

When development is conducted in an unplanned and amorphous or ambiguous pattern it can have more serious impacts on ecosystem function. Rapidly developing landscapes can result in stream degradation due to increases in stormwater runoff, sedimentation and other pollutants, and riparian habitat losses. Measures that may mitigate these impacts include preservation of forested stream buffers of appropriate size, reduction of impervious surfaces, and effective stormwater treatment.

The recommendations presented in this document to avoid or mitigate these impacts are based on the best available science and were obtained by a synthesis of scientific information in journals, publications, reference books, and personal communication with professionals familiar with North Carolina aquatic species and other natural resources. However, the recommendations may be revised as more information becomes available about species' habitat requirements and measures necessary to protect aquatic and terrestrial habitat and water quality.

General Mitigation Measures for All Watersheds (more extensive measures apply to watersheds that support federal endangered and threatened species)

Although riparian zones constitute a small percentage of the landscape, they frequently perform important ecological functions and contain a disproportionately high number of wildlife species in comparison to most upland habitats (Fischer et al. 2000; Knutson and Naef 1997). As a matter of policy, the American Fisheries Society strongly urges that riparian areas be considered unique and distinctly valuable habitats, and that such areas be declared of critical environmental concern (AFS 1985). Riparian areas perform many functions that are essential to maintaining water quality, aquatic species survival, and biological productivity.

With regards to the measures required to protect streams from pollutants, the further the intervention occurs from the source, the greater the costs to society (Reeves et al. 1991); resulting in a gradient from prevention to interdiction to restoration (Waters 1995). Watershed protection has been the most successful method of habitat rehabilitation (Reeves et al. 1991); however, given the difficulty of totally preventing or eliminating pollutants (e.g. sediment) at the source, interdiction such as the use of riparian buffers is an important tool in reducing damage to streams (Waters 1995). The functions of riparian zones are well documented and convey sometimes subtle but critical benefits to society. These functions are listed below.

Forested riparian area functions

- Reduce pollutants and filter runoff
- Improve air quality and lower ozone levels
- Maintain stable water flows
- Help sustain natural channel morphology
- Help maintain water and air temperature by providing shade
- Stabilize stream banks
- Provide most of the organic carbon and nutrients to support the aquatic food web
- Provide sources of large woody debris for the stream channel
- Help reduce the severity of floods
- Facilitate the exchange of groundwater and surface water
- Provide critical wildlife habitat

Numerous studies have evaluated buffer widths needed for stream protection. Often these have focused on a single parameter, which has resulted in a large variation in recommended buffer widths (Appendix A). For a buffer to effectively perform for all riparian processes, wider contiguous buffers (100–300 feet) are recommended (Knutson and Naef 1997;

May and Horner 2000; Martin et al. 2000; Palik et al. 2000; Richards and Hollingsworth 2000; Stewart et al. 2000). Effective buffer sizes depend upon specific site conditions, such as slope and soil type. Although variable widths may be more applicable in some circumstances, they are often more difficult to understand, implement, and enforce. Therefore, we offer generalized recommendations of minimum buffer widths for predictable application across the North Carolina landscape. Because specific conditions differ, some deviations from the general recommendation may be acceptable, however deviations should be kept to a minimum. Discussions regarding buffers or riparian corridors refer to forested buffers where the dominant vegetation consists of native trees and shrubs.

Streams with wide, forested riparian corridors in developed areas are essential for the protection of water quality and aquatic habitats. Natural riparian corridors are diverse, dynamic, and complex biophysical habitats (Naiman et al. 1993), and riparian ecosystems have the greatest vulnerability to alteration (Knutson and Naef 1997; and references therein). The maintenance of riparian habitat may yield the greatest gains for aquatic and terrestrial wildlife across the landscape while involving the least amount of area.

Numerous significant and negative consequences can result when headwater streams are lost (Meyer and Wallace 2001), and the effects of degradation accumulate; therefore, the condition of the stream in the lower reaches is closely dependent on the condition in the headwaters (Vannote et al. 1980). In addition, headwater streams can significantly reduce nutrient export to rivers (Alexander et al. 2000; Peterson et al. 2001).

1. We recommend the maintenance or establishment of a minimum 100-foot native forested buffer along each side of perennial streams and 50-foot native forested buffer along each side of intermittent streams and wetlands throughout the present and future service areas or the entire municipal jurisdiction (EPA 2000; Stewart et al. 2000). We additionally encourage the implementation of buffers on ephemeral streams due to the important functions that they provide as headwater streams (Alexander et al. 2000; Peterson et al. 2001). Buffers should be measured horizontally from the edge of the stream bank (Knutson and Naef 1997), which may result in wider buffers on higher gradients, and must be provided over the entire length of stream, including headwater streams. Further, we recommend leaving 30% of the development area as greenspace, which would include buffers and wetlands and ensure that the greenspace is connected to natural resources.

Wide, contiguous riparian buffers have greater and more flexible potential than other options to maintain biological integrity (Horner et al. 1999) and could ameliorate many ecological issues related to land use and environmental quality (Naiman et al. 1993). As expansion of developed areas continues into the watershed, wildlife habitat can change, become fragmented, and even disappear. Riparian buffers provide travel corridors and habitat areas for wildlife displaced by development. In addition, riparian buffers serve to protect water quality by stabilizing stream banks, filtering capacity of stormwater runoff, and provide habitat for aquatic and fisheries resources.

2. We recommend that delineation of streams be conducted for the municipal service area according to U. S. Army Corps of Engineers (USACOE) or N. C. Division of Water Quality (NCDWQ) methodology. This information can be found at <http://h2o.enr.state.nc.us/ncwetlans/strmfrm.html> (accessed May 2002). U. S. Geological Survey (USGS) maps underestimate the extent of streams. Recent research has shown that USGS maps can underestimate total stream length in the Piedmont of North Carolina by 25 % (Gregory et al. in press).

