Total Maximum Daily Load to Address Impaired Biological Integrity in the Perry Creek Watershed, Neuse River Basin

April 2010
EPA Approval on May 13, 2010

North Carolina Department of Environment and Natural Resources
Division of Water Quality

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SUMMARY

Based on a weight of evidence analysis for the Perry Creek watershed, the two most important factors contributing to impairment are scour and habitat degradation. These stressors and other indicator parameters are associated with the high levels of development (impervious areas) in the Perry Creek watershed.

A TMDL must address stressors believed to be contributing to the impairment. Where the major cause of impairment is stormwater runoff, the use of surrogate indicators expressed as quantitative targets is appropriate in TMDL development. Because of stormwater-associated pollutants and the effects on the system's hydrology, these targets are used as surrogates to estimate stormwater pollutant load reductions needed to meet water quality standards.

IMPLEMENTATION SUMMARY

The goal of this TMDL is to achieve water quality standards, in this case, a benthic macroinvertebrate community bioclassification of Not Impaired, Good-Fair, or better. Achievement of this water quality standard may be met by implementing management practices designed to mitigate the effects of stormwater runoff. Eliminating impervious cover (IC) is not necessary to reach the TMDL target reductions. Aquatic life (biological community) will be the measure of TMDL success.

When the TMDL is implemented, stressors (scour and habitat degradation, for example) will be reduced.

INTRODUCTION

Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations direct each State to develop a Total Maximum Daily Load (TMDL) for each impaired segment on the Section 303(d) list, taking into account seasonal variations and a protective margin of safety (MOS) to account for uncertainty. Traditionally, a TMDL reflects the total pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards.

The purpose of this report is to establish a TMDL to address the aquatic life impairments in the Perry Creek watershed. The goal is to provide the basis for improving the watershed ecosystem through implementation of stormwater best management practices such that the beneficial uses of the waterbodies are restored. Upon approval by EPA, this TMDL becomes part of the NC Division of Water Quality (DWQ) Neuse River Basinwide Water Quality Plan.

In 2002, EPA provided clarifications of existing regulatory requirements for establishing wasteload allocations (WLAs) for stormwater discharges in TMDLs (EPA Memorandum 2002). Specific key points of the memorandum include:

- EPA expects that most Water Quality Based-Effluent Limits (WQBELs) for NPDES-regulated municipal and small construction stormwater discharges will

be in the form of Best Management Practices, and that numeric limits will be used only in rare instances.

- When a non-numeric WQBEL is imposed, the permit's administrative record, including the fact sheet when one is required, needs to support that the BMPs are expected to be sufficient to implement WLA in the TMDL.

- It may be reasonable to express allocations for NPDES-regulated stormwater discharges from multiple point sources as a single categorical wasteload allocation when data and information are insufficient to assign each source or outfall individual WLAs.

- EPA expects TMDL authorities to make separate allocations to NPDES-regulated stormwater discharges (in the form of WLAs) and unregulated stormwater (in the form of load allocations). EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability in the system.

This TMDL applies to the entire Perry Creek watershed, which includes the assessment units listed in Table 1.

Table 1. Perry Creek Watershed Assessment Units and Descriptions

Stream Name	Assessment Unit Number (AU) *	Sampling Location	Description	Current Bioclassification
Perry Cr	27-25-(2)	SR 2006	From dam at Greshams Lake to Neuse River.	Fair 2005
Perry Cr	27-25-(1)	Hunters Way	From source to dam at Greshams Lake	Not Rated 2004
Unnamed Tributary Perry Cr	27-25-3-(2)	SR 3514	From dam at Camp Durant to Perry Creek	Not Rated 2004
Unnamed Tributary Perry Cr	27-25-3-(1)	N/A	From source to dam at Camp Durant	N/A

* See Figure 1 for spatial reference.

Perry Creek at SR 2006 has been on the NC 303(d) list of impaired waters since 1998. Perry Creek at Hunters Way was sampled approximately 500 meters downstream of an impoundment. Because of the sampling site's close proximity to an impoundment, a bioclassification of Not Rated was given for this location. This segment [AU#27-25-(1)] will be moved to Category 4c in a subsequent Integrated Report because of the impact of the impoundment. EPA's 4c category is defined as the non-attainment of any applicable water quality standard which is the result of pollution and is not caused by a pollutant.

The Unnamed Tributary (UT) Perry Creek at SR 3514 is considered impaired for biological integrity but is not listed on the 303(d) list due to the Not Rated bioclassification. A bioclassification of Not Rated can be assigned to streams which have a drainage area size less than three square miles and would have received a Fair or Poor

bioclassification using the benthic macroinvertebrate criteria derived for larger streams (NCDWQ 2003). The UT Perry Creek (AU#27-25-3-(1)) benthic macroinvertebrate community has not been assessed.

