CHAPTER 2: WATERSHED CHARACTERIZATION

2.1 NATURAL ENVIRONMENT

POLITICAL AND WATERSHED BOUNDARIES

Bolin Creek is a fourth order stream draining an area of about 7800 acres, or approximately 12 square miles. It starts in unincorporated parts of Orange County, NC and flows mostly southeast into first the Town of Carrboro and then into the Town of Chapel Hill. When it reaches the confluence with Booker Creek in Chapel Hill the combined streams become known as Little Creek.

Little Creek is one of the many streams included in the drainage area known as the "Upper New Hope Arm" of Jordan Lake, which also includes Morgan Creek, New Hope Creek, Northeast Creek, and Third Fork Creek. The Bolin Creek Watershed is shown in Figure 1 (in previous chapter) in relation to the drainage area for the Upper New Hope Arm of Jordan Lake, and the combined drainage areas for Little Creek and Morgan Creek. This watershed plan is an adjunct to the Local Watershed Plan developed by the Ecosystem Enhancement Program in 2006 for the Morgan and Little Creek Watersheds.

Figure 2 divides the watershed into 9 subwatersheds for purposes of analysis and cartography. These subwatersheds are the "management units" of this plan. Each subwatershed has been considered separately to facilitate specific management strategy recommendations. This approach allows efforts to be pursued in individual subwatersheds over time in order to concentrate hydrological, morphological, and biological improvements. These subwatersheds are subsets of the Ecosystem Enhancement Program's prior watershed plan for this area, the Morgan and Little Creek Watersheds Local Watershed Plan. This allows for easier comparison of the two plans. Names for the Bolin Creek Subwatersheds are thus based on the names given to the EEP Local Watershed Plan subwatersheds.

Named tributaries of Bolin Creek on USGS maps include Jones Creek, Buckhorn Branch, Jolly Branch, and Tanbark Branch. Locally, several other tributary names have been found on old UNC maps, neighborhood plats and deeds, including Dry Gulch, Mill Race, Tanyard Branch, Cole Springs Branch, and Battle Branch.

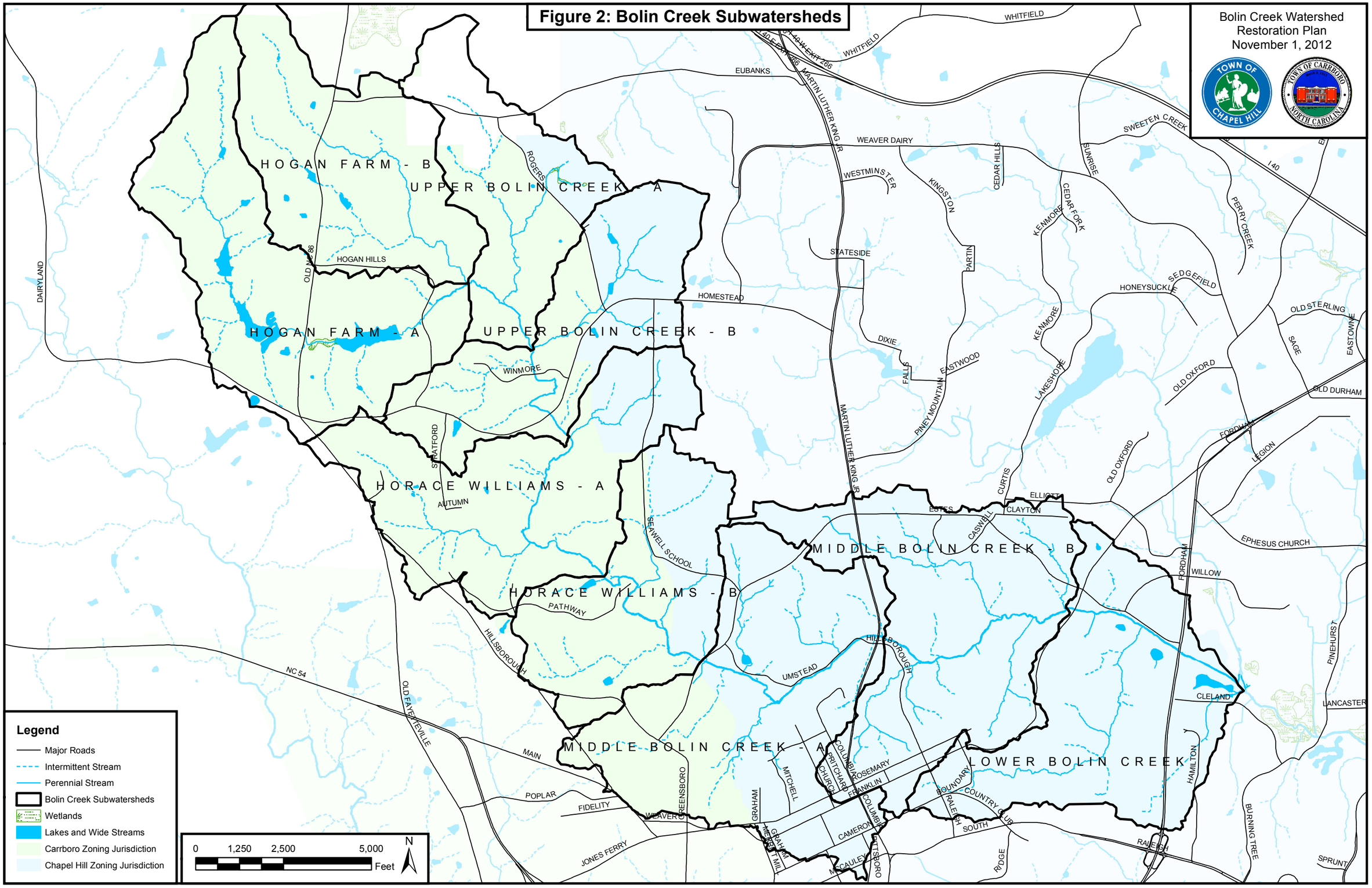
Figure 2: Bolin Creek Subwatersheds
Bolin Creek Watershed
Restoration Plan
November 1, 2012
HOGAN FARM - B
UPPER BOLIN CREEK - A
HOGAN FARM - A
UPPER BOLIN CREEK - B
HORACE WILLIAMS - A
HORACE WILLIAMS - B
MIDDLE BOLIN CREEK - B
MIDDLE BOLIN CREEK - A
LOWER BOLIN CREEK
Legend
Major Roads
Intermittent Stream
Perennial Stream
Bolin Creek Subwatersheds
Wetlands
Lakes and Wide Streams
Carrboro Zoning Jurisdiction
Chapel Hill Zoning Jurisdiction
0 1,250 2,500 5,000
Feet
N

