood Drive and Martin Luther King Jr .Blvd.

### **Problem Description**

Site 23 consists of an existing sediment basin at a pipe outlet just south of Bolinwood Drive. The basin was likely built during construction of the surrounding neighborhood to collect sediment from runoff during construction. The basin has now filled in, and consists only of a rip rap berm and a long, flat area of silt and clay. Small trees have grown up in the basin over the intervening years, and the entire site is surrounded by a young forest. Stormwater from the culvert currently passes over the basin without any significant retention or detention, and then concentrates into a scoured channel just downhill of the basin. Due to these existing conditions, there is no water quality treatment of the runoff of the contributing drainage area, which consists of a residential area of large houses and driveways. The ephemeral drain downstream of the old basin is eroding and shows signs of hydraulic stress from concentrated flows. The downstream channel is incised and actively headcutting upstream. This headcut is addressed in Site 24.

### **Proposed Solution**

The existing basin at Site 23 poses a good opportunity for a BMP retrofit in the form of a bioretention area. The existing basin is relatively long, which will provide an adequate flow path ratio of greater than 3:1, which is recommended for bioretention areas (DWQ, 2007). In addition, excavation will be limited to digging out the depth needed for adequate water quality storage volume. The storage volume in the bioretention area will reduce the runoff volume for the downstream reach, change the timing of peak flows and reduce peak flows leaving the site. This site would assist in the successful stabilization of the reach in site 24.

The current nutrient export rates, and potential benefit of a bioretention area here have been calculated based on land use, drainage area and percent imperviousness of the drainage area, and are displayed in **Table 23.1**:

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 23.1**

SITE 23	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	6.89	0.45	172.89
BIORETENTION TREATMENT REMOVAL %	35.00%	45.00%	85.00%
NET REDUCTION	2.41	0.20	146.95
FUTURE CONDITION	4.48	0.25	25.93

**Constraints**

Orange County tax parcel GIS data indicates that the property on which Site 23 is located is privately owned by a single landowner. The nearest right of way to this site is Bolinwood Drive. If Site 23 is constructed, it is advisable to implement these two designs simultaneously and access may be more feasible by selected pathway through the forest along the reach from the downstream site.

**Alternatives**

There are no alternatives proposed for this site.

**Cost-Estimate Breakdown**

**Table 23.2** shows a conceptual itemized cost estimate for Site 23. These costs represent construction and maintenance costs only. The cost for the bio-grade step is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007). The contingency fee for this site has been increased due to the difficulty of access.

**Table 23.2**

**SITE 23 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-Retention Area	2115.00	CY	12.62	\$26,691
<b>Total</b>				<b>\$26,691</b>

Mobilization (5%)	1.00	LS	\$1,335
Contingencies (15%)	1.00	LS	\$4,004

Total + Mobilization and Contingencies **\$32,030**

**Maintenance Costs**

Maintenance (5% of base construction cost of BMP)	1.0	Year	<b>\$1,601</b>
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**SITE 23**



**BOLINWOOD DR**

**MULLIN CT**

**SONGBIRD LN**

BIORETENTION AREA WITH UNDERGROUND STORAGE

INLET

RIIP RAP OUTLET

RIIP RAP

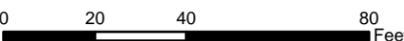
**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours




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**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



0 20 40 80 Feet  
1 inch equals 40 feet



**SITE 24**



BIOGRADE STEP WITH STORAGE

RIIP RAP OUTLET

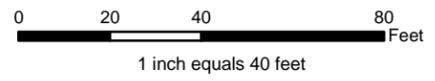
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

**BOLIN CREEK WATERSHED**  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



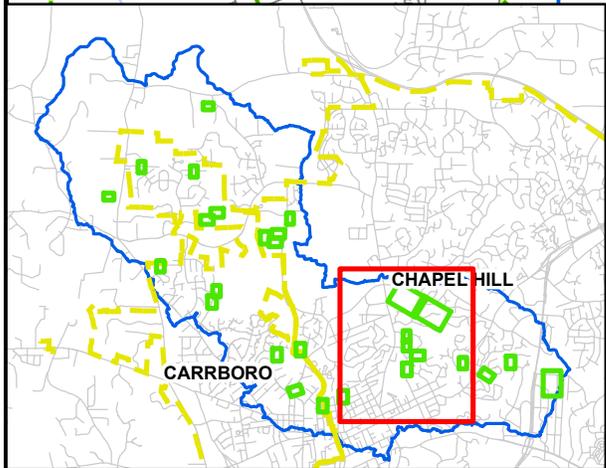
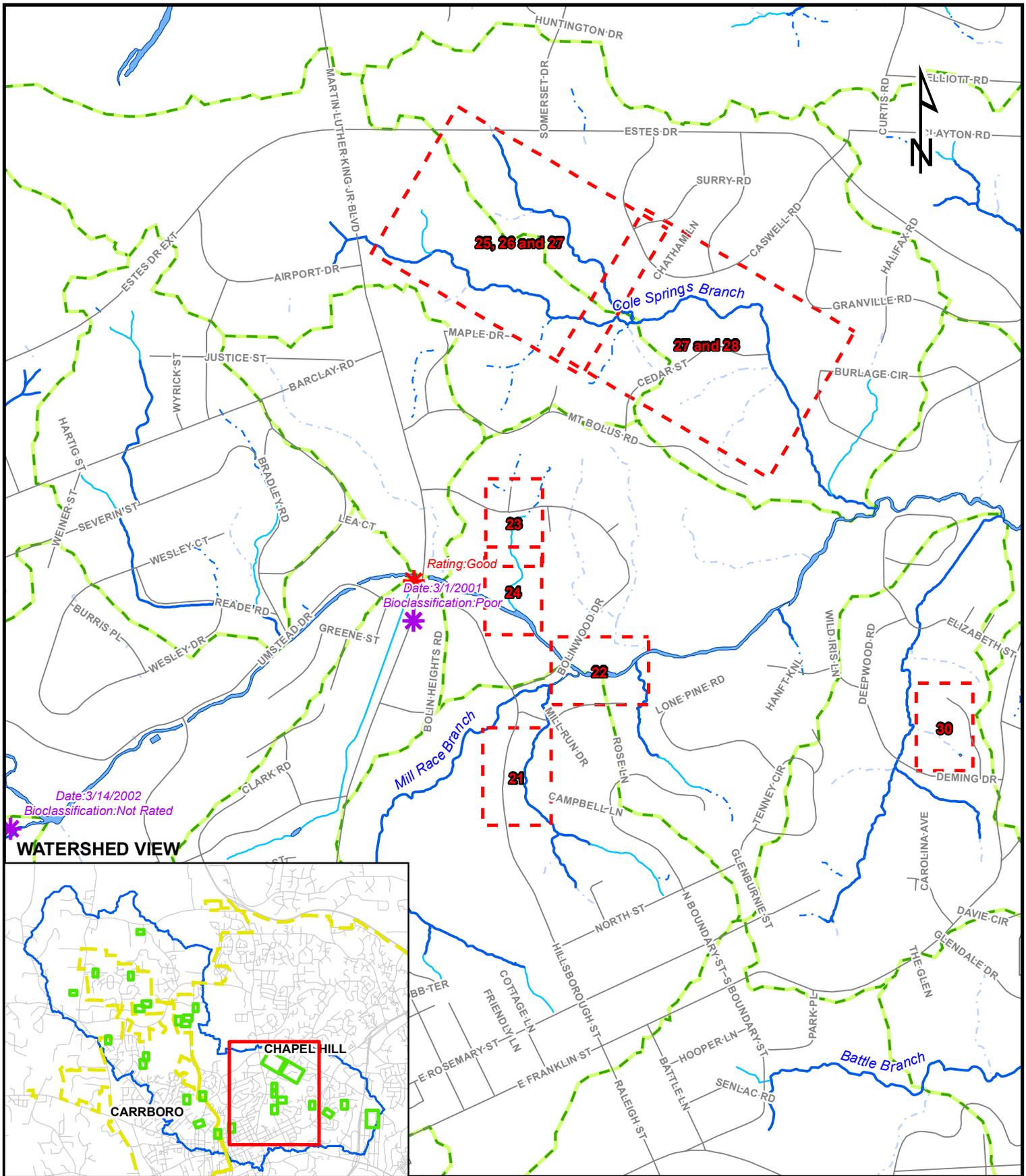
## **SITE 24**

### **Construction of Bioretention Cells for Pollutant Removal at Apartment Complex**

Index Sheet No.: 25  
Raw Data Name: BD 55



Estimated Construction Cost: \$107,500



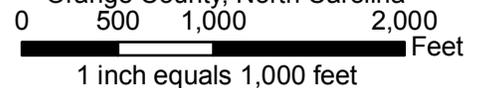
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 24  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 24	18.0	2.9	16.2%

**Location**

Site 24 is located on the western edge of an apartment complex adjacent to Bolinwood Drive, and to the north of the Bolin Creek Greenway.

**Problem Description**

Site 24 consists of 140 feet of an incised, actively eroding stream (low bank height approximately 4 feet). A very prominent headcut (approximately 3' vertical in 1' horizontal) marks the top of this site (upstream). The head cut is active and undercut, demonstrating a high degree of mobility. A BEHI rating of "extreme" was found for the entire length of the channel. Likely causes of this incision are the increase in peak flows of the contributing drainage area due to development, headcut effects caused by the past construction of the greenway downstream, and possible stream modification during the construction of the adjacent apartment complex. The stream flows into Bolin Creek only 70 feet downstream of the site, after passing under the Bolin Creek Greenway.

Using a modified BANCS model, it is estimated that approximately 377.5 tons of sediment are being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 24.1**.

**Table 24.1**

Pre-Treatment	
Estimated Total Sediment Export	377.5 tons/year
Erosion per length of Channel	2.7 tons/yr/ft
Pounds of Nitrogen	755 lbs/year
Pounds of Phosphorus	377.5 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0.3 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	0.6 lbs/year
Pounds of Phosphorus	0.3 lbs/year

**Proposed Solution**

The contributing drainage area of the stream at Site 24 is comprised of 16% impervious area, consisting of large homes, driveways, parking pads, apartment complexes and roads. Treatment of the runoff of this area is warranted especially by the fact that the

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

stream flows directly into Bolin Creek after only a short distance, without any intervening storage or detention. However, space is limited within the site, which is composed of young pines and hardwoods, and a relatively narrow valley (man made). Thus, the preferred solution is the construction of a “bio-grade step”, which is a series of small bio-retention cells filled with a filter media, such as a mixture of sand fines and organic matter (see Appendix A-Details). Ideally, this media will have a filtration rate of 1.0 to 2.0 inches per hour, to optimize pollution removal (Schueler, et. al., 2007). Each cell is connected to the other through a seepage or drain layer, thus allowing stormwater to filter through each cell and augment baseflow to the receiving channel. The combination of the underground storage volume that results from each cell can create a significant reduction in runoff volume to receiving waters and attenuates the peak flow rates. The individual cells must drain over time to regain the available storage volume for the next rain event. Below the bio-grade step, an energy dissipation, stilling/ boulder basin (see Appendix A-Details), should be built to dissipate any overflow before reaching the greenway and Bolin Creek.

**Table 24.2**

SITE 24	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	9.50	0.96	129.14
BIORETENTION TREATMENT REMOVAL %	35.00%	45.00%	85.00%
NET REDUCTION	3.33	0.43	109.77
FUTURE CONDITION	6.18	0.53	19.37

**Constraints**

The channel on which treatment is proposed is labeled as “intermittent” by Chapel Hill GIS stream data. This stream status was not verified during the course of this study. If this is the case, construction of an in-line bioretention area may not be allowed under NCDWQ rules. Earth Tech observations just upstream of this site indicate that this reach is likely to be ephemeral due to the lack of a clearly defined channel upstream of the head cut. Obviously, the scour channel downstream of the headcut gives the impression of a stream. It would require further analysis to determine the status of the channel.

The site is partially owned by the Town of Chapel Hill, and partially owned by a private landowner. If the proposed treatment is to be implemented, drainage and access easements must be acquired from the private landowner, as well as a maintenance agreement. Alternatively, a smaller length of channel could be treated using only the land owned by the Town of Chapel Hill.