APPLICABLE SURFACE WATER QUALITY STANDARDS AND RULES

TMDLs are established to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Examples of designated uses include aquatic life survival and propagation, swimming, drinking water supply, and shellfish harvesting. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The surface water classifications for the Perry Creek watershed include Class C and Class B uses. All waters in North Carolina have the base classification of "C." Class C waters are protected for aquatic life propagation and biological integrity (including fishing and fish), wildlife, secondary recreation, agriculture and other uses suitable for Class C. There are no restrictions on watershed development or types of discharges associated with Class C (15A NCAC 02B.0211, 2007).

In addition, the Perry Creek segment AU# 27-25-(1) from source to Greshams Lake dam and the UT Perry Creek segment AU# 27-25-3-(1), from source to dam at Camp Durant are protected as Class B for primary recreation. Class B uses are primary recreational activities that include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis.

Since the Perry Creek watershed is in the Neuse River Basin, waters have the supplemental water quality classification of Nutrient Sensitive Waters (NSW). This supplemental classification is intended for waters needing additional nutrient management due to their experiencing or being subject to excessive growth of microscopic or macroscopic vegetation. In general, management strategies for point and nonpoint source pollution control require control of nutrients (nitrogen and/or phosphorus usually) (15A NCAC 02B.0233, 2007). The Neuse River Basin-Nutrient Sensitive Waters Management Strategy: Basinwide Stormwater Requirements are designed for local governments to implement their own stormwater management plan (15A NCAC 02B.0235, 2007). This requirement has been in effect since August 1, 1998.

This TMDL addresses Perry Creek watershed, which has impaired biological integrity. Impairment for biological integrity is based on a narrative standard that pertains to the aquatic life use designation. Biological integrity means "the ability of an aquatic ecosystem to support and maintain a balanced and indigenous community of organisms having species composition, diversity, population densities and functional organization similar to that of reference conditions" (15A NCAC 02B.0202, 2007).

DWQ's criterion for assessing aquatic life as impaired is a biological community at a benthic macroinvertebrate or fish sampling site with a bioclassification of Poor, Fair or Severe Stress. The criterion for assessing aquatic life as supporting is a bioclassification

of Good-Fair, Good, Excellent, Not Impaired, Natural or Moderate Stress at a biological community sampling site.

Biological impairments to the Perry Creek watershed were identified using bioassessment protocols outlined in the North Carolina's *Standard Operating Procedure for Benthic Macroinvertebrates* (NCDWQ 2006). Perry Creek at SR 2006 has carried a benthic macroinvertebrate bioclassification of Fair since 1995. The supporting data analysis that resulted in the listing for impaired biological integrity is located in Appendix 1.

Habitat evaluation is not currently linked to the North Carolina Piedmont bioclassification ratings so there are no habitat thresholds or breakpoints distinguishing "condition groups" (e.g., Excellent, Good, Good-Fair, Fair, or Poor); higher overall scores simply represent better aquatic habitat than lower overall scores. To reduce the subjectivity of visual interpretations of the habitat components, the DWQ assessment form provides definitions of various conditions and the associated score (NCDWQ 2006).

The DWQ methodology (2006) for evaluating instream aquatic habitat focuses on eight key components that affect the availability and suitability of habitat. The components are rated individually and the summation of the scores ranges from 0 to 100, with 100 reflecting the highest quality habitat. Habitat scores for the sites in the Perry Creek watershed are provided in Appendix 1. The eight components and their relative weight to the overall score are:

- Channel modification (5)
- Instream habitat types (20)
- Bottom substrate (15)
- Pool variety (10)
- Riffle habitats (16)
- Bank stability and vegetation (14)
- Light penetration (10)
- Riparian vegetative zone width (10)