3. We recommend that sewer lines, water lines, and other utility infrastructure be kept out of riparian buffer areas (Knutson and Naef 1997; and references therein). All utility crossings should be kept to a minimum, which includes careful routing design and the combination of utility crossings into the same right-of-way (provided there is not a safety issue). Discontiguous buffer segments can impair riparian functions disproportionate to the relative occurrence of the breaks in the buffer (May and Horner 2000; Van Sickle 2000), and multiple crossings can result in cumulative impacts. The directional bore (installation of utilities beneath the riverbed, avoiding impacts to the stream and buffer) stream crossing method should be used for utility crossings wherever practicable, and the open cut stream crossing method should only be used when water level is low and stream flow is minimal. Manholes or similar access structures should not be allowed within buffer areas. Stream crossings should be near perpendicular (75° to 105°) to stream flow and should be monitored at least every three months for maintenance needs during the first 24 months of the project and then annually thereafter. Sewer lines associated with crossing areas should be maintained and operated at all times to prevent the discharge to land or surface waters. We recommend a minimum 50–100 feet setback on all streams, lakes, and wetlands for these structures, which falls in line with the recommended buffer widths. In circumstances where minimum setbacks cannot be attained, sewer lines shall be constructed of ductile iron or other substance of equal durability. Further, pesticides (including insecticides and herbicides) should not be used for maintenance of rights-of-way within 100 feet of perennial streams and 50 feet of intermittent streams, or within floodplains and wetlands associated with these streams.
4. Avoid the removal of large trees at the edges of construction corridors. Re-seed disturbed areas with seed mixtures that are beneficial to wildlife. Avoid fescue based mixtures because fescue is invasive and provides little benefit to wildlife. Native, annual small grains appropriate for the season are preferred and recommended (See http://www.esb.enr.state.nc.us/wetplant/wetland_plants.htm, and <http://www.co.mecklenburg.nc.us/coeng/Storm/services/vegetation/vegetation.htm>). Where feasible, use woody debris and logs from corridor clearing to establish brush piles and downed logs adjacent to the cleared right-of-way to improve habitat for wildlife. Allowing the corridor area to revegetate into a brush/scrub habitat would maximize benefits to wildlife. For areas adjacent to residential areas, a native shrub/grass option may also be beneficial. Minimize corridor maintenance and prohibit mowing between April 1 and October 1 to minimize impacts to nesting wildlife. We suggest a maintenance schedule that incorporates only a portion of the area—one third of the area, for example—each year instead of the entire project every 3 or 4 years. Herbicides and pesticides should never be used in wetland areas or near streams, as described above in item 3.
5. We recommend that the local governments prohibit commercial or residential development within the 100-year floodplain. Undeveloped floodplains strongly influence aquatic systems, support a combination of riparian and upland vegetation used by aquatic and terrestrial wildlife, supply a rich source of food to aquatic communities (Junk et al. 1989), and provide an important sediment trapping function (Palik et al. 2000). The filling of floodplains increases the potential for flooding of adjacent properties and interferes with the natural hydrologic process of the waterways. It also disrupts the continuity of migration corridors for wildlife. Instead, we recommend that developers set aside a portion of the land to be developed as green space and concentrate these areas along the streams and rivers (see Item 1 above). In addition we encourage “infill” (new development in unused or underutilized land in existing urban areas) development in

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urbanized portions of the jurisdiction and recommend the site practices for infill and brownfield development issued by the U. S. Environmental Protection Agency (EPA) (<http://www.epa.gov>; accessed May 2002) and the Center for Watershed Protection (<http://www.cwp.org/>; accessed May 2002). Floodplain maps may need to be updated to reflect development of the watershed. Floodplain remapping studies in Charlotte showed that buildout conditions would result in a floodplain width change from an average of 429 feet to 611 feet (<http://www.co.mecklenburg.nc.us/coeng/storm/floodinfo/floodmaps.htm>; accessed May 2002)

6. We recommend that the local government limit impervious surfaces to less than 10% of the watershed (Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Horner 2000; Stewart et al. 2000; Paul and Meyer 2001). The construction of roadways and other impervious surfaces in new neighborhoods can produce short-term direct impacts as well as long-term cumulative effects. Multiple studies have shown that stream degradation occurs at approximately 10% coverage by impervious surfaces (Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Horner 2000; Stewart et al. 2000; Paul and Meyer 2001). Likewise, the Wake County Watershed Management Plan Task Force performed a correlation analysis of impervious surfaces to watershed classification based on water quality data, and they found that watersheds of unimpaired streams averaged 8% imperviousness, impacted streams averaged 11%, and degraded streams averaged 24% (<http://projects.ch2m.com/WakeCounty/>; accessed May 2002).

We also recommend that the local government provide for sufficient open space to effectively reduce impervious surface so that predevelopment hydrographic conditions are maintained, limit curb and gutter in new developments, and prevent direct discharges of stormwater into streams. To achieve no net change in the hydrology of the watershed, we recommend installation of grassed swales in place of curb and gutter and on-site stormwater management (i.e. bioretention areas or other attenuation measures). These designs often cost less to install (Kwon 2000) and significantly reduce environmental impacts from residential development. Information regarding financing stormwater management can be found at <http://stormwaterfinance.urbancenter.iupui.edu/> (accessed May 2002).

Many of these recommendations have been applied in Maryland to protect the Chesapeake Bay from water quality degradation (MDE 2000). Suggested examples to accomplish the <10% impervious goal are using conventional designs at a level of <10% imperviousness or using conservation clusters with higher densities, with dedicated open space and other stormwater control measures to mimic the hydrograph consistent with an impervious coverage of less than 10%. Reduction of road widths is one method to reduce overall impervious surface coverage. The N. C. Department of Transportation (NCDOT) has issued road guidelines that allow for the reduction in street widths when compared to standard secondary road guidelines. This material can be found at <http://www.doh.dot.state.nc.us/operations/tnd.pdf> (accessed May 2002). In addition, there are site planning practices that, when incorporated with the above mentioned road building guideline, can further reduce the amount of impervious surface within a site (see recommendations in the document Better Site Design (Center for Watershed Protection; <http://www.cwp.org/>; accessed May 2002).

7. Use bridges for all permanent roadway crossings of streams and associated wetlands to eliminate the need to fill and culvert, where practicable. If culverts must be used, the culvert should be designed to allow passage of aquatic organisms. Generally, this means that the culvert or pipe invert is buried at least one foot below the natural streambed. If multiple cells are required, the second and/or third cells should be placed so that their bottoms are at stream bankfull stage. This will allow sufficient water depth in the culvert or pipe during normal flows to accommodate movements of aquatic organisms. If culverts are long and sufficient slope exists, baffle systems are recommended to trap gravel and provide resting areas for fish and other aquatic organisms. If multiple pipes or cells are used, at least one pipe or box should be designed to remain dry during normal flows to allow for wildlife passage. In addition, culverts or pipes should be situated so that no channel realignment or widening is required. Widening of the stream channel at the inlet or outlet of structures usually causes a decrease in water velocity causing sediment deposition that will require future maintenance. Finally, riprap should not be placed on the streambed.