**Alternatives**

If this reach classifies as intermittent, another approach would be warranted, such as bank stabilization and installation of grade control to limit the headcut. However, this is not treated as a formal alternative by this report.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Cost-Estimate Breakdown**

**Table 24.3** shows a conceptual itemized cost estimate for Site 24. These costs represent construction and maintenance costs only. The cost for the bio-grade step is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

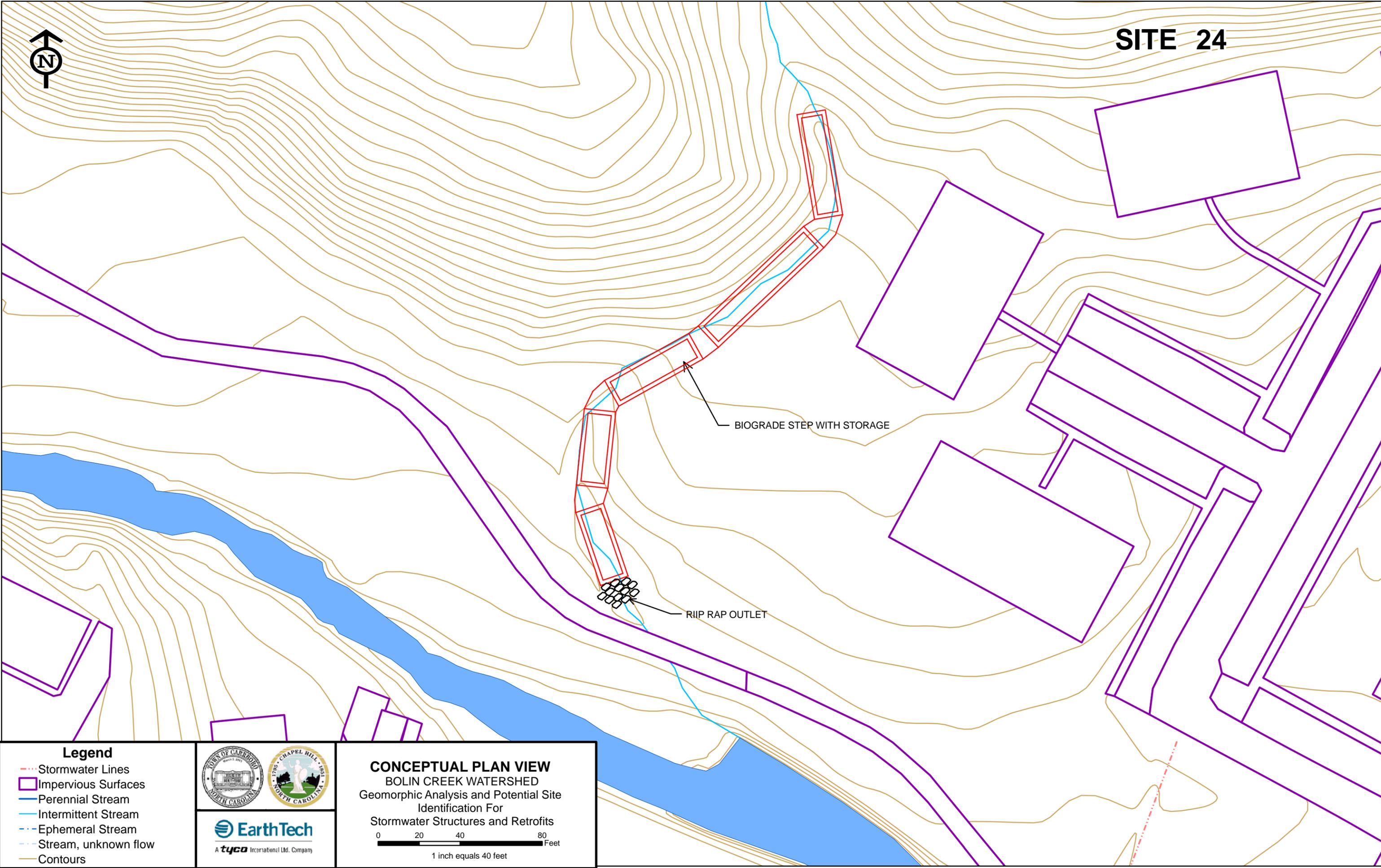
**Table 24.3**  
SITE 24 Construction Cost

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Biograde Step	7410.0	CF	12.62	\$93,514
<b>Total</b>				<b>\$93,514</b>
Mobilization (5%)	1.00	LS		\$4,676
Contingencies (10%)	1.00	LS		\$9,351
Total + Mobilization and Contingencies				<b>\$107,541</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		<b>\$5,377</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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**SITE 24**

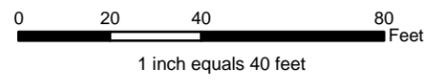


**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits





**SITE 24**



BIOGRADE STEP WITH STORAGE

RIIP RAP OUTLET

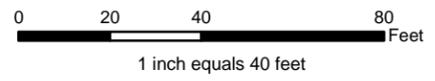
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- Stream, unknown flow



**AERIAL PHOTO VIEW**

**BOLIN CREEK WATERSHED**  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

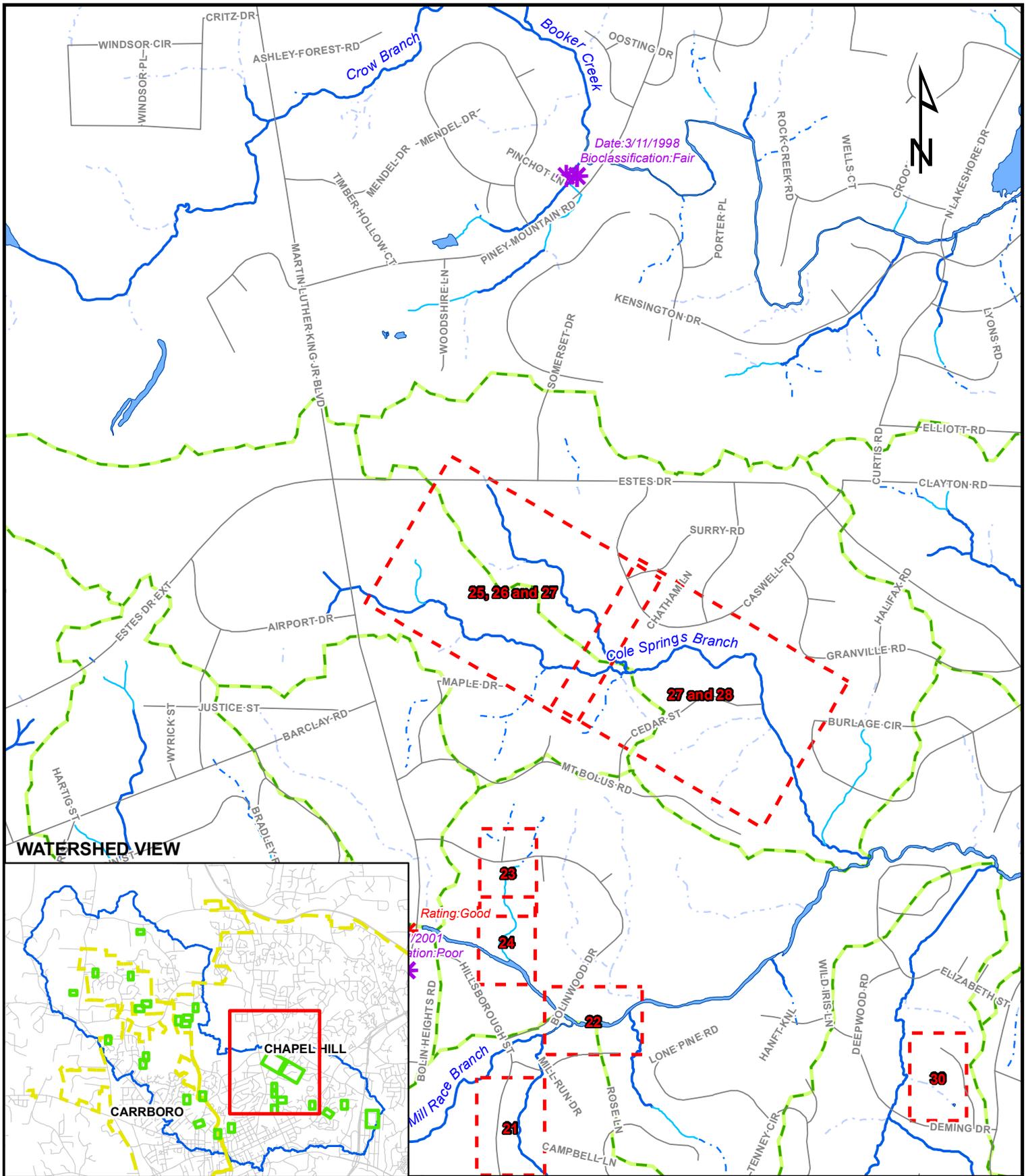


## **SITE 25**

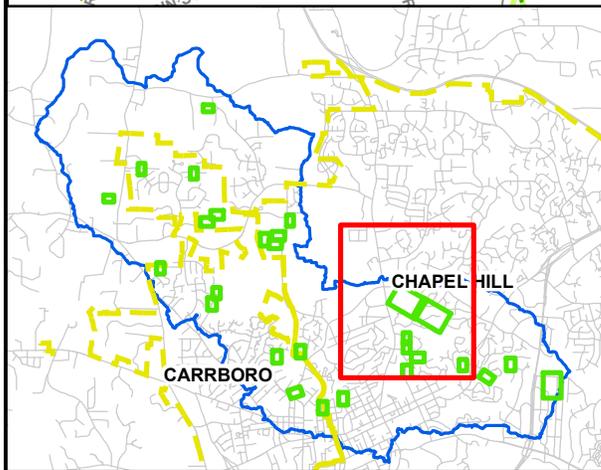
Index Sheet No.: 26  
Raw Data Name: BD 58



Estimated Construction Cost: \$84,500



**WATERSHED VIEW**



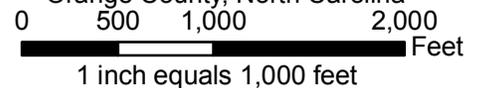
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 25, 26 and 27  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

Cole Springs Branch

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 25	161.6	33.2	20.5%

Tributary

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 25	15.0	4.8	32.0%

**Location**

Site 25 is located approximately 800 feet southeast of the intersection of Martin Luther King Jr. Blvd. and Estes Dr. The site is south of a YMCA facility, on a tributary to a perennial stream, Cole Springs Branch.

**Problem Description**

The perennial stream along which Site 25 is located, Cole Springs Branch, exhibits severe incision and erosion for most of its course from its headwaters to where it flows into Bolin Creek. The causes of this widespread degradation are apparent when examining the watershed of the stream, which consists of vast areas of impervious surface, including portions of Horace Williams Airport, the UNC facilities management complex, and high density residential developments. The crossing of Martin Luther King Jr. Blvd. also seems to have adversely affected the stream, as the accumulated and concentrated flow of most of the watersheds imperviousness is discharged after passing under that road.

While the riparian corridor of the stream after passing under Martin Luther King Jr. Blvd is largely intact, many small tributaries, most of which discharge from residential storm sewer systems, continue to flow into Cole Springs Branch before it meets Bolin Creek downstream. The combined problems of peak flow and pollutant input from all of these small drainages likely compounds the degradation already being caused by the accumulated flow and pollutants from upstream of Martin Luther King Jr. Blvd. The majority of these ephemeral swales show signs of scour and debris packing that would not normally be associated with un-stressed ephemeral channels.

Site 25 is situated on one of these small drainages, and its watershed consists of the impervious areas of a YMCA and office park facility, as well as residential areas.

**Proposed Solution**

Site 25 is located at the bottom of what was observed to be an ephemeral drainage, consisting of an incised channel. Two BMPs could possibly be constructed here. A bio-retention area could be placed in-line with the ephemeral channel just before it flows into Cole Springs Branch. Just downstream, a small stormwater wetland could be constructed as an off-line BMP where there is a flat, wide area in the valley of Cole Springs Branch. Off-line retention is needed throughout the watershed of Cole Springs Branch, both to attenuate peak flows and provide pollutant treatment. Base flow augmentation of the Cole Springs Branch could also result from this practice.

The bio-retention area is recommended as an in-line structure here, because of its ability to treat small drainage areas, the fact that it needs minimum area to construct it, and because it can function on steep slopes (NCDWQ, 2007). A bio-retention area would not likely be appropriate in the floodplain of Cole Springs Branch as an offline BMP, as it requires a minimum depth of 2 feet between the water table and the bottom of the retention area, which is a situation which is not often present in a floodplain (NCDWQ, 2007). Instead, a stormwater wetland would be more appropriate. Flow diversion into the wetland would be provided by a flow-splitting structure containing a a vane or weir, placed in Cole Springs Branch. This is a common way to “harvest” storm flows without impeding the base flows of the stream in any way. Such a structure would allow a designed volume of flow to enter into the wetland, while allowing any flow above that volume to continue downstream. If properly placed and designed, a grade control or cross vane can serve this same purpose while acting a grade control for the stream.

Pollutant loads of the contributing drainage area, as well as potential reductions, have been estimated and are displayed in **Table 25.1**.

**Table 25.1**

SITE 25	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	16.41	1.66	3344.86
BIORETENTION TREATMENT	35.00%	45.00%	85.00%
NET REDUCTION	5.74	0.75	2843.13
FUTURE CONDITION	10.66	0.91	501.73

### **Constraints**

Most of the site consists of a mature hardwood forest, and therefore tree removal will be necessary at this site for both BMPs.

The site is located on two privately owned properties. Access to the site may be difficult due to the steep terrain and wooded condition of the site.

### **Alternatives**

No alternatives are proposed for this site.

### **Cost-Estimate Breakdown**

**Table 25.2** shows a conceptual itemized cost estimate for Site 25. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997). The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

*Bolin Creek Watershed  
 Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

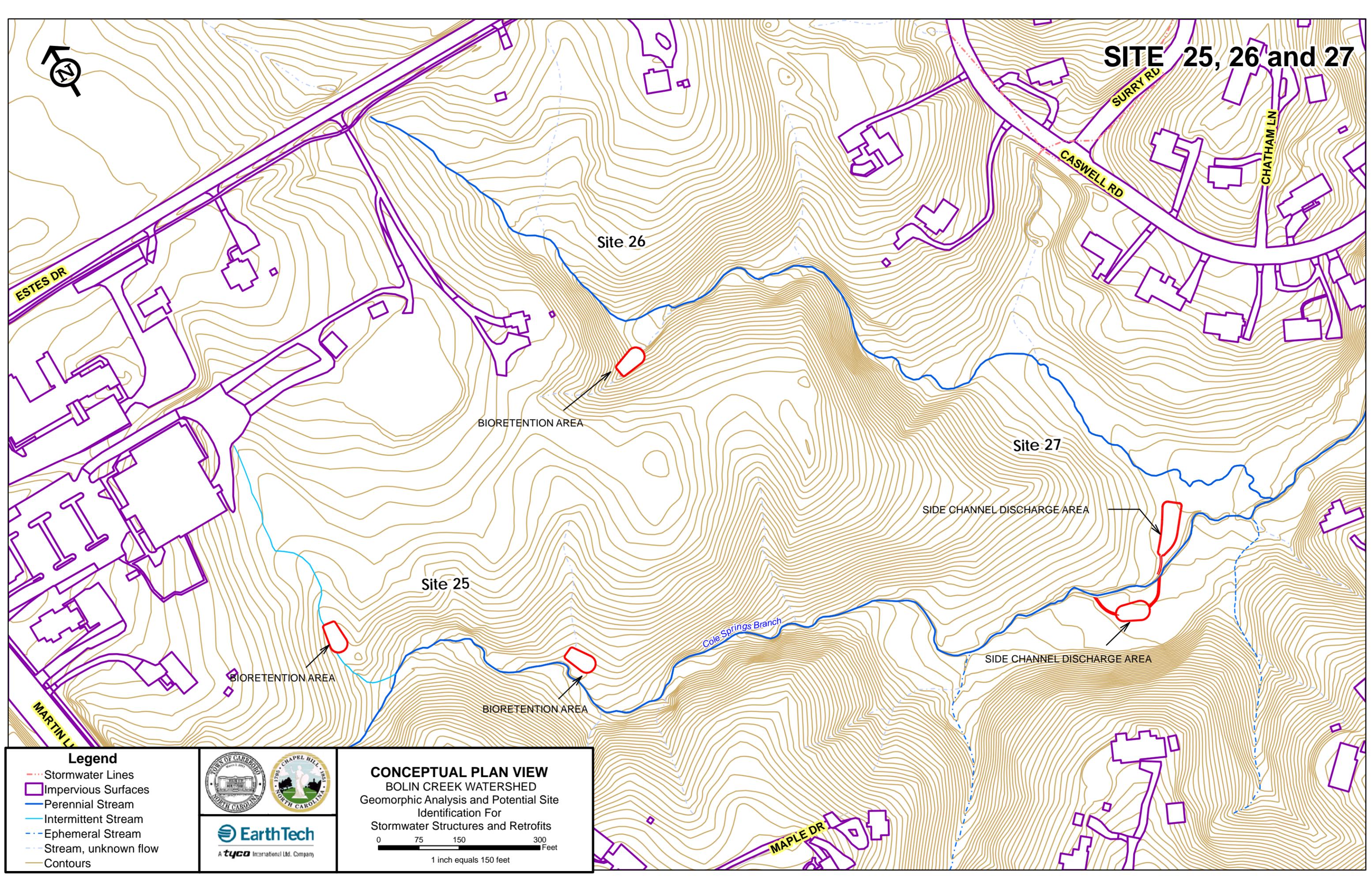
**Table 25.2**  
**Site 25 Construction Cost**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid
				Amount
Bio-Retention Area	4602.00	CF	12.62	\$58,077
Stormwater Wetland	5547.0	CF	Equation Derived	\$12,399
<b>Total</b>				<b>\$70,476</b>
Mobilization (5%)	1.00	LS		\$3,524
Contingencies (15%)	1.00	LS		\$10,571
<b>Total + Mobilization and Contingencies</b>				<b>\$84,571</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		\$4,229