WATERSHED DESCRIPTION

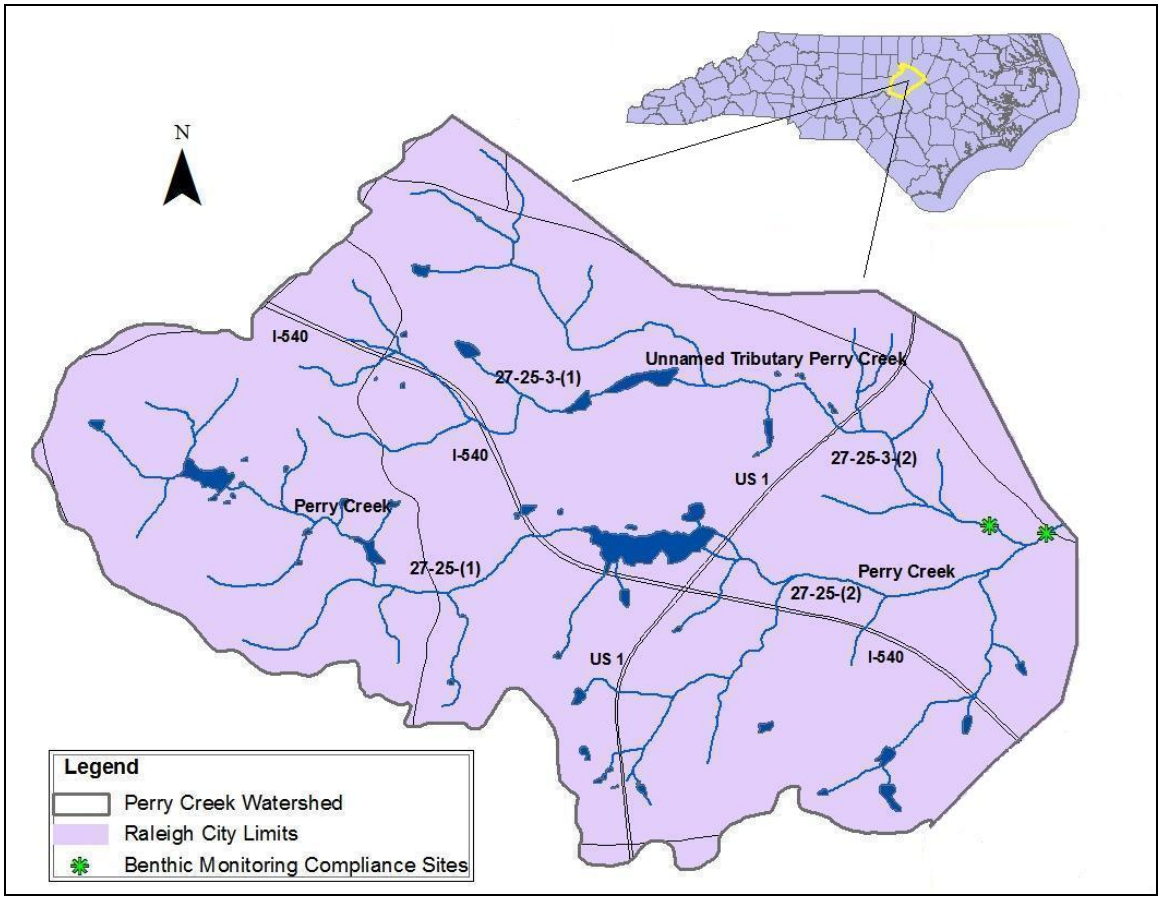
The Perry Creek watershed is located in northeast Raleigh, Wake County, in the Neuse River Basin. The mainstem of Perry Creek flows generally east toward its confluence with the Neuse River. This watershed is within the USGS 12-digit hydrologic unit (HU) 030202010704, which is approximately 31.6 square miles in area. For purposes of this TMDL, the Perry Creek watershed was extracted from the 12-digit HU. It comprises a smaller drainage area of 11 square miles (Figure 1). The TMDL watershed is defined as Perry Creek from source to SR 2006 (Perry Creek Road) and all tributaries draining to this portion of Perry Creek (Figure 1).

The TMDL watershed lies within the City of Raleigh's jurisdiction. Two major highways (US 1 and I-540) transect this TMDL watershed. The predominant land cover is developed with extensive residential subdivisions and urban office parks/commercial areas. Impervious surfaces (areas such as roof tops, roads and parking lots that prevent infiltration of precipitation into the soil) cover approximately 17% of this watershed. Significant impacts to stream biota can generally be expected with this degree of unmitigated impervious cover (Schueler, 1994).

The watershed is located in the Northern Outer Piedmont ecoregion (45f; Griffith et al. 2002). Upland soils of the watershed consist of a variety of soil associations (Cawthorn, 1970), corresponding to two major geologic belts running in a north-south direction through the study area. The western portion of the study area (encompassing the headwaters of Perry Creek to U.S. 1) has predominant soils of the Cecil-Appling associations, derived primarily from crystalline materials (mostly granite, gneiss and shist) and mudstone. Soils along the eastern portion of the study area (from U.S. 1 to the confluence of the Neuse River). are largely of the Wehadkee series. These are nearly level poorly drained soils formed in sandy alluvium and are common along streams in Wake County.

Impoundments in the watershed include Greshams Lake on Perry Creek and a lake at Camp Durant on an unnamed tributary (UT) to Perry Creek. Smaller impoundments are also present: two above Greshams Lake on Perry Creek, one above the Lake at Camp Durant, and two in the upper watershed of an unnamed tributary originating near U.S. 1.

Figure 1. Perry Creek TMDL watershed



POLLUTANT SOURCE ASSESSMENT

This TMDL report largely draws its information from two stressor studies conducted by DWQ in 2004 for the Perry Creek watershed. These efforts analyzed the causes of impairment by measuring various water chemistry, sediment toxicity, physical and biological parameters (NCDWQ 2004a, NCDWQ 2004b).