GEOLOGY, TOPOGRAPHY, HYDROLOGY, AND SOILS

The Bolin Creek Watershed is located in the Carolina Terrane (formally known as the Carolina Slate Belt) and the Durham Triassic Basin. The different geological characteristics between upper and lower Bolin Creek affect the speed at which the water flows and the shape of the river's floodplain. Further upstream, the watershed is characterized by faster moving water and relatively narrow, V-shaped river valleys and floodplains. Locally, slightly larger floodplain deposits may be present upstream of very resistant layers of rock. These resistant layers form a local base level that temporarily slows the river, allowing sediment to be deposited, and prevents the river upstream of the base level from eroding and deepening its valley. Where Bolin Creek flows into the sedimentary rocks in the Triassic lowland, the creek flows through a much broader valley. The sedimentary rocks over which it flows are soft and easily eroded. The creek is able to flow across a much wider valley and develop a wide floodplain. Figure 3 shows the geology of the area, with the approximate boundary between the Carolina Terrane (Carolina Slate Belt) and Triassic Basin.

The watershed's general topography is rolling plains, with a few areas of steeper gradients. Bolin Creek's headwaters are at about 600 feet above sea level near Old NC 86. The lowest point, at the confluence with Little Creek is about 250 feet above sea level. Figure 4 gives a color representation of the elevation differences and changes in the Bolin Creek Watershed and surrounding area.

The watershed's upland soils (in the Carolina Slate Belt) are generally fairly well drained loams and clays, derived from metamorphosed granite, metamorphosed volcanic ash and lava, and metamorphosed gabbro and diorite. These soils have supported agricultural uses historically. Bottomlands soils are often more poorly drained. Soils in the Triassic Basin tend to be heavy clays developed from underlying conglomerate, sandstone, siltstone, and mudstone. Bolin Creek and its tributaries have varying degrees of exposed bedrock substrate. Where the stream channel does not sit on solid bedrock, incision can occur as the added energy of urban runoff cuts out a deeper, and eventually wider, channel. Many of the soils in the watershed erode easily, exacerbating the phenomenon of channel enlargement and erosion and sedimentation. Lower reaches of Bolin Creek, and urban stream channels more generally, provide lower quality aquatic habitat because of the instability of the channels along with other factors such as reduced tree canopy and instream woody debris. Figure 5 shows areas of higher erosion risk due to steep slopes and erodible soils.

Bolin Creek's hydrology is affected by several small impoundments near the headwaters. Bolin Creek has limited existing wetlands due to topography, geology, and historical land use. Small farmpond impoundments at the upper ends of headwater streams are common across the Piedmont, including Bolin Creek.

Portions of region with greater topographic relief were favorable locations historically for water-driven mills, and the remains of mill dams, mill races, and the fine sediment that filled up the pool behind them can still be found along Bolin Creek and other larger creeks in the area. These areas of "legacy" fine sediment are often out of geomorphic equilibrium with the rest of the stream system, and thus can be areas subject to significant stream downcutting and bank erosion.

Most wetlands in the Bolin Creek Watershed are floodplain wetlands, and are largely found in the lower portions of the watershed after the stream has entered the Triassic Basin geologic zone. The Carolina Slate Belt is an area that tends to have water tables that drop significantly during dry periods; hence, the creeks can easily dry up. Groundwater resource users in this area rely on finding areas of fractured rock in the otherwise fairly impermeable metamorphic rocks.

Groundwater contaminants typically preferentially follow small faults and fractures in this area, rather than spreading out fairly evenly downgradient of a contamination source as you would expect in more water-permeable rocks.

Soil characteristics are particularly important when designing stormwater management treatment for developed areas, and can limit the ability to adequately treat stormwater, especially for higher-intensity land uses. Area soils have varying capability to absorb and transmit rainwater down into the ground. This ability to transmit water through soil is grouped into four Soil Hydrologic Groups, with Group A being most transmissible and Group D the least. Our area has none of the soils that most readily transmit runoff through them (Group A), and comparatively large areas of Group D. Depth to bedrock or other restrictive layer also limits how far soil water can travel downwards. The shallowest depth to the water table, usually occurring in the wintertime, also limits the distance available for filtration of rainwater through the soil. Figure 6 shows the distribution of soil hydrologic groups, depth to the water table, and depth to a restrictive layer. This distribution of soil properties contributes to the difficulty in finding feasible locations for stormwater treatment structures, including locating sites for watershed restoration projects.