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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# SITE 25, 26 and 27



Site 26

Site 27

Site 25

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

BIORETENTION AREA

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

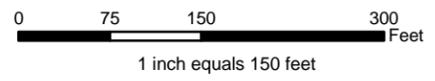
Cole Springs Branch

### Legend

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



### CONCEPTUAL PLAN VIEW BOLIN CREEK WATERSHED Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits





# SITE 25, 26 and 27

ESTES DR

SURRY RD

CASWELL RD

CHATHAM LN

Site 26

Site 27

Site 25

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

BIORETENTION AREA

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

Cole Springs Branch

MARTIN LN

MAPLE DR

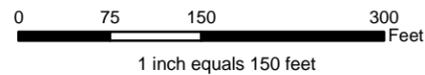
### Legend

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



### AERIAL PHOTO VIEW

**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits

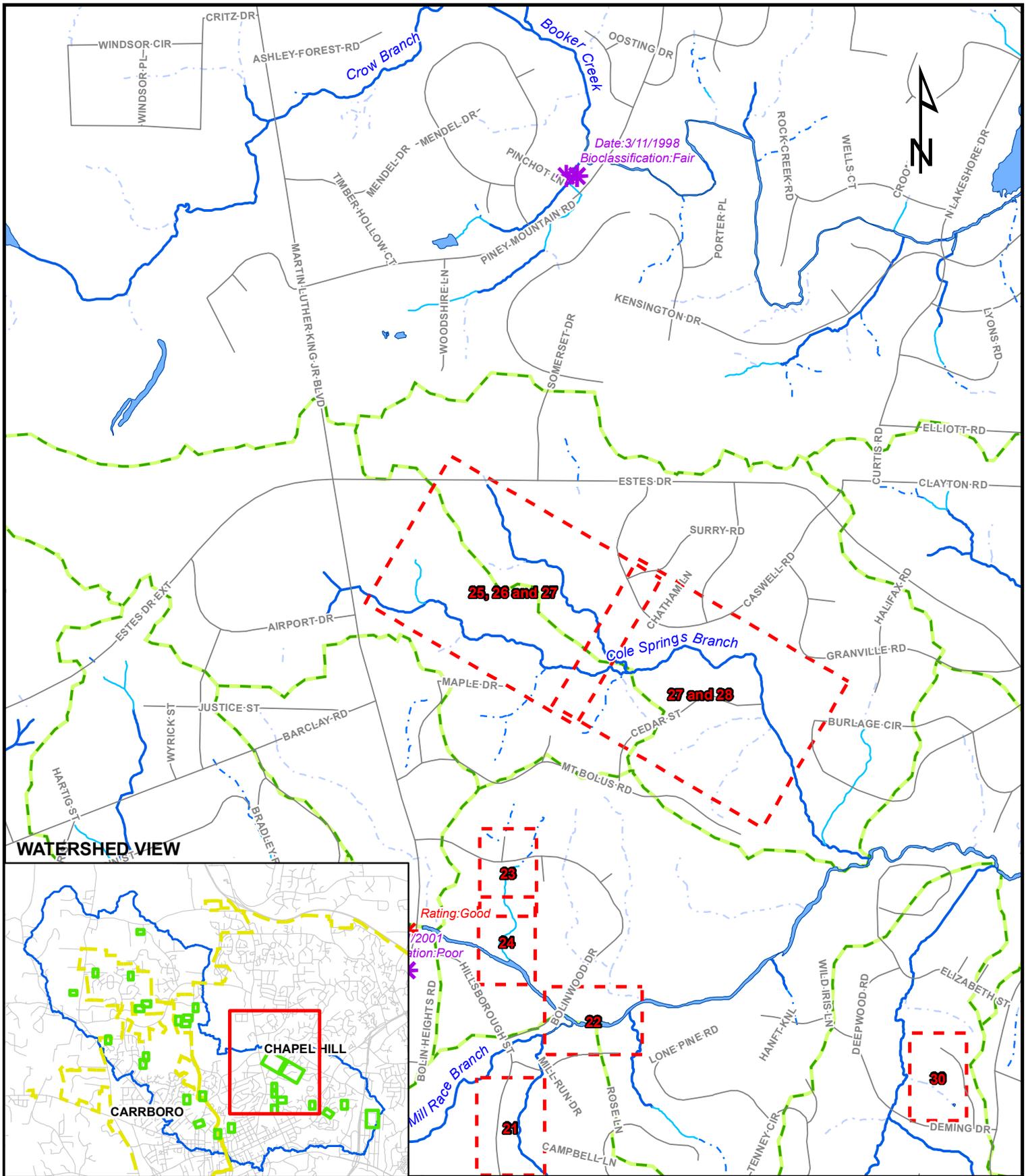


## **SITE 26**

Index Sheet No.: 26  
Raw Data Name: BD 71



Estimated Construction Cost: \$69,400



**WATERSHED VIEW**

**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



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**SITE 25, 26 and 27  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet



1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 26	29.0	3.0	10.3%

**Location**

Site 26 is located approximately 800 feet south of the intersection of Estes Dr. and Somerset Dr.

**Problem Description**

Site 26 is situated on a small tributary to Cole Springs Branch with active headcuts and bank erosion. The tributary was observed to be ephemeral, based on indicators such as position in the landscape, rooted plants in the channel and other factors. The headcut is actively cutting upstream, and needs immediate attention before it forms more of a gully. **Table 26.1** shows a summary of calculated pollutant loads being produced by the contributing drainage area.

**Proposed Solution**

The ephemeral drain provides an ideal site for bio-retention when the drain meets the floodplain of Cole Springs Branch. The storage volume and reduced velocities will aid the stability of the Cole Springs Branch. Baseflow augmentation should result from this floodplain BMP. The outlet of the proposed bio-retention area should be a level spreader that runs parallel to Cole Springs Branch. This will alleviate the concentrated flow and scour that was observed on the site. Water quality and quantity management from the bio-retention area placed at the confluence of the steep ephemeral channel and Cole Springs Branch represents the type of project that should be implemented throughout this sub-watershed. Though a liner bio-retention, such as bio-grade step, would be applicable here, it is less expensive to manage these flows where they reach the lower slope of the perennial streams floodplain.

Pollutant loads of the contributing drainage, as well as potential reductions, have been estimated and are displayed in **Table 26.1**.

**Table 26.1**

SITE 26	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	3.74	0.38	50.80
BIORETENTION TREATMENT	35.00%	45.00%	85.00%
NET REDUCTION	1.31	0.17	43.18
FUTURE CONDITION	2.43	0.21	7.62

**Constraints**

Most of the site consists of a mature hardwood forest, and therefore tree removal will be necessary at this site for the BMP.

The site is located on a privately owned property.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

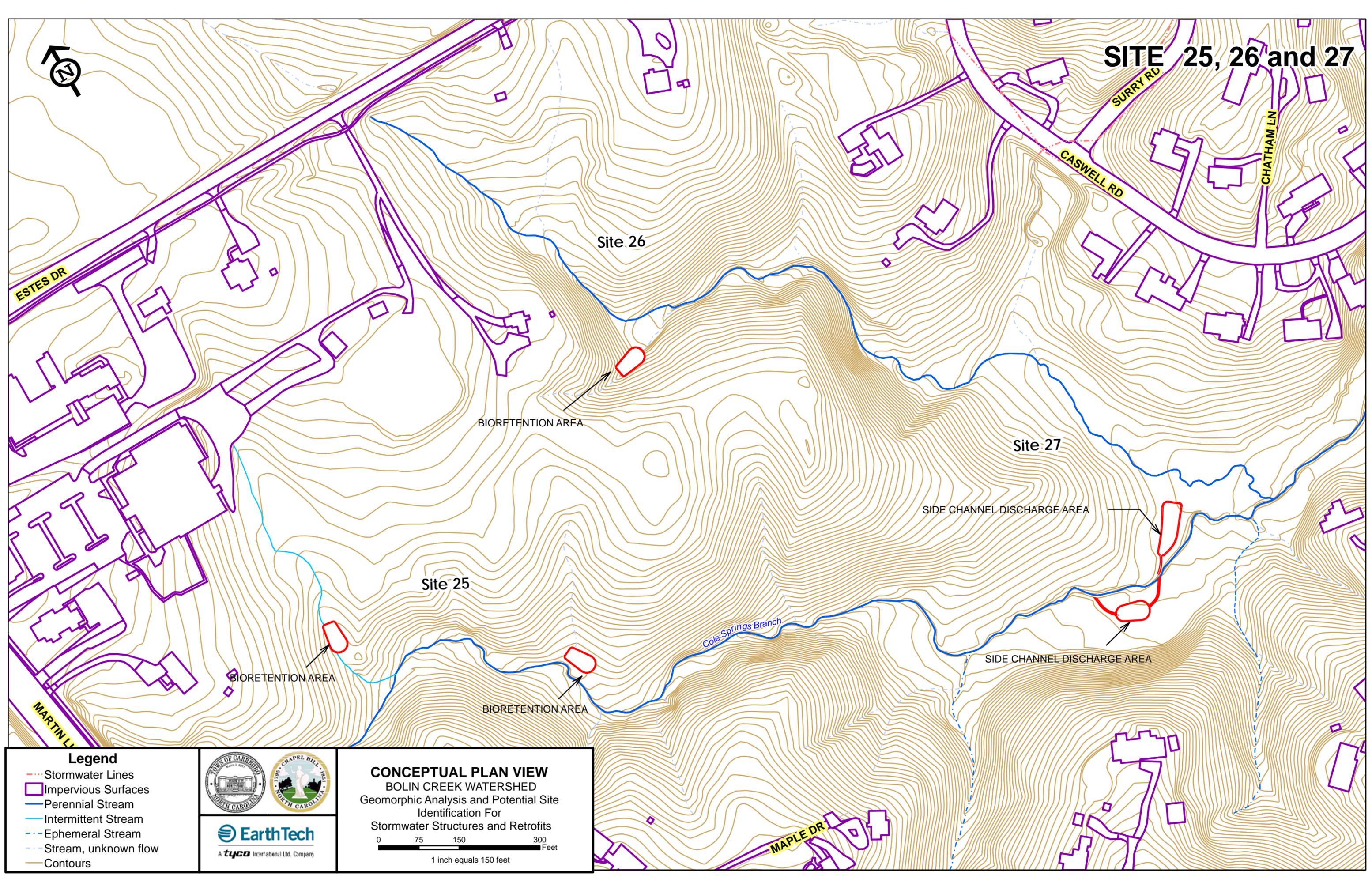
**Table 26.2** shows a conceptual itemized cost estimate for Site 26. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007). The contingency fee for this site has been increased due to the difficulty of access and proximity to a utility easement.