8. We recommend that municipalities incorporate the elements listed below into their erosion and sediment control plans (see Brown and Caraco 2000 for additional information). Sediment is considered the most important cause of water pollution in the United States (Waters 1995), and construction is considered the most damaging phase of the development cycle to aquatic resources (Brown and Caraco 2000).
 - a) Minimize clearing and grading and only perform these operations in the context of an overall stream protection strategy.
 - b) Protect waterways by preventing clearing adjacent to waterways, and stabilize drainage ways.
 - c) Phase construction for larger construction sites (≥ 25 acres) to reduce the time and area that disturbed soils are exposed.
 - d) Stabilize soils as rapidly as possible (< 2 weeks) by establishing a grass or mulch cover.
 - e) Protect steep slopes, and avoid clearing or grading existing steep slopes as much as possible.
 - f) Establish appropriate perimeter controls at the edge of construction sites to retain or filter concentrated runoff from relatively short distances before it leaves the site.
 - g) Employ advanced settling devices that contain design features which include greater wet or dry storage volume, perforated risers, better internal geometry, use of baffles, skimmers and other outlet devices, gentler side-slopes, and multiple cell construction.
 - h) Implement a certified contractors program so that trained and experienced contractors are on-site.
 - i) Sedimentation impacts should be minimized by regular inspection of erosion control measures, and sediment control devices should be maintained in good and effective condition at all times. Erosion and sediment controls should be reassessed after storms. The incorrect installation of erosion control structures and those not properly maintained can result in sedimentation impacts to nearby streams and wetlands.

Specific Mitigation Measures for Waters Containing Federally Listed Species

Federally endangered and threatened species are particularly affected by secondary and cumulative impacts associated with urban development due to their sensitivity to habitat degradation and resulting high probability of extirpation. A high proportion of listed species

occurs within portions of the state that are developing the most rapidly; some have lost major reaches of their habitats within the past few decades, others are in danger of being extirpated from entire river basins, and one species has been extirpated from the state, and thus is extinct (Carolina Elktoe, *Alasmidonta robusta*). It is not just single species that are in danger of being lost in some systems, but entire faunas and communities.

For those watersheds that support federally endangered and threatened species, the following additional conditions shall be followed. These measures provide a higher degree of protection and also serve to protect the state-listed species and the general biotic integrity of these systems. The natural resource agencies' concerns regarding indirect effects to threatened and endangered species will be alleviated by adoption of these measures. The attached map (Appendix B) shows the location of NCDWQ designated 14 digit hydrologic unit code (HUC) drainage basins that support federally endangered and threatened species, and provide an indication of where the more extensive measures will apply. This map may be updated, as more information becomes available.

Stormwater

1. Permits for new developments exceeding 6% imperviousness shall be required to include stormwater controls designed to replicate and maintain the hydrographic condition at the site prior to the change in landscape and at a minimum include provisions that satisfy WS II-HQW minimum standards (WSII-HQW waters as precedent; Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Horner 2000; Stewart et al. 2000). This can be achieved through a variety of measures (see Item 6 above).
2. Insufficient information exists in the literature for the minimum buffer widths necessary to ensure the continued survival of federally endangered and threatened aquatic species. Therefore, the following minimum buffer recommendations are based on the best scientific information available and the opinion of biologists most familiar with the species in the state. The minimum recommended buffer widths may actually need to be more or less stringent; and therefore, recommended widths may be modified as more information becomes available. A 200-foot native, forested buffer on perennial streams and a 100-foot forested buffer on intermittent streams, or the full extent of the 100-year floodplain, shall be required for new developments. Detailed studies have resulted in recommendations of 200-foot buffers and wider for protection of priority habitats in the U. S. (Knutson and Naef 1997, and references therein; Martin et al. 2000; Richards and Hollingsworth 2000). If wooded buffers do not exist, then these areas shall be revegetated or allowed to naturally revegetate (so long as the area is pervious) to increase the functionality of a forested buffer. (Knutson and Naef 1997, and references therein; 200-foot buffers on Randleman Lake; 200-foot buffers associated with protection of aquatic endangered species habitats required for Buckhorn Reservoir Expansion Project in 1995 – City of Wilson).
3. Grassed swales shall be used in place of curb and gutter for new developments, except in areas with >5% slope. Check dams, level spreaders, and other associated best management practices shall be used to minimize the effect of stormwater runoff entering the riparian buffer areas. In areas where slopes exceed 5%, stormwater collected in piped conveyance systems shall be directed away from surface waters and best management practices shall be employed at both the intake and the outlet areas. Curbs and gutters may be used in combination with sidewalks in areas where clustering of uses increases the net local density to a level greater than 4 dwelling units per acre. This will separate

the pedestrian portion of a street-scape from the automobile portion and will encourage greater pedestrian mobility within the cluster development (see recommendations in Pedestrian Facilities Users Guide at http://www.walkinginfo.org/insight/features_articles/userguide.htm; accessed May 2002). Clustering development away from riparian areas will also allow for greater stream protection.

4. We recommend that that direct discharges of stormwater to streams not be allowed. Effective energy dissipation at the pipe outlet shall be accomplished to prevent scour of the stream channel and buffer. Stream habitats are maintained most effectively when stormwater runoff is dispersed through a vegetated or grassed buffer zone prior to entering the riparian buffer. The ditching or piping of stormwater except when used in combination with grassed swales, level spreaders and check dams shall not be allowed in the riparian buffer. At no time should any mandated vegetated buffer zone be used for these engineered devices. In addition, the use of trees—particularly evergreen species—can be an effective component of an integrated stormwater management plan and can reduce the amount of surface water runoff by as much as 7% on a site due to interception, transpiration, and other processes (see http://www.sustainable-communities.agsci.ubc.ca/bulletins/TB_issueforest.pdf, and <http://wcufre.ucdavis.edu/urban.htm>; accessed May 2002).
5. Emergency management procedures shall provide for the containment of runoff from fighting residential, commercial, or industrial fires and for the removal and clean up of any hazardous spills that may endanger nearby streams, instead of flushing contaminants into waterways.

Wastewater Infrastructure

1. Force mains shall be used to the greatest extent practicable. Gravity sewer lines shall be installed to follow along the outside of the 100-year floodplain contour unless topographic features, existing development, or other conditions restrict this technique.
2. Public and private sewer lines adjacent to streams shall parallel streams and be sited as far as practicable from stream and tributary corridors (Knutson and Naef 1997; and references therein). A minimum 200-foot buffer shall be provided for perennial streams and a 100-foot buffer for intermittent streams to maintain the integrity of the buffer or the full extent of the 100-year floodplain. Sewer lines close to streams shall be constructed of ductile iron or other substance of equal durability, similar to the guidance under the general mitigation measures item number 3.
3. No new sewer lines or structures shall be installed or constructed in the 100-year floodplain or within 50 feet of wetlands associated with a 100-year floodplain (Knutson and Naef 1997; and references therein).
4. Septic tanks, lift stations, wastewater treatment plants, sand filters, and other pretreatment systems shall not be located in areas subject to frequent flooding (areas inundated at a 10-year or less frequency) unless designed and installed to be watertight and to remain operable during a 10-year storm. Mechanical or electrical components of treatment systems shall be above the 100-year flood level or otherwise protected against

a 100-year flood (As per rule 15A NCAC 18A .1950 – Location of Sanitary Sewage Systems).

5. Only aerial crossings elevated sufficiently to reduce the risk of flood damage or directional boring stream crossings shall be allowed. The placement of these crossings will be limited to major stream or creek confluences. Manholes or similar access structures shall not be allowed within buffer areas. Stream crossing areas shall be monitored once a quarter for maintenance needs.