The NCDWQ Environmental Sciences Section conducted two stressor studies in 2004. (NCDWQ 2004a, NCDWQ 2004b). Stressor studies are specialized studies that attempt to identify specific factors leading to degraded water quality conditions. The assessment included field measurements and water chemistry data identifying potential causes of impairment. Major watershed activities and sources of pollution contributing to those causes such as stream bank erosion and stormwater runoff from urban areas were identified.

In addition, DWQ's Biological Assessment unit conducted a stressor study in May 2004. This effort assessed benthic macroinvertebrates, habitat characteristics, chemical and physical data to analyze specific stressors identified as causes of impairment to the aquatic community. This study confirmed potential sources of stressors for TMDL development and determined the current status of the impairment. The supporting data analysis that resulted in the listing for impaired biological integrity is located in Appendix 1.

Conclusions of the studies show aquatic organisms in the Perry Creek watershed are heavily impacted by multiple stressors associated with high levels of development (impervious areas).

The relative contribution of these stressors cannot be clearly differentiated based on the available data. For example, increases in stream flow associated with development during storm events result in bank erosion and scour. The stream bank erosion and sedimentation associated with these events contributes to habitat degradation that would be associated with biological impairment. Additionally, nutrient enrichment associated with the residential and commercial development around Greshams Lake, possible leaking sewer lines, and the golf course and residential areas present in the watershed may also contribute to biological impairment by causing algal activity and lowered dissolved oxygen levels. A number of impoundments in the watershed were identified as hindering downstream macroinvertebrate recolonization. No single pollutant or group of specific pollutants has been identified as the cause of impairment in the watershed.

Significant contributors to impairment of Perry Creek and UT Perry Creek include the following NPDES Stormwater Phase I permit holders: City of Raleigh (NCS000245) and NC Department of Transportation (NCDOT) (NCS000250).

STRESSOR IDENTIFICATION

Studies conducted by the Environmental Sciences Section of DWQ in the Perry Creek watershed in 2004 included a detailed evaluation of the causes of impairment. The following paragraphs summarize the findings of that analysis. These studies included the following primary tasks:

- Identification of potential "candidate" causes of impairment in the watershed

- Collection of additional data
- Characterization of the causes of impairment using a "strength of evidence" approach

The strength of evidence evaluation included analysis of whether candidate stressors were primary causes of impairment, secondary causes of impairment, part of the cumulative cause of impairment, a contributing stressor, a potential cause or contributor, or an unlikely cause or contributor. Other sources of evidence evaluated included benthic macroinvertebrate community data, habitat and riparian area assessment, chemistry, toxicity data, current watershed activities, land uses, and pollutant sources.

The following candidate causes were not determined to be significant or primary causes of impairment in Perry Creek and therefore are not addressed by this TMDL:

Toxicity (resulting from residential and commercial development). Water chemistry data, sediment chemistry and bioassay data, watershed characteristics, and benthic community data were utilized in the evaluation of toxicity as a cause of impairment. Although toxic impacts are very episodic and difficult to identify, data from benthic mentum deformity tests did not show toxic conditions. Water column samples indicated elevated values for aluminum, iron, and manganese but this is not unusual due to the presence of these metals in local soil types. Sediment metals samples found no values above the hazardous waste site screening values used by the USEPA (NCDWQ 2004a).

Hydromodification – Low Dissolved Oxygen.
Although there are areas with poor habitat (including deep uniform stream channels, little habitat diversity, rip-rap, minimal stream bottom diversity, and very low or no flow velocities), dissolved oxygen levels are not viewed as a primary limiting factor for benthos. The watershed is not impaired for dissolved oxygen.

Organic and nutrient enrichment**.** Benthic community data and water quality monitoring data were utilized to evaluate organic and nutrient enrichment as a potential cause of stress on the biological community. The watershed is not impaired for chlorophyll-*a* or dissolved oxygen. Although it was difficult to distinguish between the impacts of organic and nutrient enrichment, based on algal activity there is some enrichment associated with urbanization such as commercial and residential development, possible leaking sewer lines and the golf course (NCDWQ 2004a). The control of untreated stormwater runoff to this watershed should provide benefits to the aquatic community. The nutrient rules for the Neuse River Basin are applied in the Perry Creek watershed.

The following candidate causes were determined to be significant causes of impairment in Perry Creek:

Hydromodification and associated scour due to storm flows (resulting from development)**.** The Neuse River Basinwide Water Quality Plan (NCDWQ 2009) listed habitat degradation from urban runoff as a potential cause for impairment based on biological data. Available data (benthic macroinvertebrate, habitat and riparian area assessments, stream observations and watershed characteristics) were reviewed to assess stormflow scour as a cause of impairment in the watershed. Scour associated with rapid

and significant increases in stream flow was found to be the most pervasive stressor in the watershed. The stream bank erosion and sedimentation associated with these events contribute to habitat degradation associated with biological impairment. The benthic macroinvertebrate data lacked specific indicator taxa but rather exhibited highly tolerant benthic communities, suggesting considerable impacts from urban/suburban pressures.