**Table 26.2**

**SITE 26**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-Retention Area	4581.00	CF	12.62	\$57,812
<b>Total</b>				<b>\$57,812</b>
Mobilization (5%)	1.00	LS		\$2,891
Contingencies (15%)	1.00	LS		\$8,672
Total + Mobilization and Contingencies				<b>\$69,375</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		<b>\$3,469</b>

# SITE 25, 26 and 27



Site 26

Site 27

Site 25

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

BIORETENTION AREA

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

Cole Springs Branch

ESTES DR

MARTIN LN

MAPLE DR

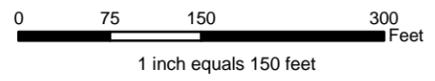
SURRY RD

CASWELL RD

CHATHAM LN



## CONCEPTUAL PLAN VIEW BOLIN CREEK WATERSHED Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits



- Legend**
- Stormwater Lines
  - Impervious Surfaces
  - Perennial Stream
  - Intermittent Stream
  - Ephemeral Stream
  - Stream, unknown flow
  - Contours



# SITE 25, 26 and 27

ESTES DR

SURRY RD

CHATHAM LN

CASWELL RD

Site 26

Site 27

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

Site 25

BIORETENTION AREA

BIORETENTION AREA

SIDE CHANNEL DISCHARGE AREA

Cole Springs Branch

MARTIN LN

MAPLE DR

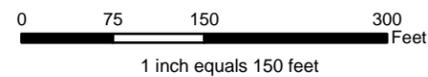
### Legend

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



### AERIAL PHOTO VIEW

**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits



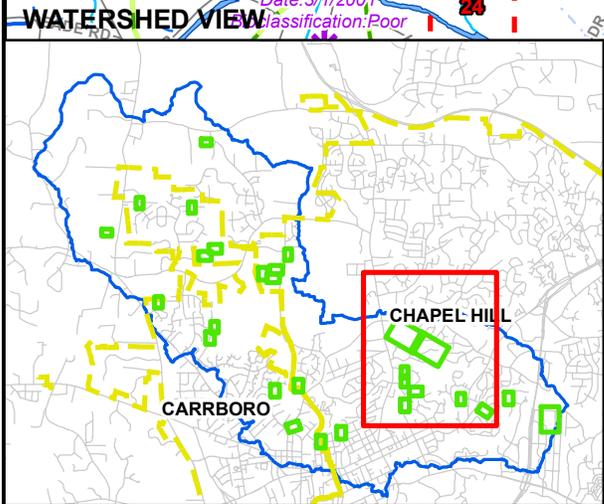
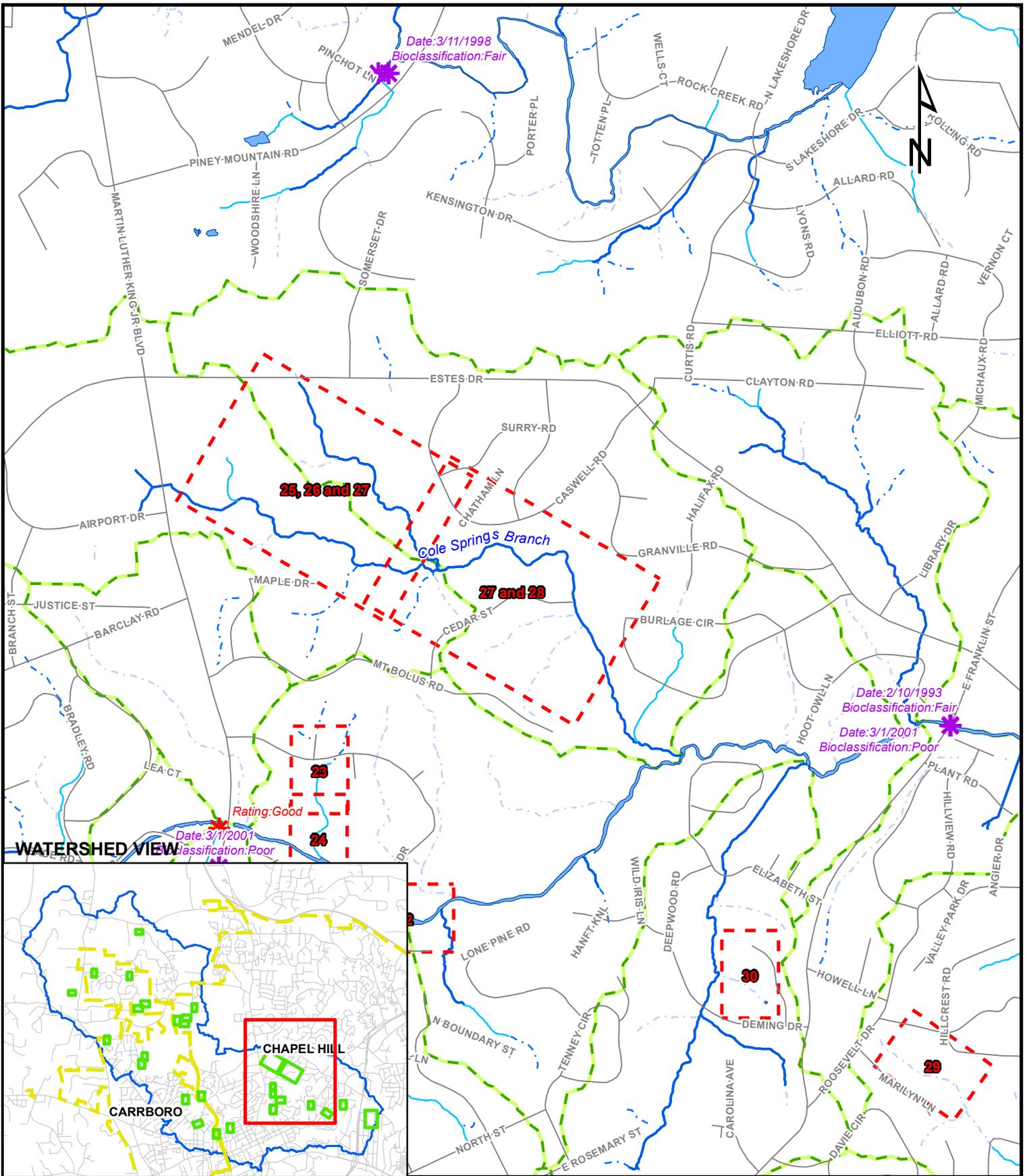
## **SITE 27**

### **Construct Side-Channel Discharge Wetlands to Attenuate Peak Flows**

Index Sheet No.: 26  
Raw Data Name: BD 65



Estimated Construction Cost: \$38,500



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



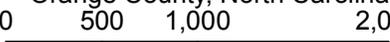



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**SITE 27 and 28  
VICINITY MAP**

Geomorphic Analysis and Identification of  
Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0    500    1,000    2,000    Feet



1 inch equals 1,000 feet

**Project Description**

Cole Springs Branch

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 27	161.6	33.2	20.5%

**Location**

Site 27 is located approximately 900 feet to the southwest of the intersection of Caswell Rd. and Chatham Ln.

**Problem Description**

The perennial stream along which Site 27 is located, Cole Springs Branch, exhibits severe incision and erosion for most of its course from it's headwaters to where it flows into Bolin Creek. The causes of this widespread degradation are apparent when examining the watershed of the stream, which consists of vast areas of impervious surface, including portions of Horace Williams Airport, the UNC facilities management complex, and high density residential developments. The crossing of Martin Luther King Jr. Blvd. also seems to have adversely affected the stream, as the accumulated and concentrated flow of most of the watersheds impervious area is discharged from a culvert after passing under that road.

While the riparian corridor of the stream after passing under Martin Luther King Jr. Blvd is largely intact, many small tributaries, most of which discharge from residential storm sewer systems, continue to flow into Cole Springs Branch before it meets Bolin Creek downstream. The combined problems of peak flow and pollutant input from all of these small drainages likely compounds the degradation already being caused by the accumulated flow and pollutants from upstream of Martin Luther King Jr. Blvd.

**Proposed Solution**

Site 27 is situated in a wide, flat portion of the Cole Springs Branch floodplain, which provides a good location for the construction of off-line BMPs for peak flow attenuation, pollutant removal and baseflow augmentation.

At least two areas within this valley could be used for off-line stormwater wetlands. Stormwater wetlands are a preferred choice here, as the floodplain may not have the minimum depth required from the water table that is required for bio-retention areas. On the other hand, having a high water table is beneficial to a wetland as it allows for permanent pools (NCDWQ, 2007). These side channel wetlands capture a portion of the runoff volume which reduced the flow rate, velocities and changes the timing of peak flows to the downstream reach. The saturated condition of the wetland may be paralleled to a beaver pond in the expectation to augment baseflow via the saturated soils within the wetland.

Flow diversion into the wetland would be provided by a flow-splitting structure containing a a vane or weir, placed in Cole Springs Branch. This is a common way to

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

“harvest” storm flows without impeding the base flows of the stream in any way. Such a structure would allow a designed volume of flow to enter into the wetland, while allowing any flow above that volume to continue downstream. If properly placed and designed, a grade control or cross vane can serve this same purpose while acting a grade control for the stream.

**Constraints**

Most of the site consists of a mature hardwood forest, and therefore tree removal will be necessary at this site for both BMPs.

The site is located on a privately owned property.

Access to the site for construction may be limited due to the wooded state of the surrounding area, and will have to be arranged with the landowners.

**Alternatives**

No alternatives are proposed for this site.

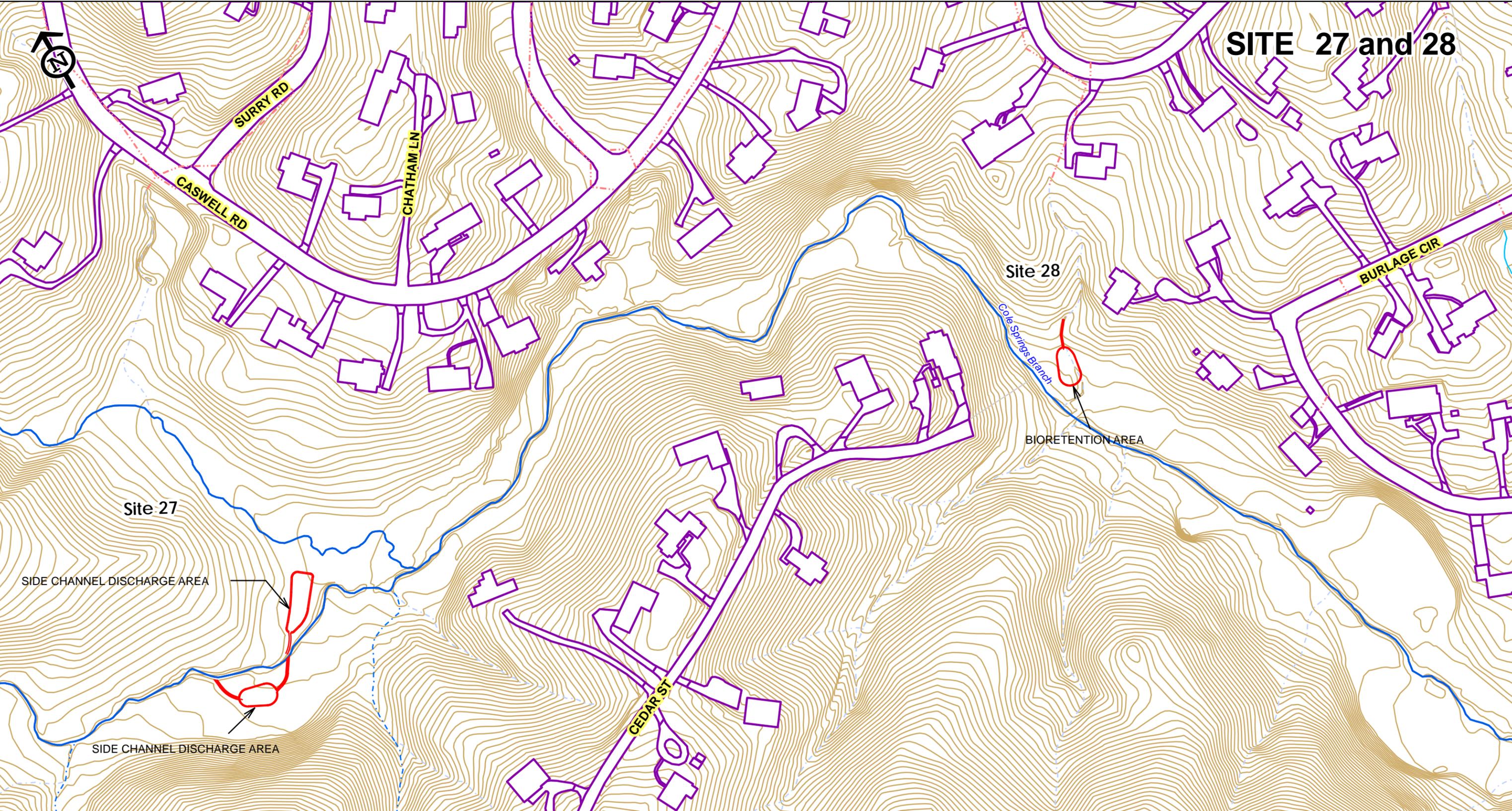
**Cost-Estimate Breakdown**

**Table 27.1** shows a conceptual itemized cost estimate for Site 27. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

**Table 27.1**  
Site 27

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	6293.0	CF	Equation Derived	\$13,545
Stormwater Wetland	9880.0	CF	Equation Derived	\$18,583
<b>Total</b>				<b>\$32,128</b>
Mobilization (5%)	1.00	LS		\$1,606
Contingencies (15%)	1.00	LS		\$4,819
Total + Mobilization and Contingencies				<b>\$38,554</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		<b>\$1,928</b>

# SITE 27 and 28



- Legend**
- Stormwater Lines
  - Impervious Surfaces
  - Perennial Stream
  - - - Intermittent Stream
  - · - · - Ephemeral Stream
  - · - · - Stream, unknown flow
  - Contours