Water and Utility Infrastructure (Electricity, Telecommunications, and Gas)

1. All water lines and utilities shall follow roads or meet the requirements associated with sewer line placements (Killebrew 1993; Knutson and Naef 1997; and references therein). Stream crossing guidance is presented under the general mitigation measures item number 3.

Maintenance of Rights-of-Ways

1. Insecticides and herbicides shall not be used within 200 feet of streams, floodplains, and associated wetlands (Knutson and Naef 1997; and references therein) except when needed to protect native flora and fauna from exotics and when using appropriately labeled products, such as biopesticides (<http://www.epa.gov/pesticides/biopesticides/>; accessed May 2002).
2. Native, forested plant communities shall be maintained within 200-foot buffer area of streams, floodplains, and associated wetlands. A closed canopy will be maintained over streams. Emphasis will be placed upon trimming trees, instead of tree removal, within 200 feet of streams, floodplains, and associated wetlands (Knutson and Naef 1997; and references therein).

Sediment and Erosion Control

1. In addition to the items listed under the general mitigation measures, locally enforced stringent erosion and sedimentation control requirements shall be developed and implemented for all construction. The development of these requirements shall be fully coordinated with the state and federal agencies involved in aquatic endangered species protection. These measures shall be state-of-the-science and significantly exceed state minimum requirements for sediment and erosion control. Local ordinances shall be developed to prevent “forestry exemptions” from turning into development opportunity without meeting the conditions identified in this memorandum.
2. Fill or buildings shall not be allowed in the 100-year floodplain (as described in previous sections).

Additional Recommendations for Federally Listed Species

1. The local government shall solicit assistance and concurrence from resource agencies such as NCDWQ, N. C. Division of Land Resources, NCWRC, N. C. Natural Heritage Program, and USFWS during the initial development and assessment of best management

practices for stormwater management, sediment and erosion control, utility placement, etc.

2. Maps shall be developed of the anticipated construction lines of utilities associated with expanded service areas. This information shall become part of a Geographic Information System (GIS) database housed and maintained by the local government. Surveys or reviews will use maps and field determinations, when necessary, in conjunction with USACOE and NCDWQ delineation criteria for wetlands and waters. As infrastructure or development is planned or developed, field surveys should be conducted to assess impacts and means to avoid impacts. Field surveys (delineation) or intensive map reviews (including soil surveys, National Wetland Inventories (NWI) maps, USGS maps, watershed protection maps of all wetlands and waters) shall be completed and mapped with GIS technology. All GIS databases and associated files shall be provided to state and federal agencies upon request.
3. Local governments shall encourage and offer incentives for new developments, as part of the subdivision review process, to use low impact development technique for stormwater control (*Low Impact Development*; EPA Document # 841-B-00-002 and 841-B-00-003), and reduce impediments to implementing the plan. Proposed projects that are subject to NCEPA review shall identify as a part of the subdivision review process anticipated impervious surface amounts prior to plat approval.
4. Developers and builders, including land-clearing operators, shall be required to participate in a local government stormwater and sediment erosion control education program. Certification and bonding is recommended.
5. Infiltration practices (e.g., reduced road widths, rain gardens, parking lot bioretention areas, increased sheet flow instead of ditching, and disconnect impervious areas) to maintain predevelopment hydrographic conditions shall be emphasized over detention ponds. Condition information should include the base flow for low flow conditions.
6. Conservation Reserve Program lands and restoration of prior converted wetlands shall be encouraged to help manage overall stormwater impacts as part of a regional integrated stormwater management plan.
7. Site gas stations, car washes, and other “spill” land uses at least 200 feet from streams and wetlands.
8. The local government shall provide an environmental check-off list that a developer must complete before the issuance of development approvals to ensure protection of aquatic habitats for threatened and endangered species and that proper state and federal permits have been obtained. This shall preclude the issuance of any subdivision plan, building, and utility permits without inclusion of pertinent protective measures. This process shall ensure that land clearing does not occur without a site plan, including erosion control.
9. A watershed impact evaluation board shall be established to review projects within the service area with aquatic, endangered species. The board would ensure compliance, preview infrastructure and development plans, and be eligible to seek funding for conservation initiatives designed to protect and preserve aquatic, endangered species.

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10. We encourage local governments to consider retrofit options, including abandonment of chronic problem areas especially where projects exist in floodplains and are on failing septic systems. These areas should not be candidates for sewer service. Local governments should explore all buyout opportunities of these areas prior to exploration of providing sewer services to these areas. In addition, this should apply to schools and other public institutions. These public facilities should be relocated to more suitable areas. Local governments are encouraged to strengthen local land development codes to ensure that private lands donated to the public for usage of schools and other public facilities (i.e. fire, police, or medical facilities) are located outside of the 100-year floodplain so as to avoid future problems.
11. We recommend the use of conservation easements, public ownership, or deed restrictions to ensure the perpetual conservation of natural buffer areas.

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Appendices

Appendix A. Minimum riparian habitat buffer widths needed to retain various riparian habitat functions as reported in the literature.

Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Filter Nutrients (General)	36(118)	Young et al. 1980 (MN)
Filter Nitrogen	18(59) retention of only 20–50% of surface ammonium and 50% of nitrite and nitrate	Daniels and Gilliam 1996 (NC)
	9(29) grass	Dillaha et al. 1989 <i>in</i> Osborne and Kovacic 1993
	30(98)	Doyle, et al. 1977 <i>in</i> Osborne and Kovacic 1993
	31(102) 94% reduction in ground water nitrate	Hanson et al. 1994
	30(100) 78% reduction in groundwater nitrate	Hubbard 1997 (GA)
	16(52)	Jacobs and Gilliam 1985 (NC)
	10(32)	James, et al. (in press) <i>in</i> Osborne and Kovacic 1993
	55(180)	Jordan et al. 1993 (MD)
	25(82)	Lowrance, et al. 1984
	10–40(33–131)	Lowrance 1992 (GA)
	16(52) or 39(127) grass	Osborne and Kovacic 1993 (IL)
	19(62) ~70–80% reduction	Peterjohn and Correll 1984 (MD)
	50(164) 80–90% reduction	Peterjohn and Correll 1984 (MD)
	30(98)	Pinay and Decamps 1988 <i>in</i> Osborne and Kovacic 1993
	27(88) grass	Schnabel 1986 <i>in</i> Osborne and Kovacic 1993
	30(98)	Spruill 2000 (NC)
	17–20(56–66) or 31(100) to produce lowest simulated outputs	Williams et al. 2000 (GA)
	21(70) reduced surface N by 67% and ammonium by 71% [recommended 40m (118)]	Young et al. 1980 (MN)
27(88) grass	Young, et al. 1980 <i>in</i> Osborne and Kovacic 1993	