Hydromodification (resulting from dams). Impacts from dams include the following:

- Prevention of downstream colonization of aquatic populations
- Lower water levels below dams
- Change in temperature and dissolved oxygen
- Change in food type

Although it is difficult to isolate these impacts from those of lower baseflows associated with urbanization, there is evidence that the lowered water levels below dams are an important stressor to the biological communities in the Perry Creek watershed. For this reason, Perry Creek at Hunters Way will be moved to Category 4c, impairment due to hydromodification. This TMDL does not address this stressor.

Based on a weight of evidence analysis, the two most important factors are scour and hydromodification (dams); the impacts of nutrient enrichment and habitat degradation are more localized. Although toxicity was not viewed as a primary cause of impairment, combined with other causes of impairment, it may contribute to the cumulative effect. All of the stressors and indicator parameters discussed above are associated with the high levels of development in the Perry Creek watershed.

WATER QUALITY TARGET

Extensive national and state level research shows strong correlations between impairment and watershed development. Stormwater runoff from impervious surfaces can carry a complex array of potential pollutants that can impact the aquatic community. Because of the uncertainty in identifying specific pollutants in urbanized stormwater runoff, difficulties arise in quantifying the real target (biological integrity) in a TMDL.

A TMDL must address stressors believed to be contributing to the impairment. Where the major cause of impairment is stormwater runoff, the use of surrogate indicators expressed as quantitative targets is appropriate in TMDL development. Because of stormwater-associated pollutants and the effects on the system's hydrology, these targets are used as surrogates to estimate stormwater pollutant load reductions needed to meet water quality standards.

Research conducted by The Center for Watershed Protection (CWP) indicated that variability in stream quality indicator data is usually dampened when impervious cover (IC) exceeds 10%, which presumably reflects the stronger influence of stormwater runoff on stream quality indicators. In particular, the chance that a stream quality indicator will attain a high quality score is sharply diminished at higher IC levels. This trend becomes pronounced within the 10 to 25% IC range and almost inevitable when watershed IC exceeds 25%. This pattern suggests that IC is a more robust and reliable indicator of overall stream quality beyond the 10% IC threshold (CWP 2003).

According to 'Estimating and Projecting Impervious Cover in the Southeastern United States' (USEPA 2005), degraded benthic community sites are evident as impervious area increases. Specifically, among sites in North Carolina with a total impervious area greater than 10%, 62% were degraded. In contrast, 90% of sites with less than 10% IC were not degraded.

Based on the above findings, the surrogate TMDL target for Perry Creek is 9% IC. This target incorporates a 1% IC margin of safety. North Carolina data in the USEPA study (2005) indicate that 10% of sites with <10% impervious cover could remain degraded. The Perry Creek TMDL target is expected to protect all waters, however, because the measure of TMDL success is based upon water quality standards for benthic macroinvertebrate data and not upon a quantified actual reduction in IC. Specifically, the goal of this target is to achieve a benthic macroinvertebrate community bioclassification of Good-Fair, Not Impaired or better. Achievement of this water quality standard may be met by implementing management practices designed to mitigate the effects of stormwater runoff. Because IC is a surrogate measure, eliminating IC is not necessary in reaching the TMDL target reductions. Measuring the aquatic life (biological community) directly will be the method for assessing attainment of the TMDL goal. "TMDLs may be established using a pollutant-by-pollutant or biomonitoring approach." (40 CFR 130.7(c)(1)(i)) This approach was first used in North Carolina for the Swift Creek TMDL (NCDWQ 2009), approved by USEPA in 2009.

SEASONAL VARIATION AND CRITICAL CONDITIONS

Regulations require that a TMDL be established with consideration of seasonal variations. Stormwater flows occur throughout the year, with different environmental effects at both low and high flows. Critical conditions for aquatic life protection are not limited to flow conditions or time of year. Benefits realized from impervious cover mitigation occur in all seasons because stormwater management will be implemented to meet the IC target and will reduce adverse impacts (pollutant loading and damaging flows) for the full spectrum of storms throughout the year.

MARGIN OF SAFETY

A Margin of Safety (MOS) is required as part of a TMDL in recognition of many uncertainties in the understanding and simulation of water quality in natural systems. For example, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex, natural water bodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection.

A 1% IC Margin of Safety (MOS) was subtracted from the surrogate TMDL target to account for uncertainty in the analysis, resulting in a combined WLA and LA target of 9%. The goal of the TMDL is to reduce impacts from stormwater on the aquatic life in the Perry Creek watershed.