**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 75 150 300 Feet  
1 inch equals 150 feet

# SITE 27 and 28



SURRY RD

CASWELL RD

CHATHAM LN

BURLAGE CIR

Site 28

Cole Springs Branch

BIORETENTION AREA

Site 27

SIDE CHANNEL DISCHARGE AREA

SIDE CHANNEL DISCHARGE AREA

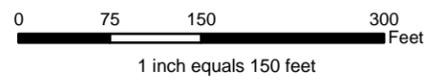
CEDAR ST



## AERIAL PHOTO VIEW

### BOLIN CREEK WATERSHED

Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits



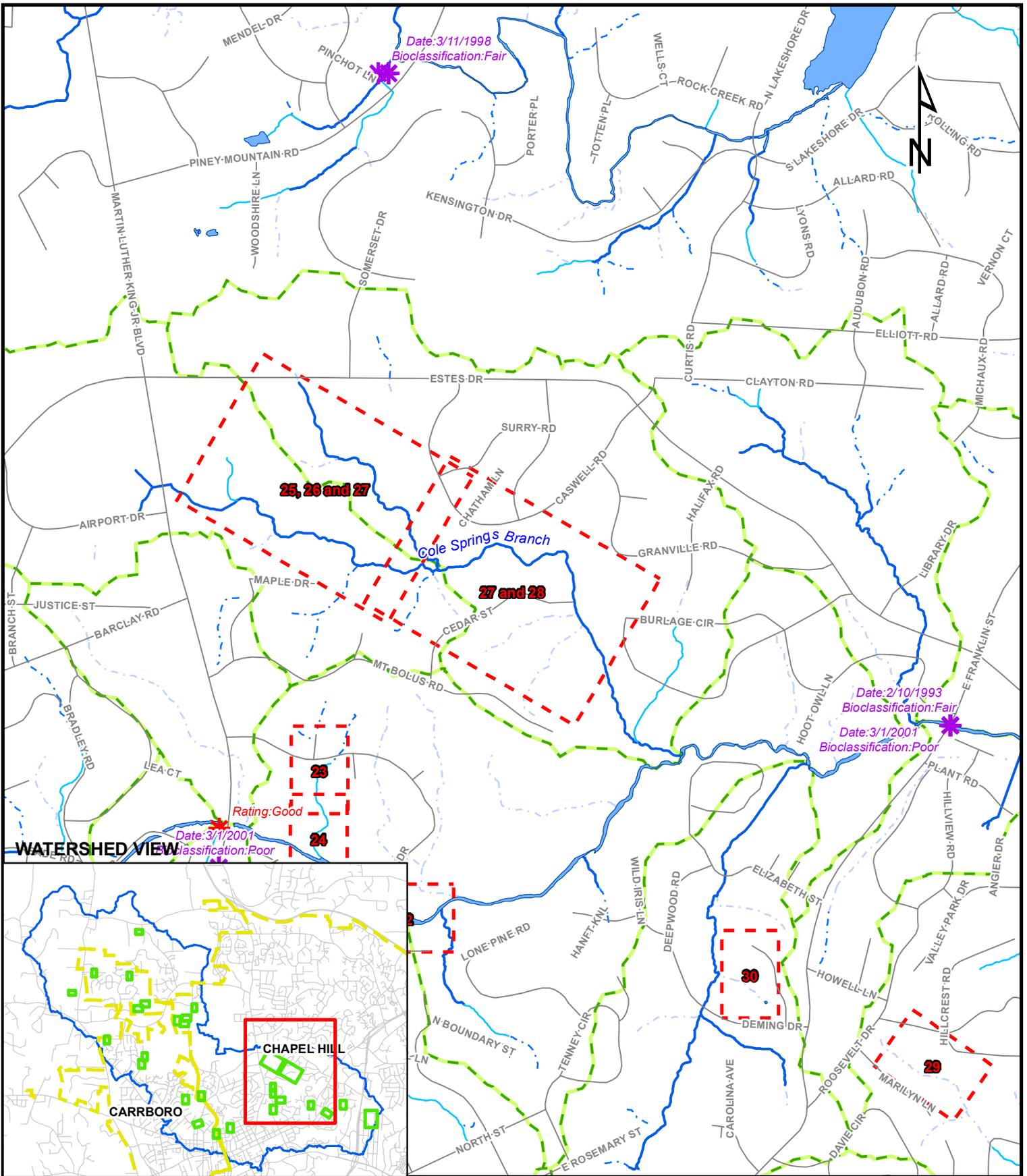
- Legend**
- Stormwater Lines
  - Perennial Stream
  - Intermittent Stream
  - - - Ephemeral Stream
  - - - Stream, unknown flow

**SITE 28**

Index Sheet No.: 26  
Raw Data Name: BD 75



Estimated Construction Cost: \$36,660



**SITE 27 and 28**  
**VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
 Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 28	16.0	4.0	25.0%

**Location**

Site 28 is located approximate 150 feet due east of the dead end road Cedar Street, along a small tributary to Cole Springs Branch.

**Problem Description**

The perennial stream along which Site 28 is located, Cole Springs Branch, exhibits severe incision and erosion for most of its course from it's headwaters to where it flows into Bolin Creek. The causes of this widespread degradation are apparent when examining the watershed of the stream, which consists of vast areas of impervious surface, including portions of Horace Williams Airport, the UNC facilities management complex, and high density residential developments. The crossing of Martin Luther King Jr. Blvd. also seems to have adversely affected the stream, as the accumulated and concentrated flow of most of the watersheds imperviousness is discharged after passing under that road.

While the riparian corridor of the stream after passing under Martin Luther King Jr. Blvd is largely intact, many small tributaries, most of which discharge from residential storm sewer systems, continue to flow into Cole Springs Branch before it meets Bolin Creek downstream. The combined problems of peak flow and pollutant input from all of these small drainages likely compounds the degradation already being caused by the accumulated flow and pollutants from upstream of Martin Luther King Jr. Blvd.

Site 28 is located just downstream of a utility crossing of Cole Springs Branch. The reach downstream of the crossing has suffered from the contraction and resulting incision from the utility crossing. Adding to the problem, and typical of this sub-watershed, just upstream of the crossing an ephemeral drain comes out of a residential area, down a steep valley, and carries high velocity flows that converge with Cole Springs Branch. The ephemeral drain is showing signs of incision and may become a head cut, creating a more significant sediment contribution in the future. The mass wasting banks that are downstream of the utility crossing are causing significant sediment contributions now.

**Proposed Solution**

This site was chosen as another site to use in this sub-watershed due to the blending of solutions that would be required to improve water quality. The ephemeral drain should be treated by the use of a stormwater wetland at the confluence with the floodplain of Cole Springs Branch. This wetland should be discharged via a level spreader, thereby reducing some of the destructive hydraulics that are impacting the immediate site. This would provide water quality treatment and quantity treatment for the runoff from the hill-top development. Immediately downstream of the wetland, the culvert at the utility crossing could be removed and the stream crossing can be accommodated by a stabilized

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

ford. This will allow flood plain access and reduce the negative effects of contraction that are created by the culvert.

Downstream of the culvert, the already damaged stream banks need stabilization. The combination of these BMP's indicates the typical situation that will be required to restore stream stability in this troubled watershed.

**Table 28.1**

SITE 26-04	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	66.79	6.74	56.74
BIORETENTION TREATMENT REMOVAL	35.00%	45.00%	85.00%
NET REDUCTION	23.38	3.03	48.23
FUTURE CONDITION	43.41	3.71	8.51

**Constraints**

Most of the site consists of a mature hardwood forest, and therefore tree removal will be necessary at this site for implementation of the BMPs.

The nearby utility line must be considered in all proposed final design plans. MOUs or MOAs may be needed to be executed with the utility owners, as periodic vegetation removal likely occurs in the utility easement.

**Alternatives**

No alternatives are proposed for this site.

**Cost-Estimate Breakdown**

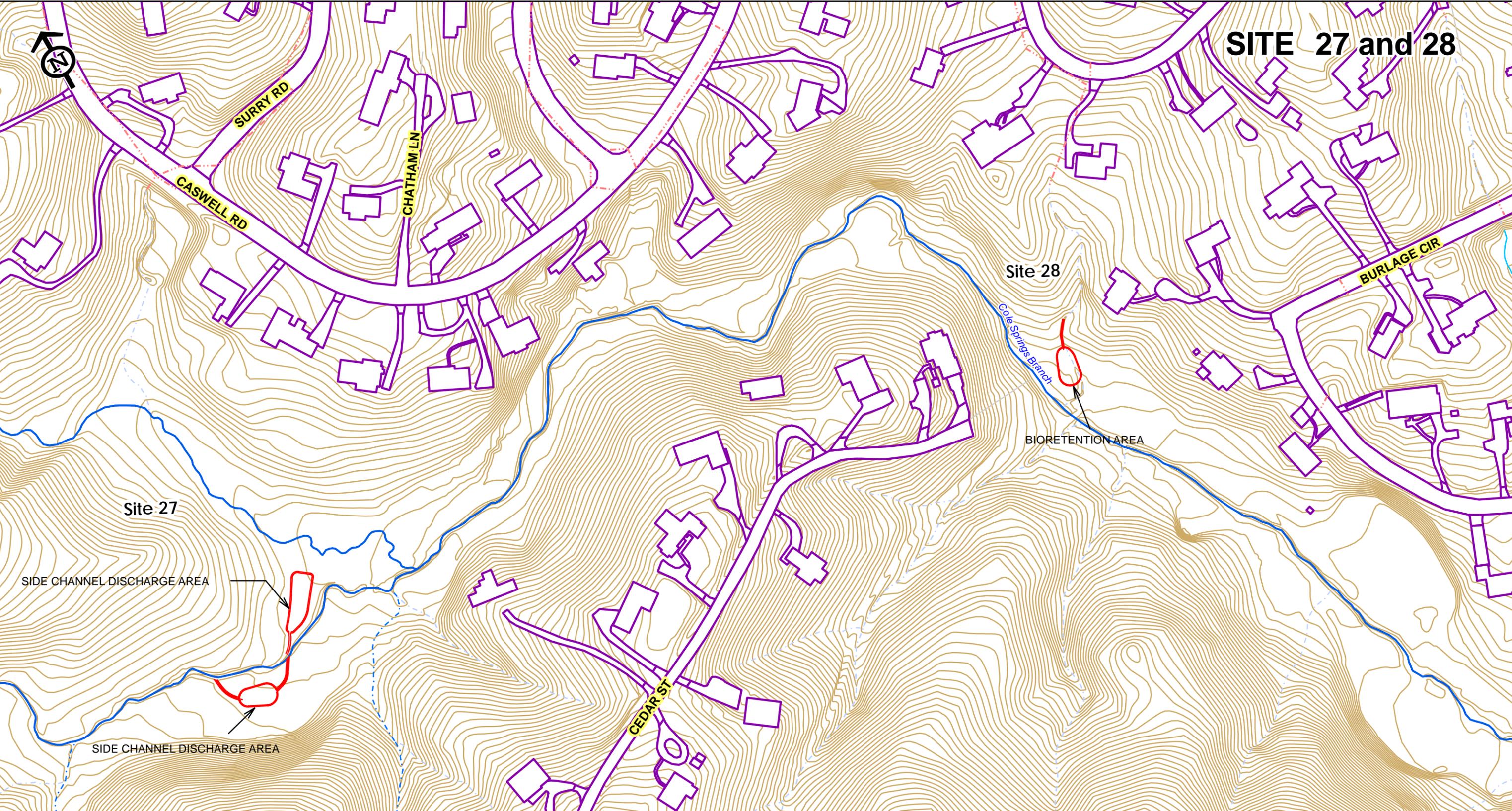
**Table 28.2** shows a conceptual itemized cost estimate for Site 28. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

**Table 28.2**

Site 28

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-Retention Area	2526.00	CF	12.62	\$31,878
<b>Total</b>				<b>\$31,878</b>
Mobilization (5%)	1.00	LS		\$1,594
Contingencies (10%)	1.00	LS		\$3,188
Total + Mobilization and Contingencies				<b>\$36,660</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		<b>\$1,833</b>

# SITE 27 and 28



- Legend**
- Stormwater Lines
  - Impervious Surfaces
  - Perennial Stream
  - Intermittent Stream
  - Ephemeral Stream
  - Stream, unknown flow
  - Contours



**CONCEPTUAL PLAN VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 75 150 300 Feet  
1 inch equals 150 feet

# SITE 27 and 28



SURRY RD

CASWELL RD

CHATHAM LN

BURLAGE CIR

Site 28

Cole Springs Branch

BIORETENTION AREA

Site 27

SIDE CHANNEL DISCHARGE AREA

SIDE CHANNEL DISCHARGE AREA

CEDAR ST



**AERIAL PHOTO VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits

0 75 150 300 Feet  
1 inch equals 150 feet

- Legend**
- Stormwater Lines
  - Perennial Stream
  - Intermittent Stream
  - - - Ephemeral Stream
  - - - Stream, unknown flow

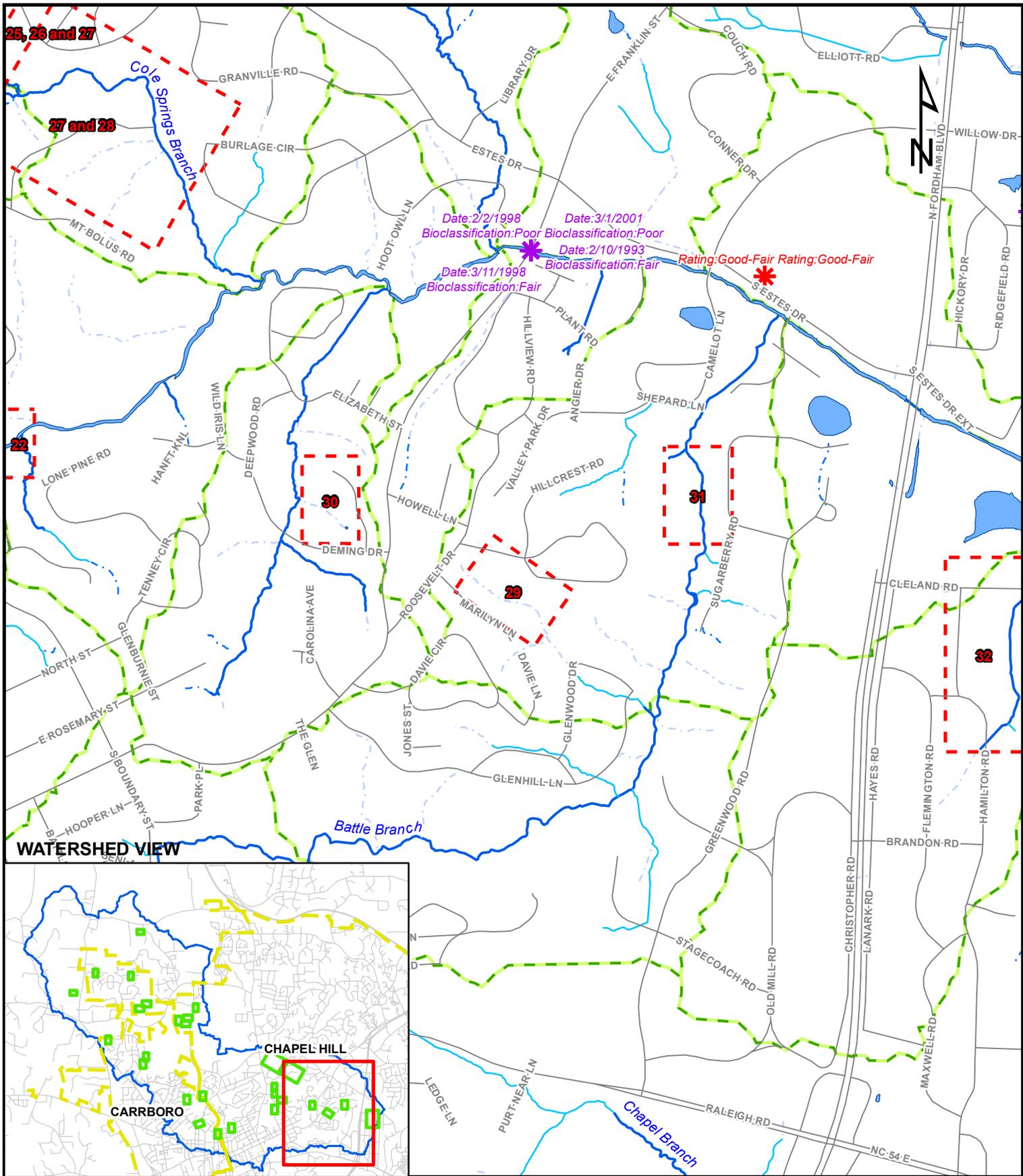
## **SITE 29**

### **Stabilization of Headcuts on Steep Hillside Using Bioretention Cells**

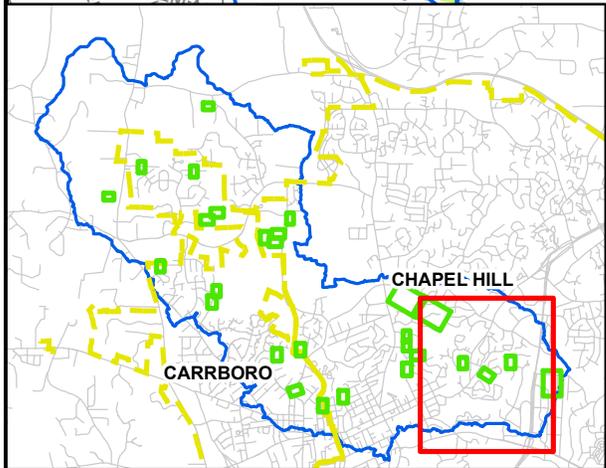
Index Sheet No.: 30  
Raw Data Name: IJ 64