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Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Filter Sediment/Phosphorus	10(32)–20(65)	Aubertin and Patric 1974 <i>in</i> Osborne and Kovacic 1993 (WV)
	Nearly 50% of ¹³⁷ Cs labeled sediment moved over 100m(328) in riparian area	Cooper et al 1987 (NC)
	16(52)	Cooper and Gilliam 1987 <i>in</i> Osborne and Kovacic 1993
	6–18(20–59)	Daniels and Gilliam 1996 (NC)
	9(30) (grass filter)	Dillaha et al. 1989 (VA); Dillaha et al. 1988 (VA); Magette et al. 1989 (MD)
	9(29)	Haupt and Kidd 1965 <i>in</i> Osborne and Kovacic 1993 (ID)
	55(180)	Jordan et al. 1993 (MD)
	Most sediment deposited within 1 st 30(98) of buffer but extends 80(262) in riparian buffers	Lowrance et al. 1988 (GA)
	30(98) removed 75-80% from storm water in logged areas	Lynch et al. 1985
	28(92) for 81% efficiency	Mander et al. 1997 (Estonia)
	16(52) or 39(127)grass	Osborne and Kovacic 1993 (IL)
	19(62) trapped 90% of sediment	Peterjohn and Correll 1984 (MD)
	50(164) trapped 94% of sediment	Peterjohn and Correll 1984 (MD)
	50(164) for 84% total and 73% soluble P removal efficiency	Peterjohn and Correll 1984 (MD)
	15(49)–45(147)	Trimble and Sartz 1957 <i>in</i> Osborne and Kovacic 1993 (NH)
	30(100) recommended for trapping sediment	Wenger 1999
	17–20(56–66) or 28(92) to produce lowest simulated outputs	Williams et al. 2000 (GA)
	21(69) for 67% total and 69% soluble P removal efficiency	Young et al. 1980 (MN)
27(90) removed 93% sediment from feedlot; 23(75) removed only 33% from dairy farm runoff	Young et al. 1980 (MN); Horner and Mar 1982 <i>in</i> Castelle et al. 1994	

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Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Filter Contaminants	9(30) (fecal coliform/grass filter)	Coyne et al. 1998 (KY)
	15–80 (49–262) adequate for nonpoint source pollution	Phillips 1989 (NC)
Erosion Control	55(180)	Jordan et al. 1993 (MD)
	30(100)	Raleigh et al. 1986 <i>in</i> Knutson and Naef
Stream Type Maintenance (Rosgen 1996)	20x bankfull width each side (E channel type streams >10 ft wide at bankfull and <5% slope)	Llhardt, et al. 2000 (Eastern U.S.)
	10x bankfull width each side (other channel type streams >10 ft wide at bankfull and <5% slope)	Llhardt, et al. 2000 (Eastern U.S.)
	Entire floodplain + $\geq 30(100)$ (For identifiable floodplain and terrace slopes)	Llhardt, et al. 2000 (Eastern U.S.)
	$\geq 61(200)$ (>5% slope)	Llhardt, et al. 2000 (Eastern U.S.)
Large Woody Debris	>30(100)	Fetherston, et al. 1995 (Pacific NW)
	Majority of recruitment within 45(148)	Knutson and Naef 1997 (review)
	46(150)	Robinson and Beschta 1990
Water Temperature Control	10(32)–20(65)	Aubertin and Patric 1974 <i>in</i> Osborne and Kovacic 1993 (WV)
	$\geq 30(100)$ provides shading of old growth forest	Beschta et al. 1987 <i>in</i> Castelle et al. 1994 and Knutson and Naef
	10(32)	Brazier and Brown 1973 <i>in</i> Osborne and Kovacic 1993 (OR)
	12(39)	Corbett, et al. 1978 <i>in</i> Osborne and Kovacic 1993 (NC)
	31(101)	Lynch and Corbett 1990 <i>in</i> Osborne and Kovacic 1993 (PN)
Microclimate Influence	>45(148) and up to 300(985)	Brososfske, et al. 1997 (WA)
	61–122(200–399)	Chen et al. 1990 <i>in</i> Knutson and Naef

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Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Food Resources	>30(100) particulate organic matter (POM)	Palik, et al. 2000 (Eastern U.S.)
Instream habitat and aquatic resources	73–275(240–902) semi-aquatic resources	Burke and Gibbons 1995 (SC)
	≥30(100) to minimize short-term logging impacts on streams	Davies and Nelson 1994 (Australia)
	15–30(50–100) for minimum maintenance	Johnson and Ryba 1992 <i>in</i> Knutson and Naef
	>30(100)	May and Horner 2000 (WA) ; Martin et al. 2000 (MI, VA) ; Stewart et al. 2000 (WI)
	>61(200)	Richards and Hollingsworth 2000 (Eastern U.S.)
	164(534) semi-aquatic resources	Semlitsch 1998 (multi state)

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State and Federal Laws: What do they mean for me?

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UNC School and Institute of Government

The major environmental laws that govern the interaction of local development projects and aquatic species in North Carolina are set out in the following table (federal programs are shaded):

Law	Lead agency	Triggers	Goals	Implications and notes
National Environmental Policy Act (NEPA)	[whichever federal agency is considering the triggering action]. Regulations by Council on Environmental Quality (CEQ) and lead agency.	Major federal action significantly affecting the quality of the environment. Any project with federal funding, control or permits is likely to be covered.	Force agency awareness of environmental consequences & consideration of alternatives and mitigation	If triggered, an environmental assessment (EA) and finding of no significant impact (FONSI) or an environmental impact statement (EIS) must be prepared, unless the action is categorically excluded (CATX).
State Environmental Policy Act (SEPA)	[whichever state agency is considering the triggering action]; State Clearinghouse in Dept. of Administration	1) a state action, 2) an expenditure of public money or private use of public land, and 3) a potential environmental effect. State permit or funding may trigger SEPA for local projects.	Force agency awareness of environmental consequences & consideration of alternatives and mitigation	If triggered, an environmental assessment (EA) and finding of no significant impact (FONSI) or an environmental impact statement (EIS) must be prepared, unless the action is covered by a minimum criterion.
Endangered Species Act	U.S. Fish and Wildlife Service, Dept. of Interior	Action which may take (kill, harass or harm directly or through habitat modification) a federally listed species	Prevent the loss of species	Potential “takes” require consultation with USF&W. Incidental take permit may be possible via habitat conservation plans or safe harbor provisions.
State Endangered Species Act & WRC Habitat Conservation Program	Wildlife Resources Commission, DENR	Action which may take (kill, harass or harm directly or through habitat modification) a state listed species or otherwise degrade game or non-game habitat	Prevent the loss of species; improve wildlife habitat	Potential takes or habitat degradation will result in mitigation suggestions during SEPA review and possibly other permit reviews. Failure to heed suggestions may slow projects.
Instream flow; minimum release requirements for federally licensed dams (Federal Power Act)	Federal Energy Regulatory Commission	Renewal or changes in licenses for federally regulated dams	Assure adequate flow for in-stream ecology along with other goals of Federal Power Act	Waste assimilation and water withdrawals may compete with mandated instream flow requirements
Instream flow; minimum release requirements for state regulated dams (NC Dam Safety Law)	Div. of Water Resources, DENR	Renewal or changes in permits for state regulated dams	Assure adequate flow for in-stream ecology	Waste assimilation and water withdrawals may compete with mandated instream flow requirements