WASTELOAD ALLOCATION (WLA) AND LOAD ALLOCATION (LA)

In the Perry Creek watershed there are no continuous NPDES wastewater discharges, individual industrial stormwater discharges, or permitted animal operations. There are two intermittent NPDES permitted dischargers in the Perry Creek watershed. The City of Raleigh (NCS000245) and the NC Department of Transportation (NCS000250) are regulated under Phase I NPDES Stormwater permits. The WLA portion of this TMDL applies to these Phase I NPDES permits. This TMDL applies to designated and future MS4 permits that are subject to the NPDES program.

Stormwater discharges are highly variable in frequency and duration. It is reasonable to express allocations for NPDES-regulated stormwater discharges from multiple point sources as a single categorical wasteload allocation when data and information are insufficient to assign each source or outfall individual WLAs (EPA Memorandum 2002). This TMDL applies the surrogate 9% IC target to the stormwater drainage area affecting both regulated and non-regulated sources in this watershed.

To calculate the equivalent of % IC reductions required to achieve the TMDL target:

Equivalent of percent IC reduction = [(IC Current Condition – surrogate IC Target)/IC Current Condition)] x 100
where surrogate IC Target = 9%

The equivalent of percent IC reduction (Table 2) was calculated for the Perry Creek TMDL watershed (Figure 1). The equivalent IC reduction is 47% for the TMDL watershed (Table 2). This TMDL watershed was extracted from the USGS 12-digit hydrologic unit (HU) 030202010704 and is approximately eleven square miles in area. The current condition (Table 2) was calculated from analysis of existing percent imperviousness using the National Land Cover Dataset (2001), supplemented by the *Watershed Assessment Model for North Carolina* (Pate 2009). The current condition for the Perry Creek TMDL watershed is 17% impervious.

Table 2. TMDL Targets, Surrogate Targets, and Equivalent Percent Reductions for Perry Creek TMDL Watershed

TMDL Target Bioclassification	Percent Impervious Cover				Equivalent % Reduction *
	TMDL Surrogate Target	WLA and LA	MOS	Current Condition	
Good-Fair or better	10%	9%	1%	17%	47% Equivalent of % IC reduction accomplished by improved stormwater management.

* Equivalent of %IC reduction means actions that mitigate the adverse impacts of stormwater, including but not limited to reducing pollutant loading and reducing the volume of storm runoff. Such actions could include disconnecting IC, installing infiltration basins, eliminating illicit discharges, etc.

Achieving the equivalent %IC reduction will require mitigation of the adverse impacts of stormwater, including but not limited to reducing pollutant loading and reducing the volume of storm runoff. Such actions could include disconnecting IC, installing

infiltration basins, eliminating illicit discharges, etc. The TMDL target bioclassification of Good-Fair or better will be measured at the benthic compliance points (Figure 1).

TMDL IMPLEMENTATION

EPA is not required to, and does not, approve TMDL implementation plans. This section is intended to provide some initial assistance for implementing this TMDL.

This TMDL applies to designated and future MS4 permits that are subject to the NPDES program. The linkage of the TMDL with the NPDES Stormwater Phase I permits will constitute a significant portion of the implementation. The goal of this TMDL is to reduce the effects of stormwater impacts to the receiving streams so that water quality standards for biological integrity are met. Attainment of such a standard is achieved when a benthic macroinvertebrate community sample receives a bioclassification of Not Impaired, Good-Fair or better. Compliance will be measured at the benthic sampling sites at Perry Cr at SR 2006 and UT Perry Cr at SR 3514 (Figure 1).

Implementation for this TMDL will best be accomplished through incorporating an adaptive management strategy for stormwater runoff. Such a strategy should include one or more of the following for new and existing development:

- Installing engineering BMPs to reduce the impacts of stormwater runoff from impervious areas.
- Minimizing additional disturbance to maintain existing natural buffering capacity
- Disconnecting impervious cover from the surface waterbodies to reduce peak flows and volumes of stormwater runoff.
- Reducing impervious cover.
- Adopting land use ordinances that require or allow Low Impact Development (LID) techniques or other non-structural best management practices.
- Detecting and eliminating illicit discharges.
- Developing an educational component and outreach program.

Affected entities may propose alternative measures that meet the intent of the TMDL.

Stormwater impacts include erosion and damage to instream aquatic habitat, a complex mix of pollutant loading, and lack of infiltration to provide stable base flow to streams. When the TMDL is implemented, stressors affecting aquatic life will be reduced or not delivered to the waterbody in the first place.