Estimated Construction Cost: \$128,600



**WATERSHED VIEW**



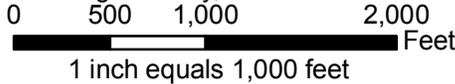
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 29  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 29	14.0	2.5	17.6%

**Location**

Site 29 is located east of the intersections of Roosevelt Drive, Hillcrest Rd and Maryilyn Ln, just to the east of downtown Chapel Hill. Access to the site can be gained by parking on Weaver Rd, which is southwest of the site, and walking northwest along an unpaved utility service road that parallels the stream.

**Problem Description**

Site 29 consists of a stream located on a steep hillside, on which the erosive velocities of peak stormflow have created at least three headcuts. The slope of the hillside, at approximately 10 %, along with the runoff produced by the 18% impervious surface of the contributing drainage area, has created high velocity flows that are eroding portions of the hillside. Given enough time, the headcuts will continue to erode uphill, releasing massive amounts of sediment and causing the stream to become a steep gully. In addition to sediment, the relatively high imperviousness of the urbanized drainage area is contributing pollutants to the watershed, which should be treated before flowing into nearby Battle Branch, which is a major tributary to Bolin Creek.

Using the BANCS model, it is estimated that approximately 566 tons of sediment are being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 29.1**.

**Table 29.1**

Pre-Treatment	
Estimated Total Sediment Export	566.6 tons/year
Erosion per length of Channel	1.3 tons/yr/ft
Pounds of Nitrogen	1133.1 lbs/year
Pounds of Phosphorus	566.6 lbs/year
Post-Treatment	
Estimated Total Sediment Export	4.5 tons/year
Erosion per length of Channel	0.032 tons/yr/ft
Pounds of Nitrogen	9.1 lbs/year
Pounds of Phosphorus	4.5 lbs/year

**Proposed Solution**

Site 29 poses a difficult situation for traditional stormwater BMP treatment because of the lack of available space due to the steep slope and narrow valley of the stream. A solution for treatment at this site is to construct a “bio-grade step”, which is a series of small bio-retention cells, each cell lower in elevation than the previous cell, filled with a filter media, such as a mixture of sand, fines and organic mater (see Appendix A-Details). Ideally, this media will have a filtration rate of 1.0 to 2.0 inches per hour, to optimize pollution removal (Schueler, et. al., 2007). Each cell is connected to the other through this same media, thus allowing stormwater to filter through each cell without the expense of an underdrain. Overflow of each cell would be provided by a “lip” constructed at the downstream end of each cell.

This treatment option will provide a linear, grade-control solution to reduce erosive velocities of the stream, thereby reducing sediment export, while also treating stormwater runoff for pollutants. The depth of each cell can vary depending on choice of planting materials. Trees, with a deeper rooting structure, will require deeper soils, while herbaceous plants and shrubs can have soils as shallow as 1.5 feet (Schuler et. al, 2007).

Below the proposed area of the bio-grade step, the slope of the hill flattens, and the stream flows diffusely through a sewer easement lined with rip-rap. This location affords a good opportunity for construction of a stormwater wetland, as a final means of pollutant removal and attenuation of peak flows before the stream concentrates once again into an incised channel downstream of the site.

Potential pollution removal rates using this treatment method have been estimated and are shown in **Table 29.2**.

**Table 29.2**

SITE 29	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	141.53	14.29	1923.76
BIORETENTION TREATMENT REMOVAL %	35.00%	45.00%	85.00%
STORM WATER WETLAND TREATMENT REMOVAL %	37.00%	35.00%	85.00%
NET REDUCTION	34.04	2.75	245.28
FUTURE CONDITION	107.49	11.54	1678.48

**Constraints**

Based on available GIS data, Site 29 appears to be located in a right of way owned by the Orange Water and Sewer Authority (OWASA), therefore land acquisition and access should not be a constraint to this project.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Alternatives**

There are no alternatives proposed for this site.

**Cost-Estimate Breakdown**

**Table 29.3** shows a conceptual itemized cost estimate for Site 29. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997). The cost for the bio-grade step is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007).

**Table 29.3**  
SITE 29 Construction Cost

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Biograde Step	7869.0	CF	12.62	\$99,307
Stormwater Wetland	5642.0	CF	Equation Derived	\$12,547
<b>Total</b>				<b>\$111,854</b>
Mobilization (5%)	1.00	LS		\$5,593
Contingencies (10%)	1.00	LS		\$11,185
Total + Mobilization and Contingencies				<b>\$128,632</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		<b>\$6,432</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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HILLCREST RD

SITE 29

STORM WATER WETLAND

BIOGRADE STEP



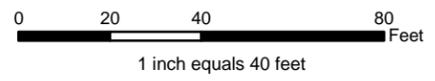
OUTLET

**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





HILLCREST RD

SITE 29

STORM WATER WETLAND

BIOGRADE STEP



OUTLET

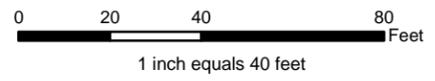
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- · - Stream, unknown flow



**AERIAL PHOTO VIEW**

BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



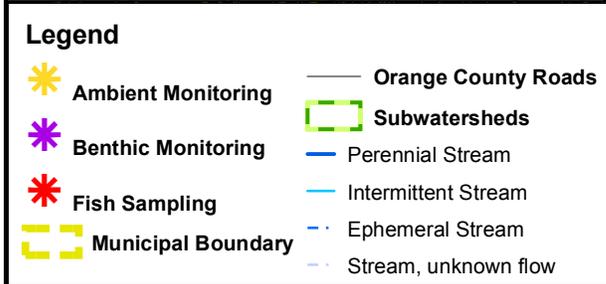
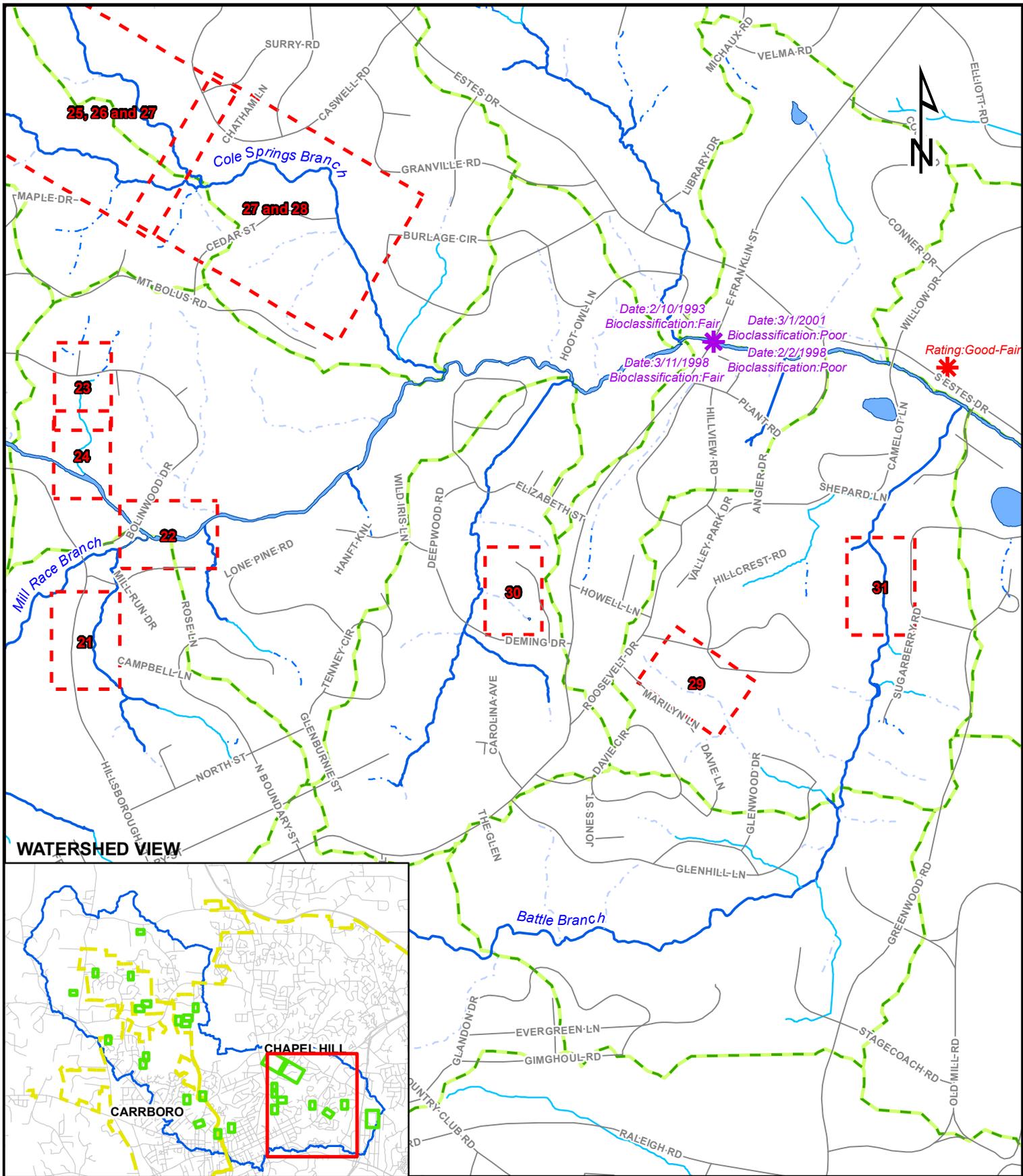
## **SITE 30**

### **Retrofit of Existing Sediment Basin and Stabilization of Hillside erosion.**

Index Sheet No.: 30  
Raw Data Name: IJ 60



Estimated Construction Cost: \$28,500



**SITE 30 VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 30	1.3	0.5	39.9%

**Location**

Site 30 is downhill and to the west of Hoteling Ct. The site can be reached from E. Franklin Street by turning onto Deming Drive,, taking the first right turn onto Hoteling Ct. and parking at the end of the cul-de-sac.

**Problem Description**

Site 30 consists of an existing sediment basin on a steep hillside, just below a residential development constructed on top of the hillside. The basin has filled in since the construction of the residential area, and is no longer storing the runoff produced from the street, rooftops and driveways. In addition, there is no evidence that the basin was ever intended for water quality treatment. Runoff flows over the rip-rap berm of the basin, into an apparently ephemeral drainage and then into a perennial stream at the bottom of the hill.

A concrete pipe outlet is located uphill of the existing basin, but has no stormwater control structure immediately below it. Because of this, the steep slope below the outlet has begun to erode. In the span of a month, between two visits to the site, the hillside below the outlet visibly increased in erosion. Evidence of the increased peak flows being produced by the drainage area can also be seen in the perennial stream located downhill from the site. Significant bank erosion is apparent where the ephemeral drainage joins with the stream, which is otherwise stable throughout most of its course.

**Proposed Solution**

The existing sediment basin at this site provides a good location for a stormwater retrofit. The solution at Site 30 is targeted at the treatment of pollutants from runoff, the stabilization of an actively eroding hillside to reduce sediment export and the attenuation of peak flows to prevent impacts to the perennial stream downhill from the site. This will be accomplished through the following:

- Retrofit the basin into a small, bioretention area with an overflow to a level spreader. An underdrain may be required to meet the required infiltration rate (NCDWQ, 2007).
- Stabilize the eroding hillside below the existing outlet by constructing a concrete lined “flume” with friction blocks. The friction blocks will provide a means of reducing the velocity of storm flow before entering the wet detention basin.
- Provide an energy dissipation basin where the flume meets the bio-retention area

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

These retrofits will reduce the velocities from the residential stormwater system before they flow reaches the receiving channel. A bioretention area will allow for treatment of the pollutants from the residential area and attenuate the peak flows of the site.

Based on the above treatment, pollutants are expected to be reduced in the amounts shown in **Table 30.1**.

**Table 30.1**

SITE 30	Pollutant Load (lbs)		
	TN	TP	TSS
EXISTING CONDITION	19.88	2.01	270.19
WET DETENTION TREATMENT REMOVAL %	25.00%	40.00%	85.00%
NET REDUCTION	4.97	0.80	229.67
FUTURE CONDITION	14.91	1.20	40.53

**Constraints**

Site access and construction will be difficult due to the steep terrain. This BMP is located on private property. Tree removal will be required.