Interbasin transfers of water certificate (Regulation of Surface Water Transfers)	Div. of Water Resources & Environmental Management Comm'n (EMC), DENR	Withdrawals from streams in excess of 2 mgd or 25% increase in existing transfer	Provide orderly allocation of surface water in state	Like permits for new wastewater discharges, certificates for interbasin transfers can take a long time. Both have implications for downstream communities.
Wetlands dredge or fill, Clean Water Act § 404	U.S. Army Corps of Engineers	Adding materials or structures or removing same from waters of the U.S.	Prevent encroachment on public trust rights in water; limit wetlands losses	Wetlands impacts will generate mitigation requirements—avoidance, restoration, protection
State water quality certification, Clean Water Act § 401	Div. of Water Quality & EMC, DENR	Federal permit or license for a discharge into surface water. Under U.S. Supreme Court case in PUD#1 v. Washington, state 401 review can include actions (such as instream flow requirements) well outside traditional concerns of the USACE.	Maintain surface water quality under § 303 of the federal Clean Water Act; maintain designated uses of water	State may have independent mitigation requirements for projects that involve fill, structures or dredging in surface water. NC has an Ecosystem Enhancement Program with fairly elaborate mitigation programs managed centrally.
State wetlands rules	Div. of Water Quality & EMC, DENR	Disturbing isolated wetlands not covered by § 404/401 program	State has exercised its authority independent of the federal Clean Water Act to regulate all wetlands, not just those under federal jurisdiction, due to the ecological importance of remaining wetlands	Federal decisions limiting the extent of federal jurisdiction over isolated wetlands do not allow unregulated draining, ditching or other development on North Carolina wetlands.
NPDES discharge permit	Div. of Water Quality & EMC, DENR	Discharges to surface waters of the state	The original federal water pollution control act permitting program, designed to maintain water quality and designated water uses even in the presence of point source discharges of pollutants	Any point source discharge of pollutants to water requires thorough regulatory review. Some waters in North Carolina are “fully assimilated” meaning that further waste discharges are not allowed, unless other, existing discharges are removed.
Total Maximum Daily Load restrictions	Div. of Water Quality & EMC, DENR	Surface waters that fail to meet their designated uses and are thus “impaired”	When the discharge permitting programs have failed to bring water segments into compliance with their use classifications under § 303 of the Clean Water Act, state and federal agencies are to develop other strategies (TMDLs) to bring those water	If you have impaired waters in or downstream from your jurisdiction, it is possible that all other water permitting (NPDES point source and stormwater, 404/401, etc.) will have an additional overlay of requirements designed to cure the cause of the water quality impairment.

			bodies into compliance	
Nutrient Sensitive Waters and other specially classed waters restrictions (including Water Supply Watersheds)	Div. of Water Quality & EMC , DENR	All waters of the state are classified, but some, such as waters with excess nutrients, trout waters, other high quality waters, outstanding resources waters, water supply watersheds, and shellfish waters, have special protections	Protect special uses of water such as drinking water, shellfishing, trout habitat and important water recreation areas, as well as cure difficult nonpoint source problems such as excess nutrients	If your jurisdiction has specially classed waters in it, then projects that raise concerns about impairment of those special uses will get heightened regulatory scrutiny.
Stormwater laws and rules	Div. of Water Quality, DENR or Div. Of Coastal Management, DENR	There are many state stormwater programs. Triggers include development in coastal areas of environmental concern, water supply watersheds, municipal separate stormwater systems in urbanized areas, and nutrient sensitive waters	Polluted stormwater is a leading cause of water quality degradation in the state, and thus programs to address stormwater pollution (both state and federal) have proliferated over the past two decades.	The newer stormwater programs (e.g. in nutrient sensitive water river basins and Phase II communities) have permit requirements, so SEPA review may more frequently be triggered . Local stormwater permits may have special provisions to address aquatic species problems.
Coastal Area Management Act (CAMA)	Div. of Coastal Management, DENR	Development in areas of environmental concern in the twenty coastal counties	Rapidly increasing coastal development clashes with sensitive waters of the estuaries and shore.	CAMA development is subject to its own set of local planning requirements.
Erosion and Sediment Control Act	Div. of Land Resources, DENR	Land disturbing activity on one acre or more	Sedimentation is probably the state's worst water quality problem.	Monitoring and enforcement of erosion and sediment control plans is historically very under-resourced in the state, and pervasive clay soils are inherently hard to control once particles are suspended. So sedimentation remains a major problem despite a mature regulatory program.
Contaminated property restrictions	Div. of Waste Management, DENR	Sites with residual contamination (not fully cleaned up) may have restrictions that affect water use in and around them.	To facilitate cleanups, sites increasingly are left with residual contamination and some sort of controls on the use of the land.	It is increasingly likely that contaminated sites will have institutional and/or engineered controls that "run with the land" and that may affect future development in and around the contaminated property.