CLIMATE AND PRECIPITATION

The local climate is warm-humid temperate, with very mild seasonal variation in rainfall patterns (peaks in the late winter and again in mid-summer coincident with tropical storm systems). This area is subject to occasional severe to exceptional droughts, with the most recent drought of 2008 being the drought of record for the area. Droughts in particular have long-lasting effects on stream organisms, and may result in suppression of stream biodiversity for years until organisms recolonize.

The El Nino / Southern Oscillation climate pattern of the Pacific Ocean has noticeable effects on wintertime precipitation and temperature patterns. The late-winter precipitation peak is a good opportunity for groundwater recharge, as fewer plants will be pulling water from the soil at that time of year. Thus, any changes to El Nino patterns will have effects on wintertime groundwater recharge.

Precipitation patterns tend towards intense short storms rather than milder long storms, especially during the warmer season. Precipitation frequency estimates (recurrence intervals of 1 year or more) are shown on Table 1. To understand this table, “Duration” is the length of time of a rainfall event of a given intensity, and “recurrence interval” is the average amount of time between storms of this duration and amount of rainfall. For example, a short, 5-minute rainstorm totaling 0.41 inches of rain happens on average once a year. However, it does not mean that one of each of the different duration storms listed for a 1-year return interval is what happens on average. Frequencies are calculated for longer-duration storms to be inclusive of shorter-duration based on statistical analysis of complete storms and portions of storms. So an average 24 hour storm totaling 2.96 inches (one that happens once per year) is likely to have within it a 5 minute time period where 0.41 inches falls, a 10 minute period where 0.66 inches falls, or a 15 minute period where 0.82 inches falls, and so forth.