**Alternatives**

There are no alternatives proposed for this site.

**Cost-Estimate Breakdown**

**Table 30.2** shows a conceptual itemized cost estimate for Site 30. These costs represent construction and maintenance costs only. The cost for the bioretention area is derived from a cost per cubic foot treated for bioretention areas as reported by Schueler, et. al. (2007). The contingency fee for this site has been increased due to the difficulty of access and proximity to a utility easement.

**Table 30.2**

SITE 30				
Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Bio-Retention Area	1882.00	CF	12.62	\$23,751
			<b>Total</b>	<b>\$23,751</b>
Mobilization (5%)	1.00	LS		\$1,188
Contingencies (15%)	1.00	LS		\$3,563
			<b>Total + Mobilization and Contingencies</b>	<b>\$28,501</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		\$1,425



HOTELING CT

SITE 30

BIORETENTION AREA

INLET

CONCRETE LINED WITH FRICTION BLOCKS

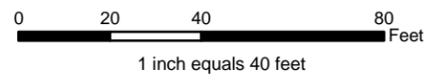
LEVEL SPREADER

**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





**SITE 30**

**HOTELING CT**

BIORETENTION AREA

INLET

CONCRETE LINED WITH FRICTION BLOCKS

LEVEL SPREADER

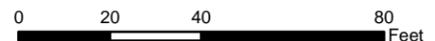
**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- - - Ephemeral Stream
- - - Stream, unknown flow




**EarthTech**  
A tyco International Ltd. Company

**AERIAL PHOTO VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site Identification For Stormwater Structures and Retrofits



0 20 40 80 Feet  
1 inch equals 40 feet

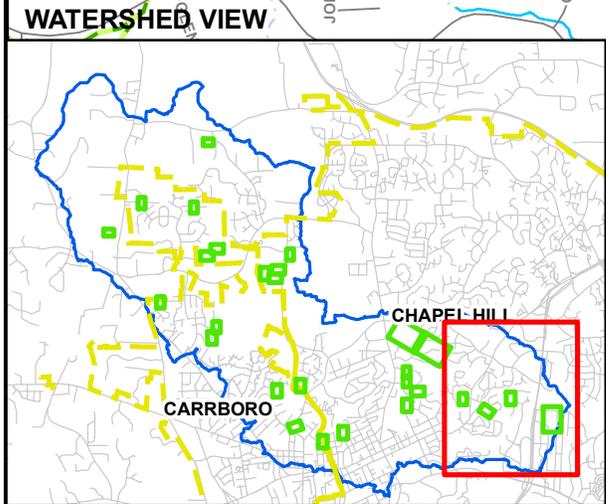
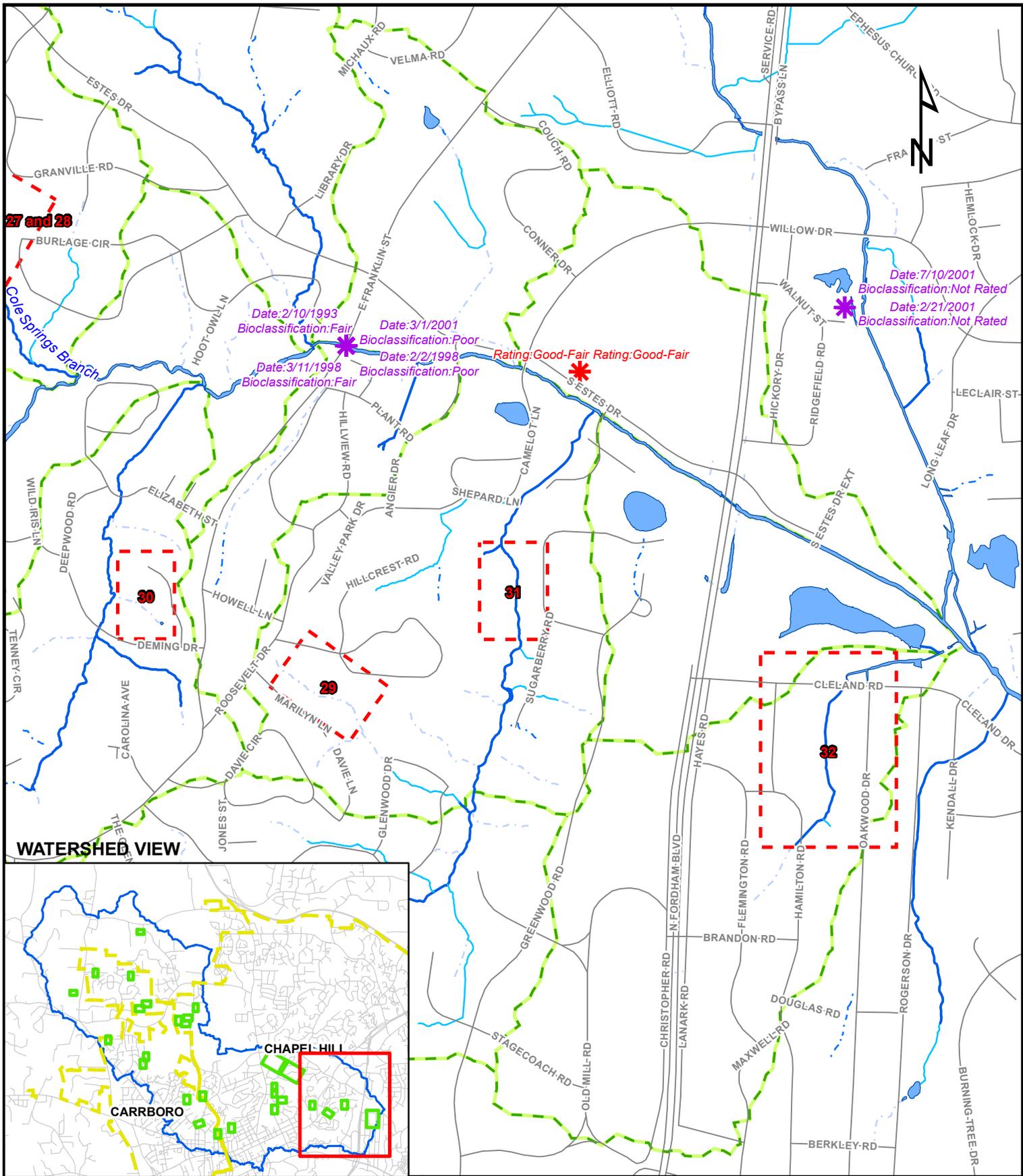
## **SITE 31**

### **Apply Treatment to an Existing Ditch in the Floodplain of Battle Branch.**

Index Sheet No.: 34  
Raw Data Name: BD 88



Estimated Construction Cost: \$10,000- \$21,000



**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow

**EarthTech**  
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**SITE 31 VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina

0 500 1,000 2,000 Feet

1 inch equals 1,000 feet

**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 31	12.2	2.1	17.2%

**Location**

Site 31 is located to the west and downhill of Sugarberry Rd.

**Problem Description**

Site 31 consists of an actively eroding ditch in the floodplain of Battle Branch. The ditch is approximately 2.5 feet deep and 5 feet wide and approximately 317 feet long. It appears to have been constructed along with the sewer line that parallels Battle Branch. The ditch receives the flow from a stormwater collection system of a residential arra, and therefore is subject to increased peak flows due to impervious surfaces. The flows from the residential area have no apparent treatment of water quality and do not have treatment of water quantity.

Using the BANCS model, it is estimated that approximately 517 tons of sediment are being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 31.1**.

**Table 31.1**

Pre-Treatment	
Estimated Total Sediment Export	517.4 tons/year
Erosion per length of Channel	1.7 tons/yr/ft
Pounds of Nitrogen	1034.7 lbs/year
Pounds of Phosphorus	517.4 lbs/year
Post-Treatment	
Estimated Total Sediment Export	0 tons/year
Erosion per length of Channel	0 tons/yr/ft
Pounds of Nitrogen	0 lbs/year
Pounds of Phosphorus	0 lbs/year

**Proposed Solution**

Treatment of the runoff from the contributing drainage area of Site 31, as well as the reduction of sediment can be accomplished through construction of a stormwater wetland in the floodplain of Battle Branch, expanding on the area of the existing ditch. The outlet of this wetland will consist of an overflow structure with a level spreader situated parallel to Battle Branch.

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

The site should also be planted with native vegetation, which is currently lacking from much of the floodplain leading up to Battle Branch.

**Constraints**

The site is located on three privately owned properties.

**Alternatives**

**Alternative 1:**

Construct a stormwater wetland in the place of the existing ditch, as detailed above

**Alternative 2:**

An alternative to constructing a stormwater wetland at this site is to fill the existing ditch with a filtration media, consisting of a mix of sand, fines and silt, and allow it to function as a bioretention area. The length of the ditch will provide a sufficient flow path for infiltration and treatment of runoff from the contributing drainage area.

**Cost-Estimate Breakdown**

**Table 31.2** shows a conceptual itemized cost estimate for the two alternatives at Site 31. These costs represent construction and maintenance costs only. The cost for stormwater wetlands is derived from an equation developed by Brown and Schueler (1997).

**Table 31.2**  
SITE 31 ALTERNATIVE 1

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Stormwater Wetland	9072.0	CF	Equation Derived	\$17,504
<b>Total</b>				<b>\$17,504</b>
Mobilization (5%)	1.00	LS		\$875
Contingencies (10%)	1.00	LS		\$1,750
<b>Total + Mobilization and Contingencies</b>				<b>\$20,130</b>
<b>Maintenance Costs</b>				
Maintenance (5% of base construction cost of BMP)	1.0	Year		\$1,006

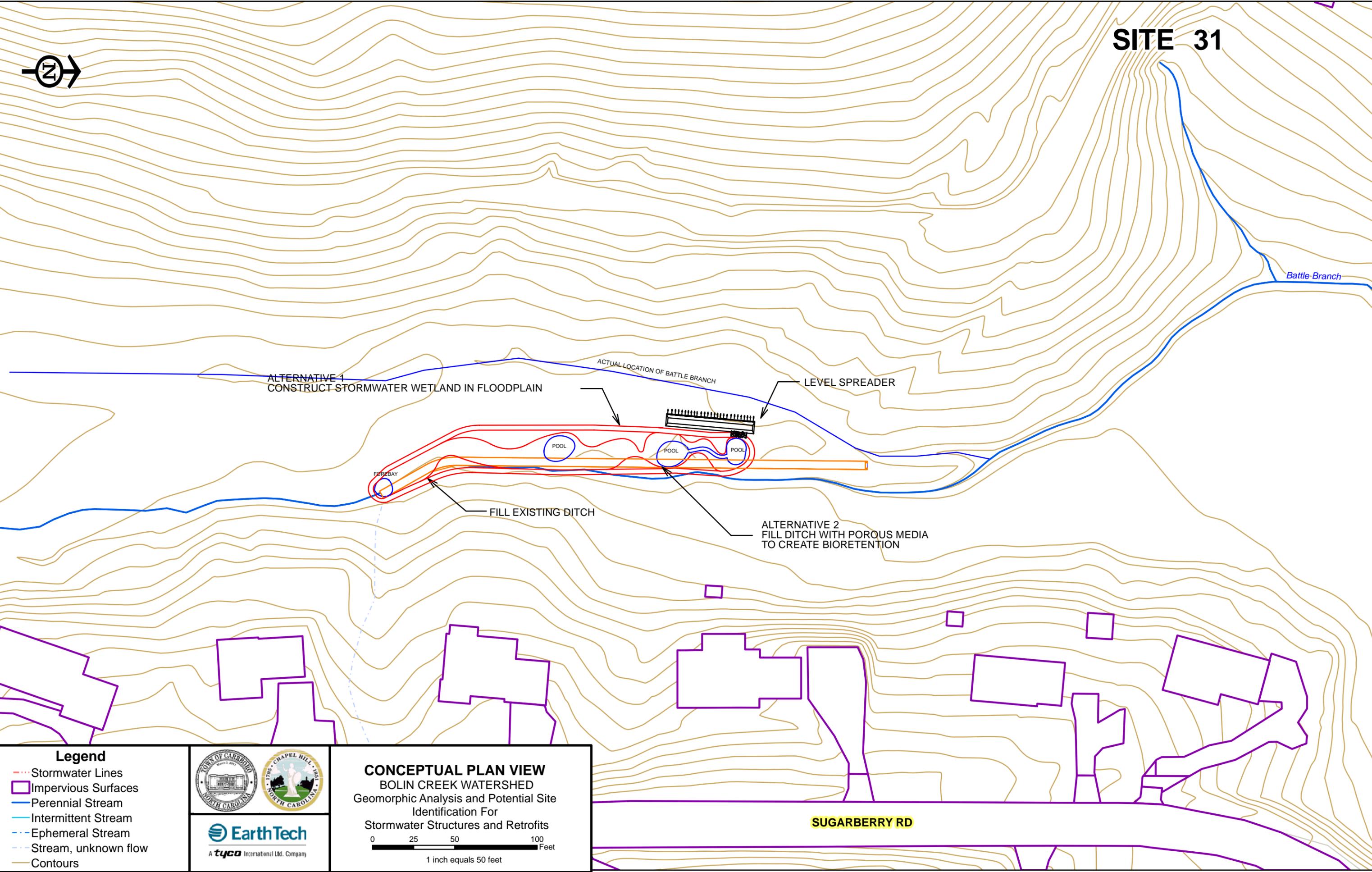
*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

**Table 31.3**  
**SITE 31 ALTERNATIVE 2**

Pay Item Description	Estimated Quantity	Unit	Unit Bid Price	Bid Amount
Excavation	180.00	CY	15.00	\$2,700
Site Preparation and Planting	0.10	Ac	7500.00	\$750
Rip Rap Class B	5.00	Tons	45.00	\$225
Filter Fabric	50.00	SY	5.00	\$250
Silt Fence	350.00	LF	3.75	\$1,313
Construction Safety Fence	400.00	LF	2.50	\$1,000
Construction Entrance	1.00	Ea	2500.00	\$2,500
<b>Total</b>				<b>\$8,738</b>
Mobilization (5%)	1.00	LS		\$437
Contingencies (10%)	1.00	LS		\$874
<b>Total + Mobilization and Contingencies</b>				<b>\$10,048</b>