The waterbodies draining this watershed are located in urbanized areas that are subject to the requirements of North Carolina's NPDES Phase I Stormwater permit. Several efforts for addressing stormwater runoff are currently in place for the City of Raleigh under their permit. The city must develop, implement and enforce a Stormwater Management Plan and ordinances approved by the NC Department of Environment and Natural Resources (NCDENR). The plan includes educational and regulatory initiatives to ensure sound development. Ordinances approved by NCDENR and adopted by Raleigh address requirements for new development, illicit discharges detection and elimination, watershed protection, and sediment and erosion control. The City of Raleigh was issued a NPDES Stormwater Permit, effective June 1, 2007. Under the NPDES permit, stormwater runoff from new development that disturbs greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of

development or sale, must be controlled and treated in accordance with the conditions of the permit and the Stormwater Management Plan. The permit and Stormwater Management Plan mandate:

1. A public education and outreach program on the impacts of stormwater discharges and how to reduce pollutants in stormwater runoff.
2. A public involvement and participation program.
3. A program to detect and eliminate illicit discharges within the jurisdictional area.
4. A program to reduce pollutants in any stormwater runoff from construction activities resulting from a land disturbance of greater than or equal to one acre.
5. A program to address post-construction stormwater runoff from new development that cumulatively disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale; and
6. A pollution prevention/good housekeeping program for municipal operations that addresses operation and maintenance, including a training component, to prevent or reduce pollutant runoff from those operations.

Raleigh and Wake County are subject to the Neuse River Basin –Nutrient Sensitive Waters Management Strategy: Basinwide Stormwater Requirements (15A NCAC 02B.0235).

Since implementation is expected to meet TMDL requirements at the compliance points (Figure 1, benthic macroinvertebrate sampling sites), an ongoing biological monitoring program is critical in assessing the effectiveness of the implementation efforts. DWQ will continue monitoring the biological communities in this watershed to track TMDL implementation and attainment of water quality standards. This will be an iterative process to meet TMDL targets for attaining a bioclassification of Good-Fair or better at the compliance points. This process is recognized as lengthy, possibly spanning multiple permit cycles.

IMPLEMENTATION RESOURCES

Resources are available to assist in the implementation of this TMDL.

The Center for Watershed Protection has produced a series of Urban Subwatershed Restoration Manuals. The manuals provide comprehensive information on watershed restoration techniques by introducing an integrated framework for restoration and techniques for assessing urban watersheds. The manual series can be located here: *http://www.cwp.org/PublicationStore/USRM.htm*

A report prepared for The United States Environmental Protection Agency, *Stormwater TMDL Implementation Support Manual, March 2006 (Project No: 10598-001-500)* shows the impervious cover method used in developing TMDL targets. The report can be located here: http://www.epa.gov/ne/eco/tmdl/assets/pdfs/Stormwater-TMDL-Implementation-Support-Manual.pdf

The *North Carolina Division of Water Quality 2007 Stormwater BMP Manual* provides guidance for meeting stormwater regulations and designing stormwater BMPs that meet water quality objectives. The manual can be located here: *http://h2o.enr.state.nc.us/su/bmp_updates.htm*

The North Carolina State University developed a NC Low Impact Development Technique document. The project documented changes in runoff and pollutant export resulting from the construction of a low impact development residential subdivision. This is located here: *http://www.bae.ncsu.edu/programs/extension/wqg/*.

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Appendix 1. Summary data for all benthos sites in the Perry Creek Watershed, from 1995 to present.

	Perry Cr Hunters Way 5/11/2004	Perry Cr SR 2006 7/25/1995	Perry Cr SR 2006 12/9/1996	Perry Cr SR 2006 7/6/2000	Perry Cr SR 2006 5/10/2004	UT Perry Cr SR 3514 5/10/2004
COMMUNITY						
Ephemeroptera	2	5	6	6	5	6
Plecoptera	0	0	3	0	0	0
Trichoptera	3	3	2	2	4	4
Coleoptera	4	0	0	0	8	4
Odonata	5	0	0	0	7	8
Megaloptera	0	0	0	0	1	1
Diptera: Chironomidae	13	0	0	0	26	31
Misc. Diptera	5	0	0	0	4	4
Oligochaeta	4	0	0	0	3	5
Crustacea	1	0	0	0	2	1
Mollusca	3	0	0	0	2	4
Other	4	0	0	0	1	1
Total Taxa Richness	44	8	11	8	63	70
EPT Richness	5	8	11	8	9	10
Seasonal Corr (- out of season spp)	5	8	8	8	9	10
EPT Abundance	34	30	51	50	67	77
Biotic Index	6.97	-	-	-	6.88	6.92
Seasonal Correction	7.17	-	-	-	7.08	7.12
EPT BI	6.97	5.87	5.57	5.23	6.26	5.84
Bioclassification	Not Rated	Fair	Fair	Fair	Fair	Not Rated
HABITAT						
Stream Width	3	9	5	7	5	4
Average Depth	0.1	0.2	0.2	0.2	0.2	0.2
Flow/ Current	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Bank Height	1.5				1.5	0.5
Bank Angle (º)	60				90	90
Bank Erosion	None	Severe	Severe	Moderate	Moderate	None
Canopy (%)	98	90	50	80	70	90
Canopy Type	Deciduous	Deciduous	Deciduous	Deciduous	Deciduous	Deciduous
Aufwuchs	None	None-Moderate	Moderate	Abundant	None	None
Pedostemum	None	None	None	None	None	None
Tribs Present?	No	No	No	No	Yes	No
Substrate (%)						
Boulder	20	0	0	0	0	0
Rubble	30	0	0	0	0	0
Gravel	30	10	35	20	0	10
Sand	20	80	60	80	70	90
Silt	0	10	5	0	30	0
Other	0	0	0	0	0	0
Habitat Score	71	60	70	56	54	56
CHEMISTRY						
Temp ºC	22	27	6	25	22	21.2
DO mg/l	6.3	6.9	--	8.2	7.1	7.7
Cond µS/cm	116	110	66	150	148	115
pH	6.7	7	--	7.2	6.6	6.7
LOCATION/ GENERAL						
Basin (subbasin)	Neuse 02	Neuse 02	Neuse 02	Neuse 02	Neuse 02	Neuse 02
County	Wake	Wake	Wake	Wake	Wake	Wake
Latitude	355230	355250	355250	355250	355247	355249
Longitude	783556	783250	783250	783250	783253	783309
Collection Card	9376	6887	7232	8141	9375	9374
Sample Type	Full Scale	EPT	EPT	EPT	Full Scale	Full Scale
Drainage Area (approx sq mi)	3.5	9.5	9.5	9.5	9.5	2