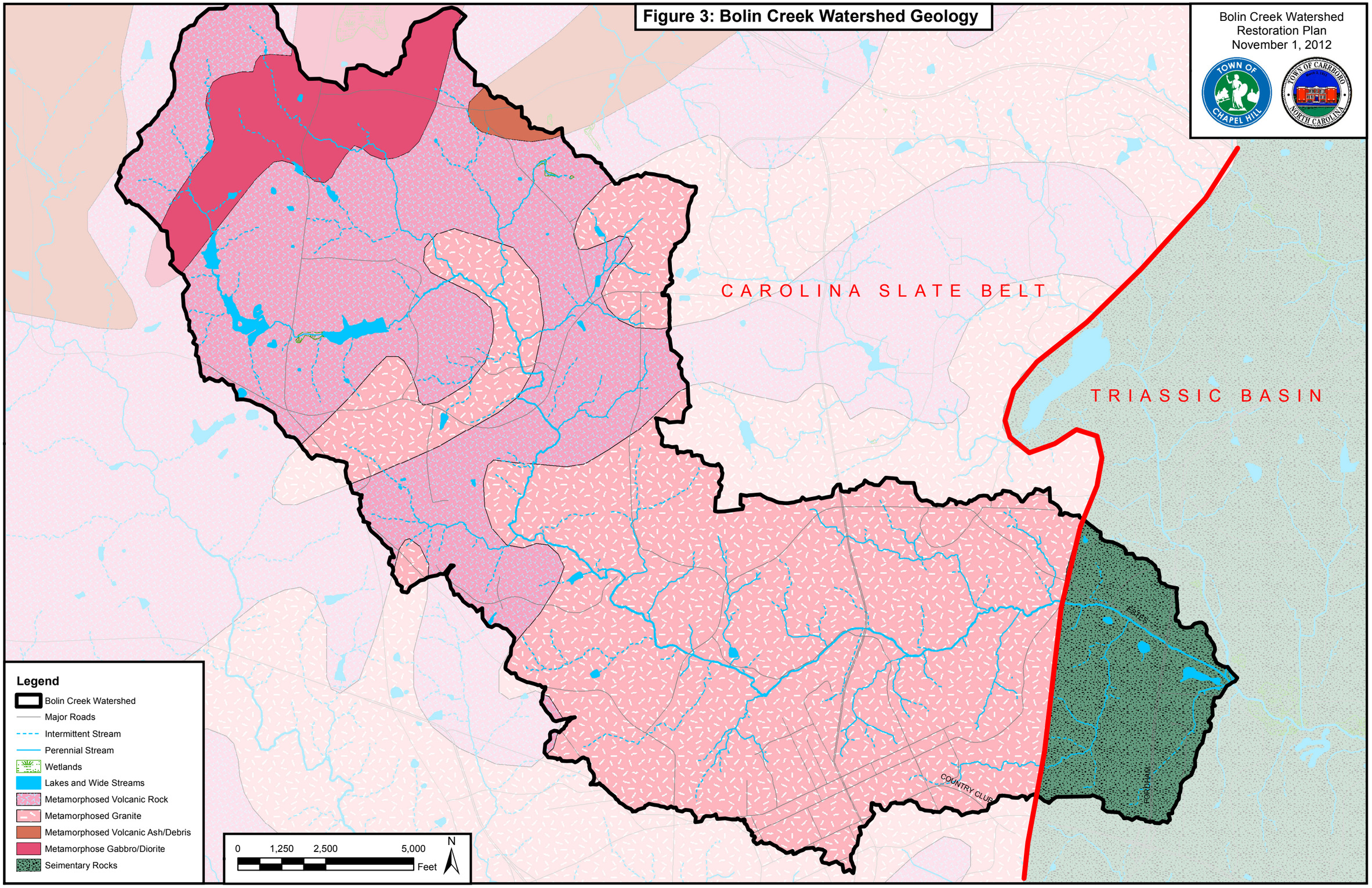
Figure 3: Bolin Creek Watershed Geology
Bolin Creek Watershed
Restoration Plan
November 1, 2012
CAROLINA SLATE BELT
TRIASSIC BASIN
ESTES
FORDHAM
COUNTRY CLUB
Legend
Bolin Creek Watershed
Major Roads
Intermittent Stream
Perennial Stream
Wetlands
Lakes and Wide Streams
Metamorphosed Volcanic Rock
Metamorphosed Granite
Metamorphosed Volcanic Ash/Debris
Metamorphose Gabbro/Diorite
Seimentary Rocks
0
1,250
2,500
5,000
Feet
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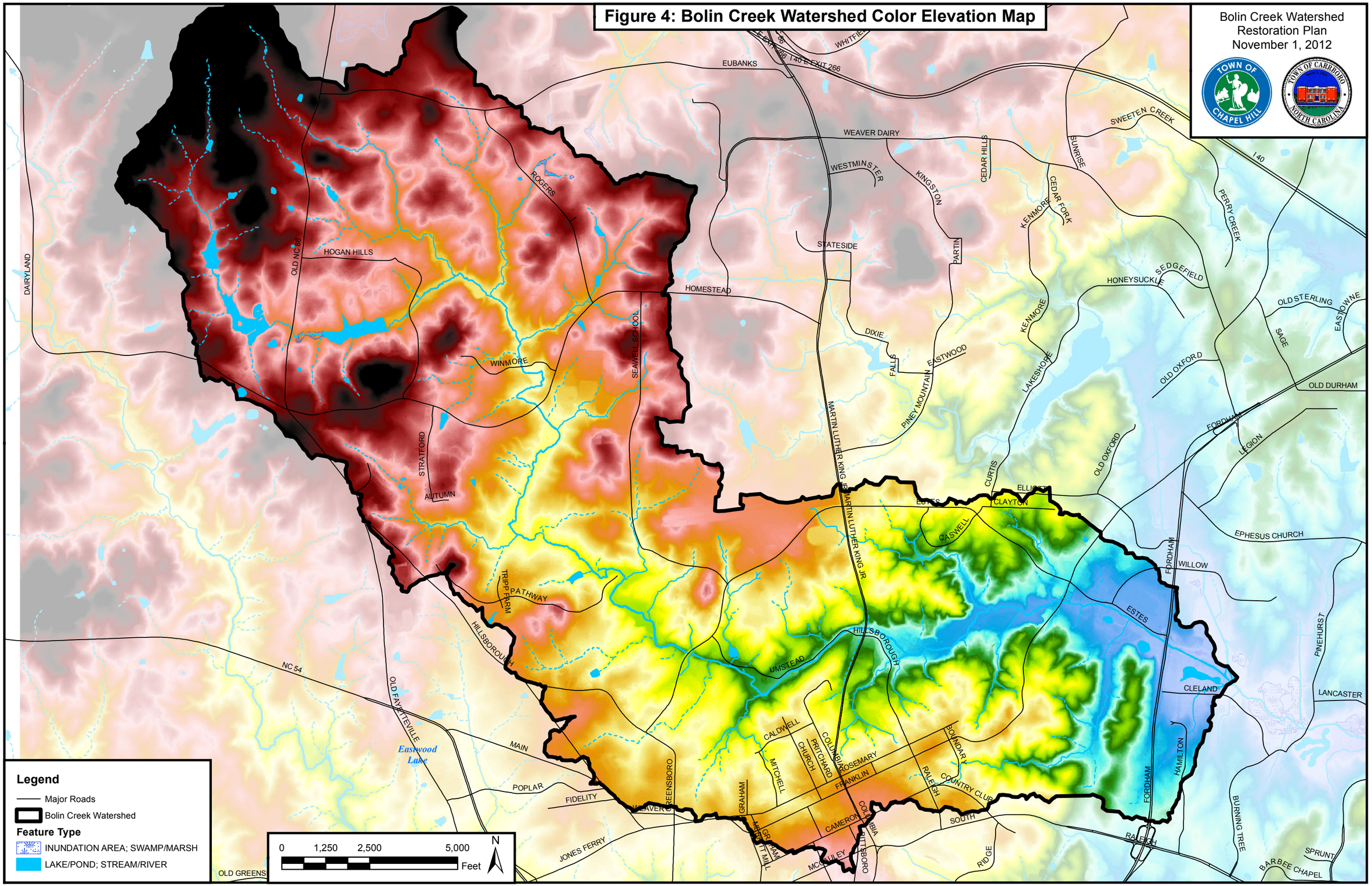
Figure 4: Bolin Creek Watershed Color Elevation Map