*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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ALTERNATIVE 1  
CONSTRUCT STORMWATER WETLAND IN FLOODPLAIN

ACTUAL LOCATION OF BATTLE BRANCH

LEVEL SPREADER

FOREBAY

FILL EXISTING DITCH

ALTERNATIVE 2  
FILL DITCH WITH POROUS MEDIA  
TO CREATE BIORETENTION

Battle Branch

POOL

POOL

POOL

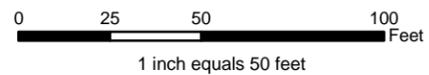
SUGARBERRY RD

**Legend**

-  Stormwater Lines
-  Impervious Surfaces
-  Perennial Stream
-  Intermittent Stream
-  Ephemeral Stream
-  Stream, unknown flow
-  Contours



**CONCEPTUAL PLAN VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits





Battle Branch

ALTERNATIVE 1  
CONSTRUCT STORMWATER WETLAND IN FLOODPLAIN

ACTUAL LOCATION OF BATTLE BRANCH

LEVEL SPREADER

FOREBAY

FILL EXISTING DITCH

POOL

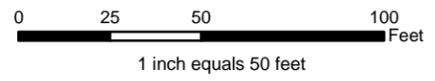
POOL

POOL

ALTERNATIVE 2  
FILL DITCH WITH POROUS MEDIA  
TO CREATE BIORETENTION



**AERIAL PHOTO VIEW**  
BOLIN CREEK WATERSHED  
Geomorphic Analysis and Potential Site  
Identification For  
Stormwater Structures and Retrofits



SUGARBERRY RD

- Legend**
- Stormwater Lines
  - Perennial Stream
  - Intermittent Stream
  - Ephemeral Stream
  - Stream, unknown flow

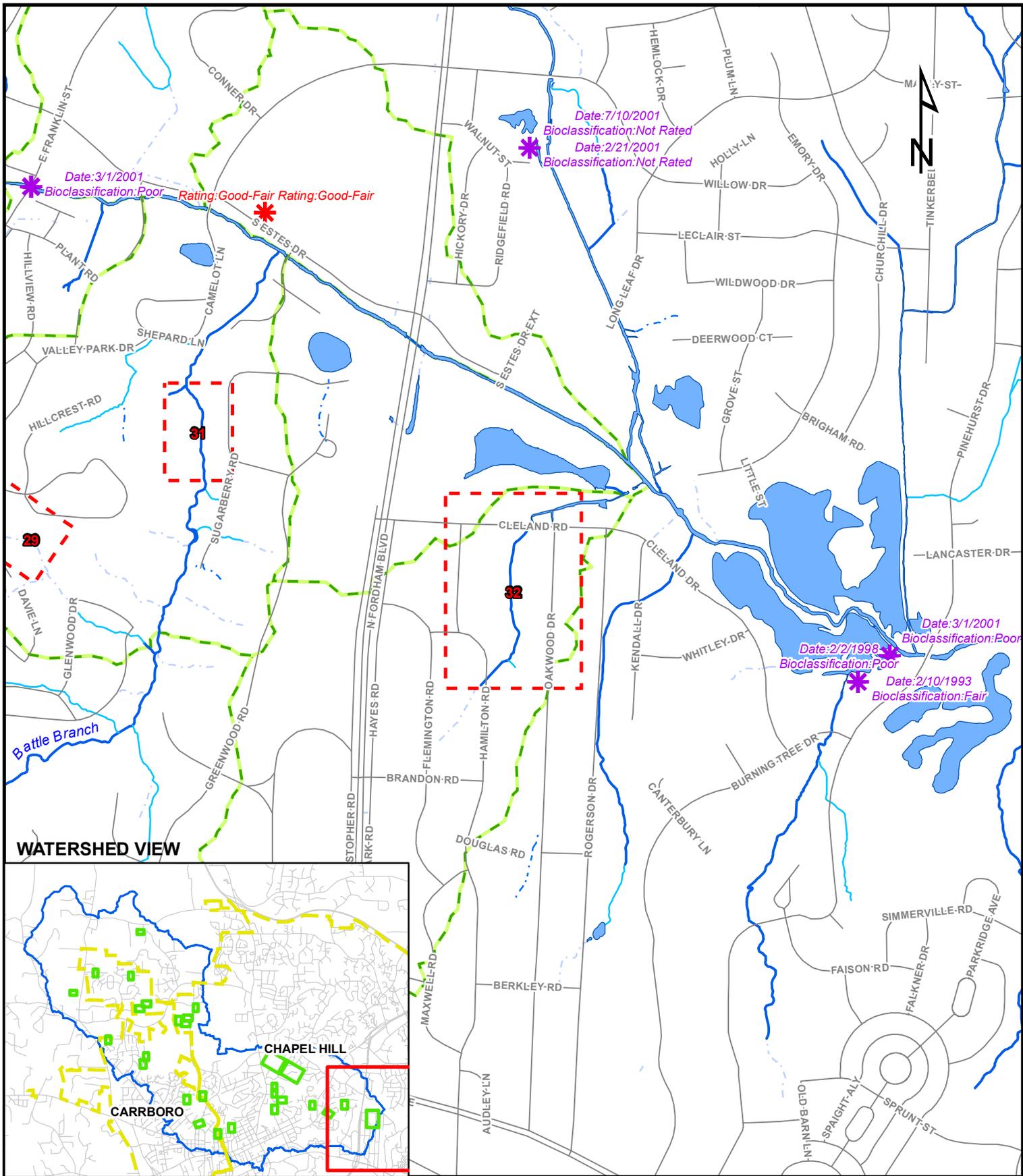
## **SITE 32**

### **Restoration of Stream channel off Cleland Rd**

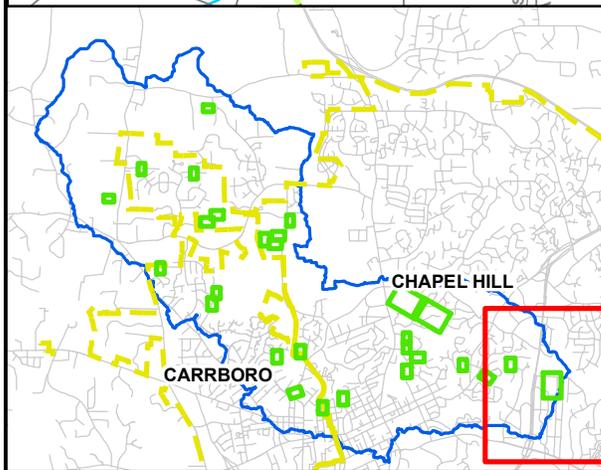
Index Sheet No.: 34  
Raw Data Name: BD 90



**Estimated Construction Cost: \$207,000**



**WATERSHED VIEW**



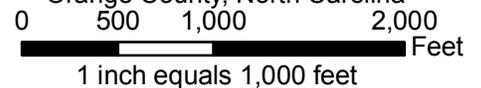
**Legend**

- Ambient Monitoring
- Benthic Monitoring
- Fish Sampling
- Municipal Boundary
- Orange County Roads
- Subwatersheds
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow



**SITE 32  
VICINITY MAP**

Geomorphic Analysis and Identification of Potential Sites for Stormwater BMPs  
Orange County, North Carolina



**Project Description**

	Drainage Area (acres)	Impervious Area (acres)	% Impervious
Site 32	149.6	38.0	25.4%

**Location**

Site 32 is located to the south of Cleland Rd, near the intersection of Cleland Rd and Oakwood Drive, and approximately 0.2 miles east of the intersection of US 15-501 and Cleland Rd. Several soccer fields are adjacent to the site.

**Problem Description**

Site 32 consists of a channelized, incised stream channel in the lower portion of the Bolin Creek Watershed. The stream appears to have been channelized and straightened at some point in the past, possibly during construction of the surrounding residential area and soccer fields. The resulting channel is incised and devoid of any natural stream habitat. The relic floodplain of the stream is filled with piles of spoil material, and heavily infested with exotic invasive species such as wisteria, multiflora rose, and privet. The contributing drainage area of the stream is comprised of medium to heavily developed residential areas, and a portion of US 15-501. Most of the stormwater in this drainage area is piped and discharges from an outlet at the southernmost edge of the Site 32. Bank erosion and BEHI ratings of “high” were observed along the entire reach.

Using the BANCS model, it is estimated that approximately 62 tons of sediment are being exported from the site each year. Concomitant nutrient export associated with the sediment has also been calculated and is listed in **Table 32.1**.

**Table 32.1**

Pre-Treatment	
Estimated Total Sediment Export	62.4 tons/year
Erosion per length of Channel	0.058 tons/yr/ft
Pounds of Nitrogen	124.8 lbs/year
Pounds of Phosphorus	62.4 lbs/year
Post-Treatment	
Estimated Total Sediment Export	3.6 tons/year
Erosion per length of Channel	0.003 tons/yr/ft
Pounds of Nitrogen	7.3 lbs/year
Pounds of Phosphorus	3.6 lbs/year

### **Proposed Solution**

The stream channel that is the focus of treatment at this site is an ideal site for Priority I Restoration. Priority I restoration involves reconnecting the stream with the relic floodplain by raising the elevation of the bed, thereby restoring floodplain hydrology, reducing near bank stress and thus limiting the bank erosion problem. This site possesses ideal circumstances for this practice: a wide, intact relic floodplain and little need to meet elevations, other than the outlet pipe at the upstream end and the roadway culvert at the downstream end. Most of all, almost the entire floodplain is on state owned land, providing ample opportunity for changes in the planform and sinuosity of the stream. Besides the sediment reduction, stream restoration will provide the restoration of critical habitat for numerous aquatic species, as well as the hydrology needed to support riparian wetlands.

A conceptualized plan view of the site, based on average stream variables for the drainage area, is shown in the Plan View of Site 32 contained in this summary.

### **Constraints**

Tree removal will be necessary if restoration is implemented at this site. The spoil piles will also need to be removed, requiring additional earthwork.

Flooding issues may arise if the stream is reconnected to the relic floodplain, thus a flooding analysis and submission of a CLOMR will be required to determine if the project would affect the FEMA 100-year floodzone.

### **Alternatives**

No alternatives are proposed for this site.

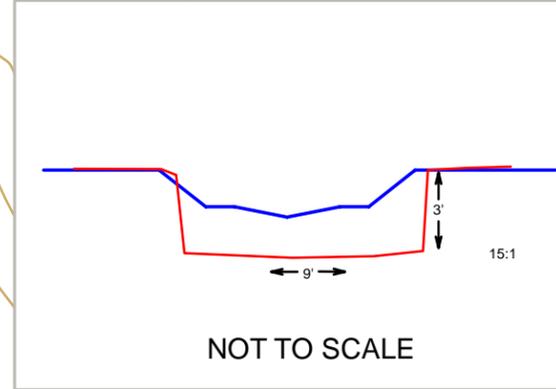


*Bolin Creek Watershed  
Geomorphic Analysis and Potential Site Identification for Stormwater BMPs and Retrofits*

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**CONCEPTUAL CROSS SECTION**



**HAMILTON RD**

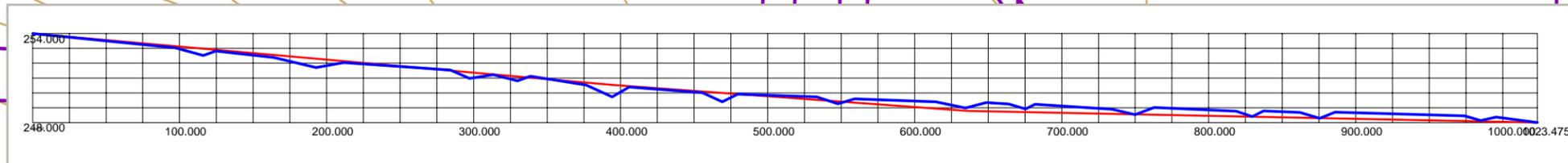
**CLELAND RD**

**CONCEPTUAL STREAM CHANNEL**

**BEGIN CONSTRUCTION**

**END CONSTRUCTION**

**CONCEPTUAL PROFILE**



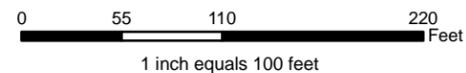
**OAKWOOD DR**

**Legend**

- Stormwater Lines
- Impervious Surfaces
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow
- Contours



**CONCEPTUAL PLAN VIEW**  
**BOLIN CREEK WATERSHED**  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits



**SITE 32**

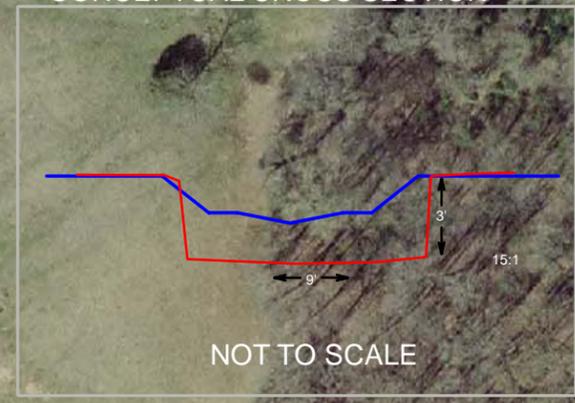


**HAMILTON RD**

**CLELAND RD**

**OAKWOOD DR**

CONCEPTUAL CROSS SECTION



CONCEPTUAL STREAM CHANNEL

BEGIN CONSTRUCTION

END CONSTRUCTION

CONCEPTUAL PROFILE



**Legend**

- Stormwater Lines
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream
- Stream, unknown flow

**AERIAL PHOTO VIEW**  
 BOLIN CREEK WATERSHED  
 Geomorphic Analysis and Potential Site  
 Identification For  
 Stormwater Structures and Retrofits

0 55 110 220 Feet  
 1 inch equals 100 feet

## **References**

Center for Watershed Protection. October 30<sup>th</sup>, 2007. *Stormwater Management Fact Sheet: Stormwater Wetland*. Accessed online at [[http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6\\_Stormwater\\_Practices/Wetland/Wetland.htm](http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Wetland/Wetland.htm)].

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