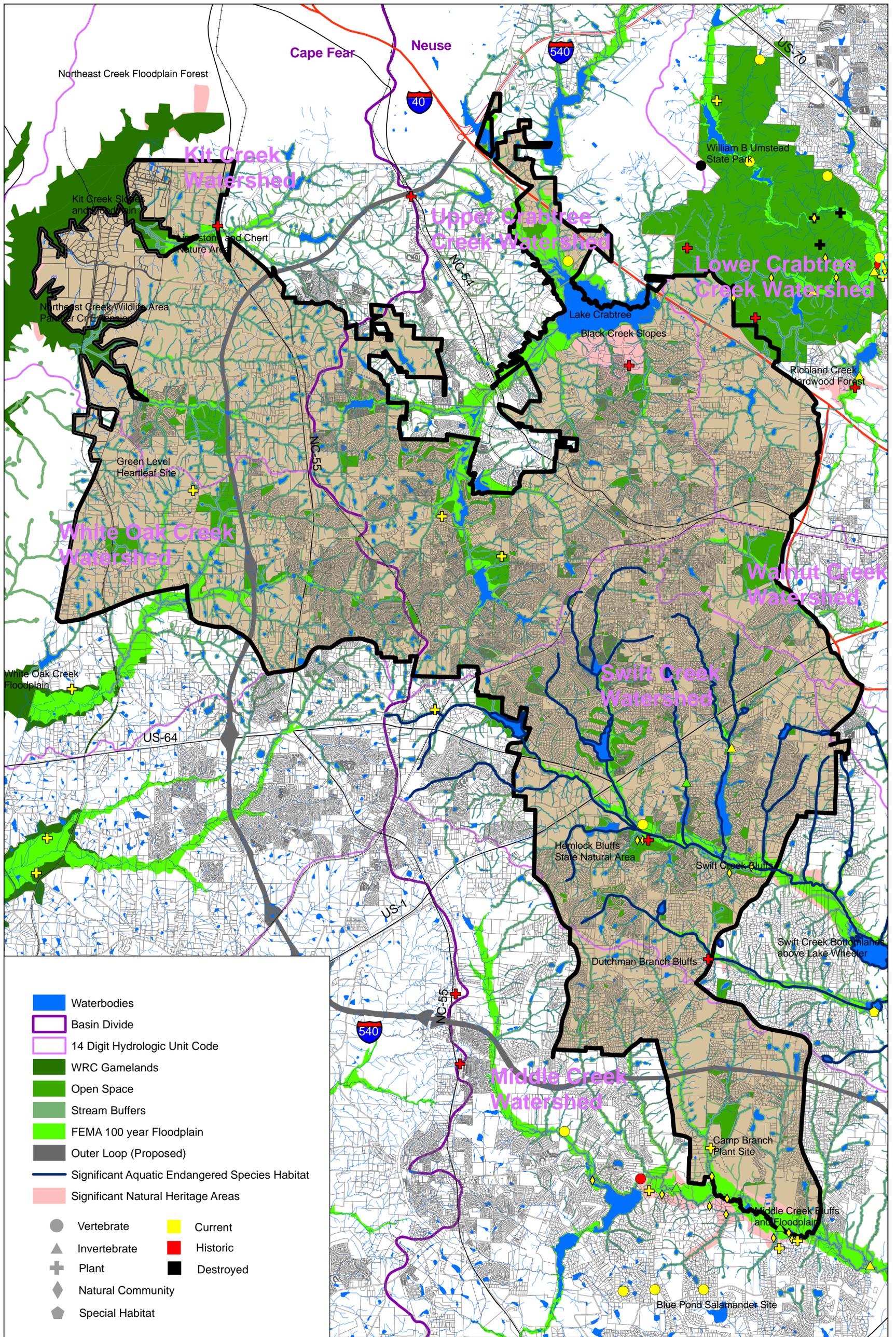


Figure 4-1

Town of Cary - Environmental Features
Secondary and Cumulative Impacts Master Mitigation Plan



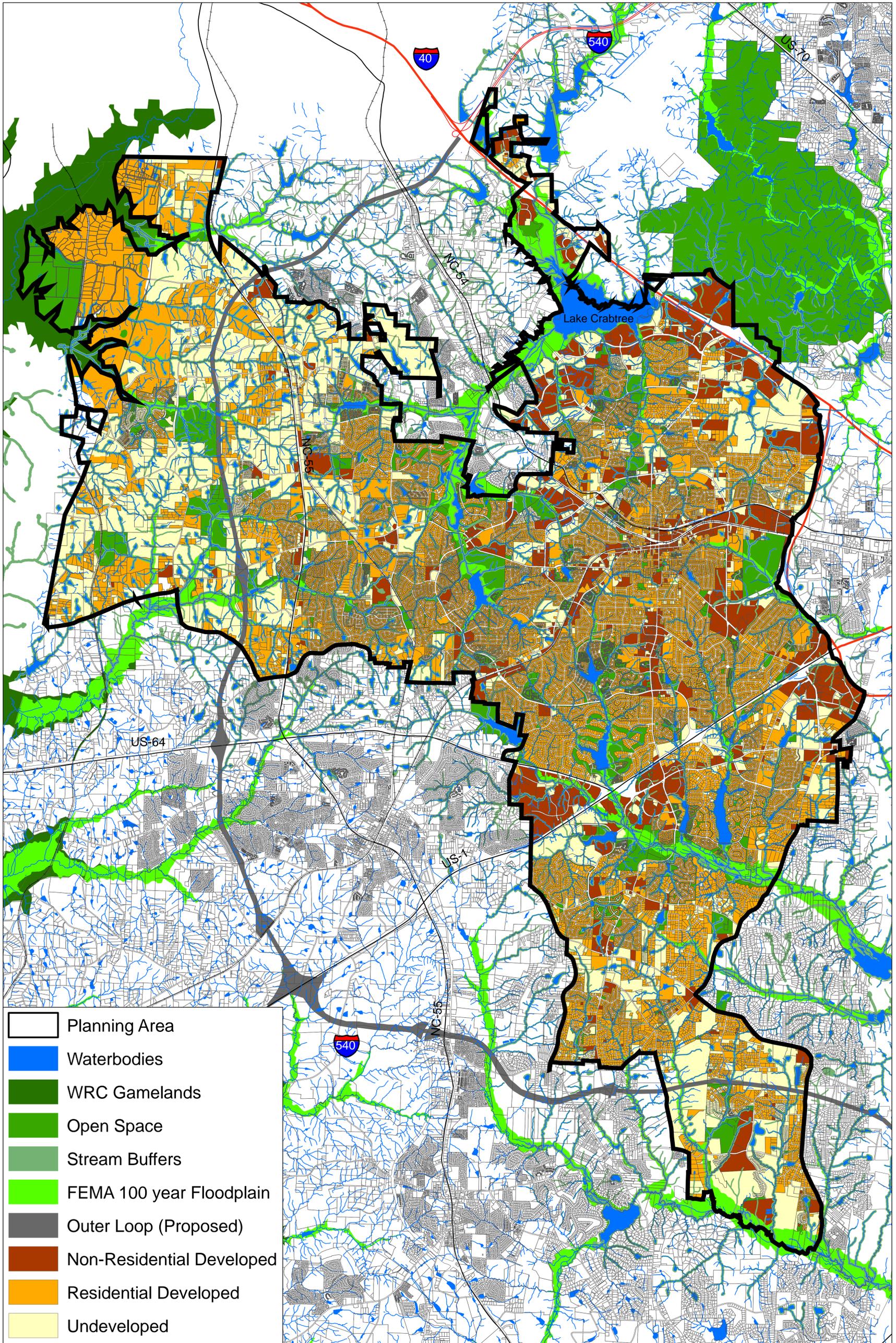
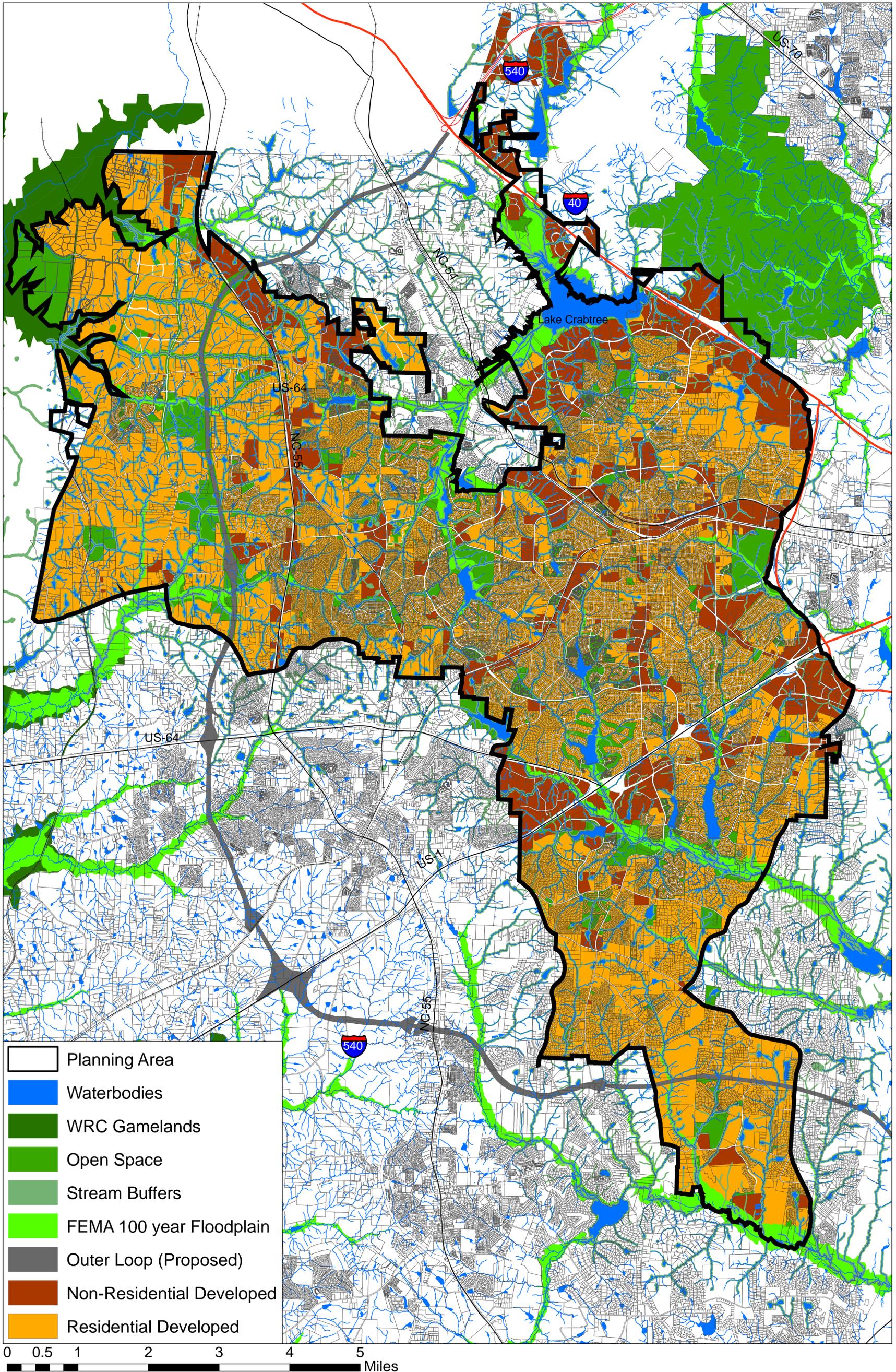