Bolin Creek Watershed
Restoration Plan
November 1, 2012



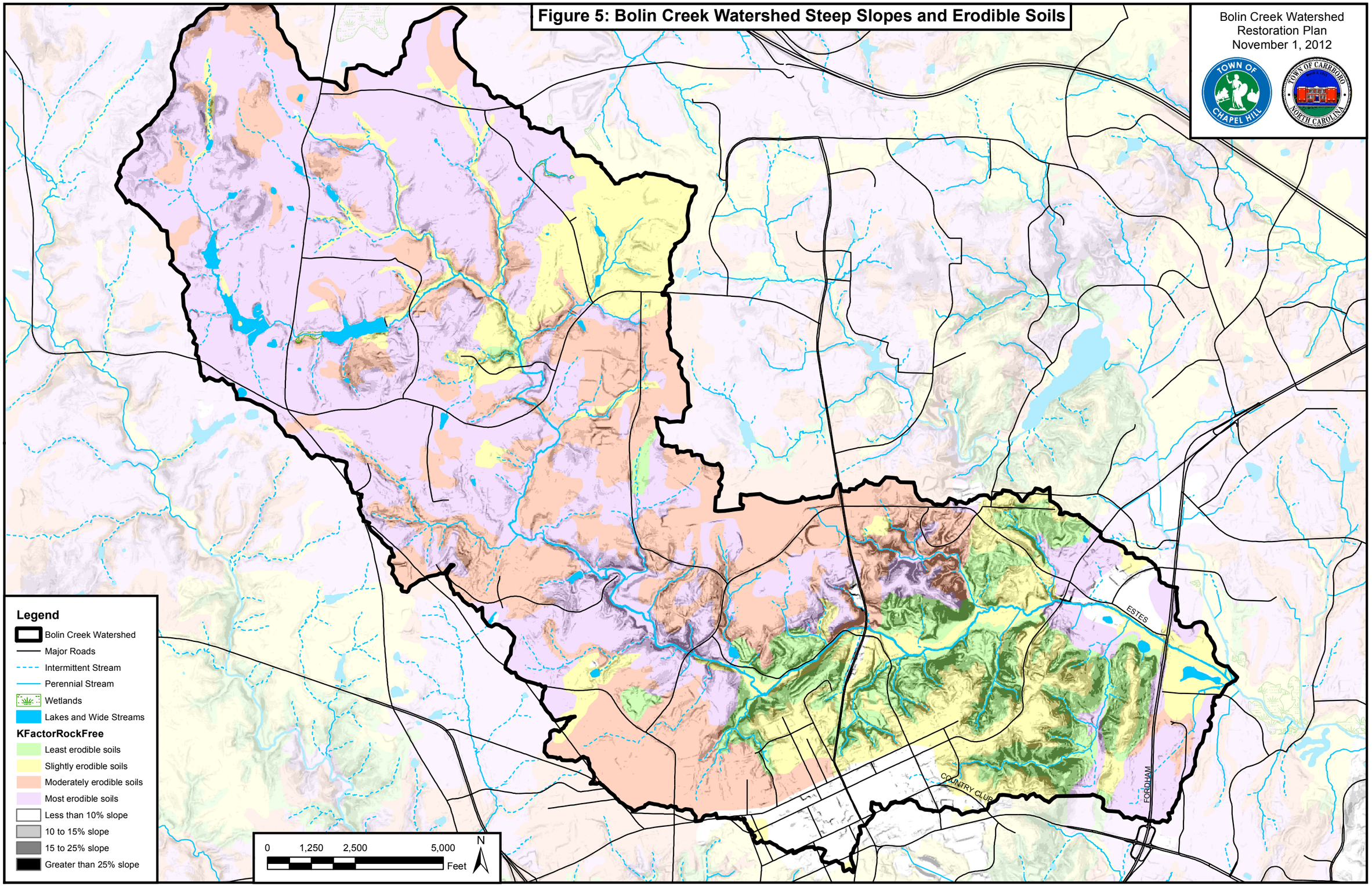
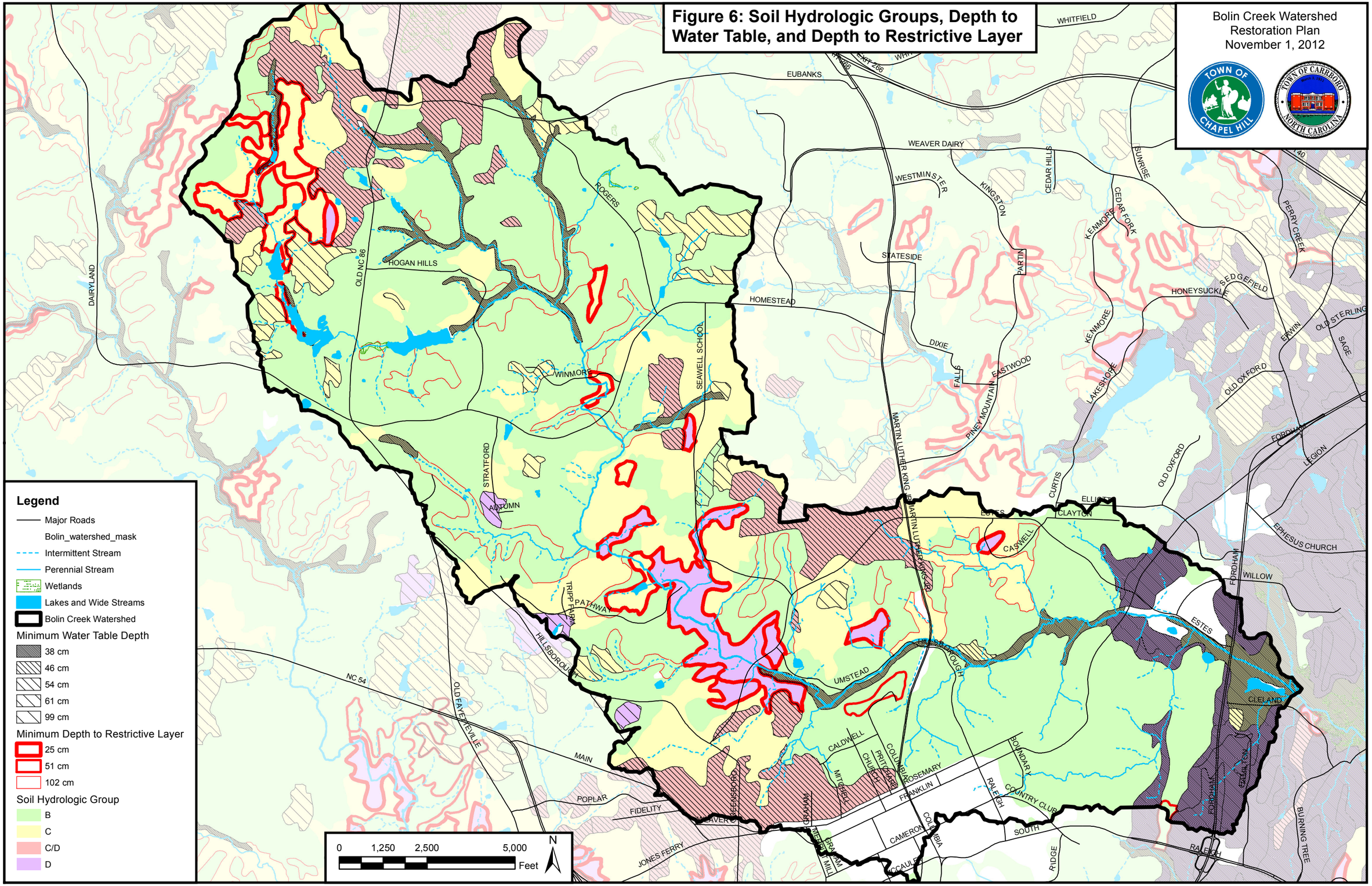


Figure 5: Bolin Creek Watershed Steep Slopes and Erodible Soils
Bolin Creek Watershed
Restoration Plan
November 1, 2012
TOWN OF CHAPEL HILL
TOWN OF CARRBORO
NORTH CAROLINA
Legend
Bolin Creek Watershed
Major Roads
Intermittent Stream
Perennial Stream
Wetlands
Lakes and Wide Streams
KFactorRockFree
Least erodible soils
Slightly erodible soils
Moderately erodible soils
Most erodible soils
Less than 10% slope
10 to 15% slope
15 to 25% slope
Greater than 25% slope
0
1,250
2,500
5,000
Feet
N
ESTES
COUNTRY CLUB
FORDHAM

Figure 6: Soil Hydrologic Groups, Depth to Water Table, and Depth to Restrictive Layer

Bolin Creek Watershed
Restoration Plan
November 1, 2012



These precipitation frequencies and intensities are used in the engineering modeling and design of stormwater conveyances and treatment systems to make sure they can handle the volumes and intensities of rainfall. The particular values used are based on the return frequencies specified in stormwater management ordinances. For instance, on new development projects Chapel Hill requires capture and slow release of rainfall from the 24-hour duration storms that occur on average once every year, every 2 years, and every 25 years.

Table 1: Precipitation frequency estimates (inches) for Chapel Hill NOAA site (ID 31-1667)[1]

	Average recurrence interval (years)									
Duration	*1*	*2*	*5*	*10*	*25*	*50*	*100*	*200*	*500*	*1000*
5-min	0.41	0.48	0.56	0.61	0.68	0.72	0.76	0.79	0.82	0.85
10-min	0.66	0.77	0.89	0.98	1.08	1.14	1.2	1.25	1.3	1.34
15-min	0.82	0.97	1.13	1.25	1.36	1.45	1.52	1.57	1.64	1.68
30-min	1.12	1.34	1.6	1.8	2.02	2.18	2.33	2.45	2.6	2.72
60-min	1.4	1.69	2.06	2.35	2.69	2.95	3.2	3.44	3.73	3.96
2-hr	1.68	2.02	2.49	2.87	3.33	3.7	4.05	4.4	4.86	5.23
3-hr	1.79	2.16	2.66	3.08	3.61	4.04	4.46	4.89	5.46	5.93
6-hr	2.15	2.59	3.2	3.71	4.37	4.92	5.47	6.03	6.8	7.44
12-hr	2.54	3.06	3.8	4.44	5.28	5.99	6.71	7.47	8.53	9.43
24-hr	2.96	3.58	4.47	5.17	6.11	6.86	7.62	8.41	9.5	10.35
2-day	3.46	4.17	5.17	5.95	6.99	7.81	8.64	9.49	10.66	11.58
3-day	3.67	4.41	5.44	6.25	7.33	8.19	9.07	9.96	11.2	12.17
4-day	3.87	4.64	5.71	6.54	7.68	8.57	9.49	10.44	11.73	12.76
7-day	4.44	5.3	6.44	7.34	8.57	9.54	10.53	11.56	12.96	14.06
10-day	5.05	6	7.21	8.15	9.42	10.43	11.44	12.47	13.87	14.97
20-day	6.76	7.97	9.41	10.56	12.11	13.34	14.57	15.83	17.55	18.89
30-day	8.39	9.88	11.47	12.72	14.36	15.62	16.87	18.12	19.8	21.09
45-day	10.69	12.52	14.32	15.72	17.55	18.95	20.31	21.67	23.46	24.83
60-day	12.84	14.97	16.89	18.37	20.28	21.72	23.11	24.46	26.21	27.53

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).Please refer to NOAA Atlas 14 document for more information.

NATURAL COMMUNITIES

The Bolin Creek Watershed lies predominantly in the Carolina Slate Belt Ecoregion, with the lower section in the Triassic Basin Ecoregion. The overarching Freshwater Ecoregion is the Appalachian Piedmont. In the eastern US, the shape and function of natural streams are dictated by the plant communities they flow through. The "forest makes the stream", so to speak, because of the different ways plant species affect drainage patterns, stream channel stability, instream habitat structure, and material at the base of the food chain. Natural plant communities in this area include various mixes of softwood (pine) and hardwood tree species, shrub and brush species, with small

areas of remnant, isolated prairie. Forest fires are not known to be important to forest community composition in this area, as compared to forests in eastern North Carolina.