Figure 4-2
 Town of Cary - Existing Land Use
 Secondary and Cumulative Impacts Master Mitigation Plan



Miles

Figure 5-1
Town of Cary - Future Land Use
Secondary and Cumulative Impacts Master Mitigation Plan

Before Your Project Begins . . .

- Are permits required for your project?
- If permits are required for your project, contact your permitting agency to discuss whether a SEPA document is required.

Information Sources

- N.C. Department of Environment and Natural Resources (<http://www.enr.state.nc.us>)
- Customer Service Center (<http://www.envhelp.org>)
- State Clearinghouse (<http://www.enr.state.nc.us/files/laws.htm>)

What Your Environmental Document Needs

- Accurate project description
- Clear statement of project purpose and need
- Description of the site, surrounding area and service area
- Description of environmental impacts within the project boundary
- Inclusion of sensitive features (e.g. endangered species, natural heritage sites)
- Selection of feasible alternatives
- Adequate mitigation and means to enforce (after avoidance)
- Consideration of direct, secondary and cumulative impacts
- Maps

Planning Checklist:

- Have you contacted state or federal natural resource professionals to discuss your project (scoping)?
- Have you identified sensitive species and habitats in your area?

Databases to Use

- N.C. Wildlife Resources Commission (<http://www.ncwildlife.org>)
- N.C. Natural Heritage Program (<http://www.ncnhp.org>)
- N.C. Division of Water Quality (<http://h2o.enr.state.nc.us/>)
- N.C. OneMap (<http://www.NCOneMap.com>)
- N.C. Center for Geographic Information and Analysis (<http://www.cgia.state.nc.us/>)

Planning Checklist continued:

- N.C. Pollution Prevention and Environmental Assistance (www.p2pays.org)
- U.S. Fish and Wildlife Service (<http://www.fws.gov/>)
- Low Impact Development Center (<http://www.lowimpactdevelopment.org>)
- National Flood Insurance Program (<http://www.ncfloodmaps.com>)
- National Wetlands Inventory (<http://www.fws.gov/nwi/>)
- Coastal Habitat Protection Plan (<http://www.ncfisheries.net/habitat/chpp2.htm>)

Does your area have a land-use plan?

Creating Land-Use Plans

- N.C. Councils of Government (<http://www.ncregions.org/>)
- The Community Planning Program (<http://www.nccommerce/en/communityservices/communityplanningassistance/>)
- UNC School of Government (<http://www.sog.unc.edu/organizations/planning/othrsite.htm>)

Does the land-use plan direct growth away from sensitive species and habitats?

Are adequate mitigation and best-management practices in place to protect your natural resources?

Are forested buffers in place?

Is utility infrastructure routed outside of the forested buffer?

Is development being planned outside the 100-year floodplain?

Are impervious surfaces being controlled and stormwater adequately treated?

Are erosion, sediment and toxic chemicals being controlled and waterways protected?

Are you preserving green space and minimizing land disturbance?

Are you preserving natural areas, plants and wetlands?

Are you protecting natural processes?

Have you protected the watershed through land acquisition or conservation easements?

Clean Water Management Trust Fund (<http://www.cwmtf.net>)

Conservation Trust for North Carolina (www.ctnc.org)

N.C. Nonpoint Source Management Program (<http://h2o.enr.state.nc.us/nps>)

N.C. Public Water Supply Section (<http://www.deh.enr.state.nc.us/pws/index.htm>)

Source Water Assessment and Protection in North Carolina (<http://204.211.89.20/Swap/>)