The Natural Heritage Program has mapped out the plant community types for North Carolina (shown in Figure 7), and published maps of Significant Natural Heritage Areas. The National Wetlands Inventory has mapped wetland areas. Significant Natural Heritage Areas and wetlands are shown in Figure 8.

Forests in the watershed harbor a great many terrestrial and aquatic animal species common and uncommon in the eastern US, including forest mammals such as beaver, muskrat, white-tailed deer, skunk, a large variety of bird species, and a few amphibians, reptiles, and freshwater fish. Orange County has a fairly dense population of white-tailed deer, largely from abundant food sources and lack of predation. Coyotes have been observed in the County and the Towns, and it is expected they may put some predation pressure on deer populations.

Forests and streams in the watershed provide important ecosystem services and functions, including groundwater recharge, filtering pollutants from runoff, nutrient processing and cycling, clean air, beneficial soil organisms, temperature moderation, food and habitat for pollinator species, food and habitat for wildlife and wildflowers, and educational and recreational opportunities. These areas, in addition to urban trees and dense landscaped areas, provide shade for buildings and pedestrians, a softening of the urban environment, increased property values, lower rates of crime, and improved mental and physical well-being for residents.

Different types of natural areas differ in sensitivity to disturbance and ecological resilience. Steep slopes and erodible soils are more sensitive areas at risk of erosion and degradation, which can lead to changes in plant community and soil function, as well as the export of fine sediment that can negatively impact stream health. (Figure 5 above shows a map of steep slopes and erodible soils.) Riparian areas and natural floodplains are subject to different amounts of flood inundation. Many important biogeochemical processes take place in riparian zones and depend on normal processes of flooding and draining, requiring "connection" of streams to their floodplains or riparian zones. These processes can be interrupted by severe stream channel erosion or intentional modifications to stream channels, which prevents high-flowing water from reaching the riparian zone. Small streams in particular serve as important refuge and colonization sources for stream organisms, particularly streams fed by reliable groundwater. These colonization sources may be critical for maintaining a healthy biological community in larger streams such as Bolin Creek that experience severe scouring flows, "flashy" peaks in flow, and very low dry weather flows, all of which can dislodge or be inhospitable to aquatic organisms.

Healthy, contiguous forests with high plant biodiversity and structure (tall trees, mid-story, understory, and groundcover) are more resistant to damage from windstorms and ice storms, and fend off invasive plant species more successfully than forests with uniform structure, low biodiversity, or multiple interruptions and openings in the canopy. Small streams in particular are dependent on a continuous forest buffer for maintaining channel stability, riparian biogeochemical processes, runoff filtration and infiltration, shade and temperature modulation, habitat features, and material for the food web. Invasive plants, especially vines and other species that reduce tree cover along the stream, change the physical and biological characteristics of the streams flowing through those areas.

Figure 7: Natural Heritage Program Plant Community Classifications

Bolin Creek Watershed
Restoration Plan
November 1, 2012

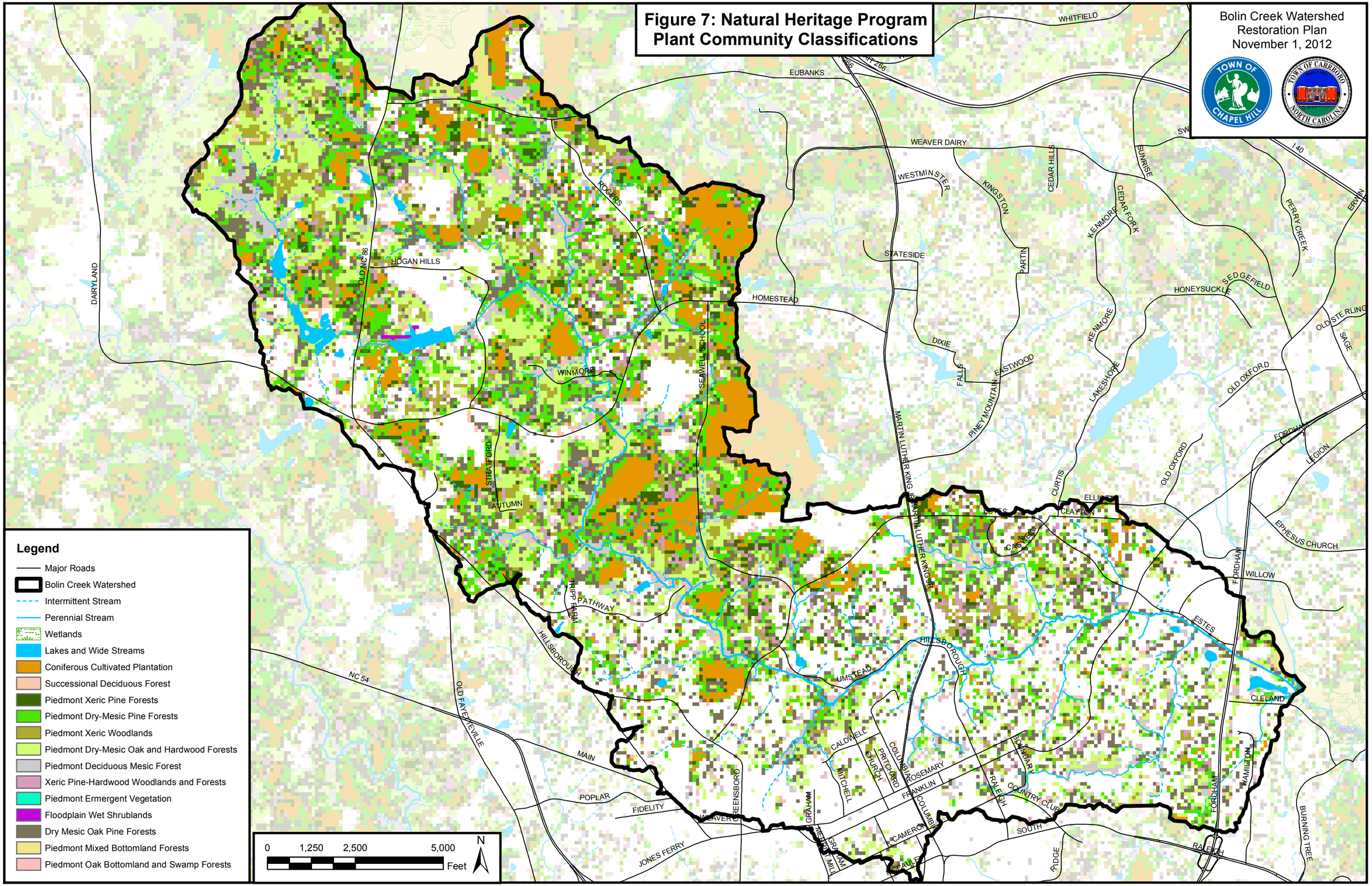
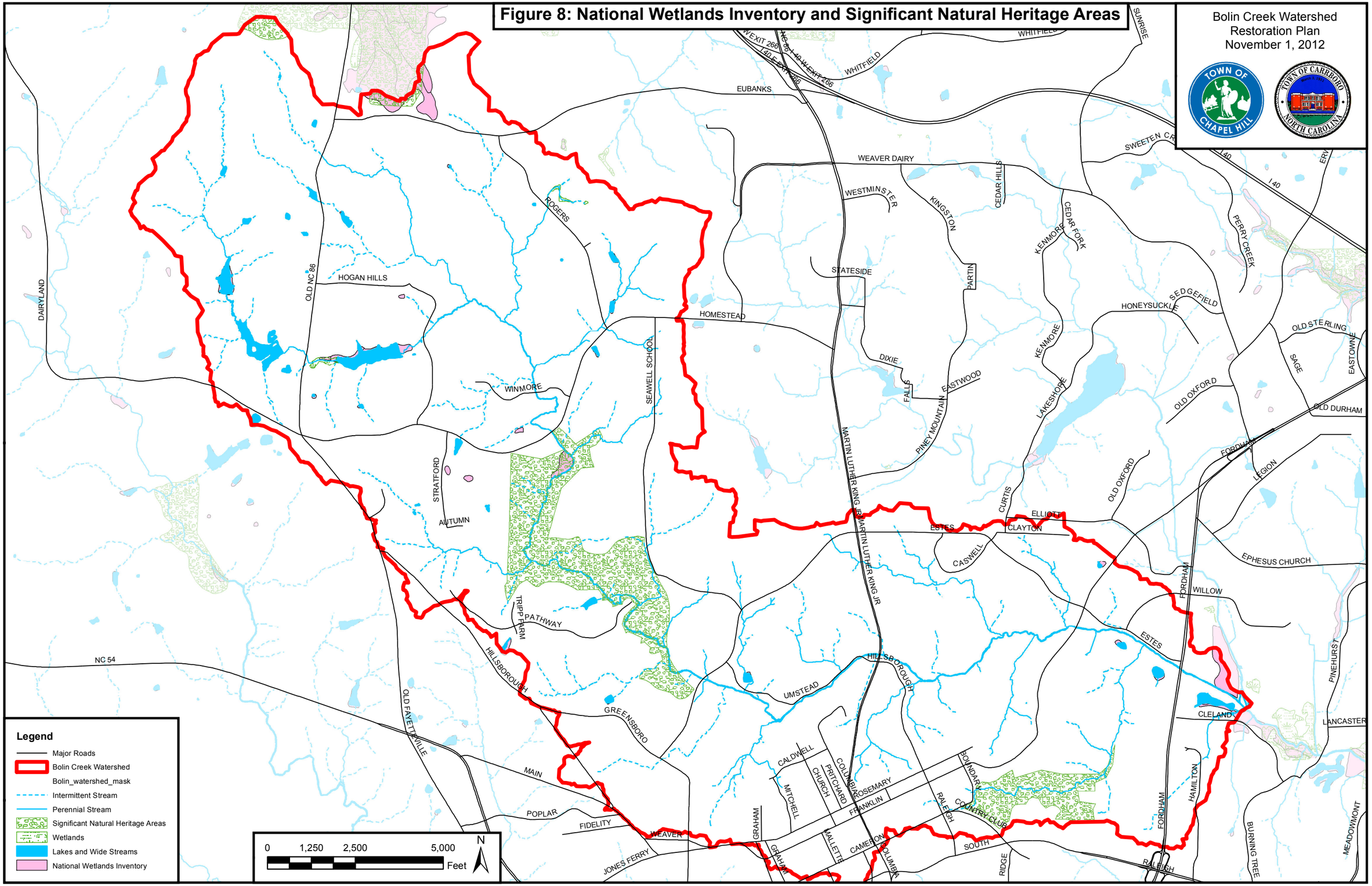



Figure 8: National Wetlands Inventory and Significant Natural Heritage Areas