Shaded columns denote samples collected for the 2004 Stressor Study.

ATTACHMENT A

Public Notice

A public notice was posted to the DWQ TMDL website and notice was sent to a mailing list of interested parties.

Notice was also posted in the Raleigh NC News and Observer newspaper. The Affidavit of Publication is provided below.

ATTACHMENT B

Public Comment

The public comment period extended from October 24, 2009 through November 27, 2009. Comments were received from four entities:

City of Raleigh
Wake County
City of Charlotte
NC Department of Transportation

These comments with NC Division of Water Quality responses are provided in the Responsiveness Summary (below).

Meetings

In addition, the following meetings were held with the affected MS4s:

- City of Raleigh on September 22, 2009
- NC Department of Transportation on October 5, 2009

Another meeting was held with an interested party:

- Wake County on October 30, 2009

One commenter suggested that other surrogate measures be used to draft a TMDL for addressing biological integrity. The Center for Watershed Protection study does not indicate that mitigating high IC levels enough to create a net IC level of approximately 10% will necessarily return high stream quality indicator scores.
Response: There are several citations in the Federal Regulations that support the use of surrogate measures for TMDL Development. For example, 40 CFR §130.2-(i) states that "TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure." In addition 40 CFR §130.7 (c)(1)(i) "states that TMDLs may be established using a pollutant-by-pollutant or biomonitoring approach." We would be willing to consider other targets, surrogate targets and non-TMDL approaches for impaired biological integrity streams in Charlotte. The commenter did not suggest an alternative surrogate.

One commenter suggested that local data be collected to determine conditions that result in high stream quality indicator scores which lead to a more appropriate surrogate.
Response: The TMDL is not so prescriptive to limit local government's collection of additional data to develop the most effective management strategy. The goal of this TMDL is to achieve a bioclassification of Good-Fair or better, not necessarily to achieve the surrogate target. Percent impervious cover serves as a surrogate measure of the complex mixture of pollutants transported by stormwater. Since the impairment cannot be attributed to a specific pollutant, impervious cover (IC) was used as a surrogate measure of the complex array of stressors associated with stormwater that impact aquatic life. We would be willing to consider other targets, surrogate targets and non-TMDL approaches.

One commenter stated that using a 9% IC target is inconsistent with minimum Post-Construction Controls Ordinance (PCCO) rules. The State's minimum PCCO regulations require controls when IC meets 24%. Although not part of the TMDL, and if an IC surrogate is ultimately used, we recommend that this discrepancy be addressed to avoid the resulting burden that will be placed on regulated municipalities to make up the difference through TMDL implementation.
Response: The PCCO Rules were not aimed at restoring impaired biological integrity and do not address existing development. Local governments have the option of adopting more restrictive ordinances.

One commenter stated that to address degraded habitat and scour, stream bank restoration is a necessary precursor to begin biological restoration and will address other related impairments such as turbidity. Therefore, we believe that stream stabilization and restoration, not IC removal, is a more appropriate first step and a partial (and likely significant) success toward biological recovery.

Response: The TMDL is not requiring IC removal nor does it propose to be the only solution in restoring the biological community. In addition, stabilization and restoration without mitigation of stormwater impacts would not provide a permanent solution. We recognize that any approach at water quality improvement that requires management changes in existing areas creates implementation challenges. That is why the TMDL document notes the need for an iterative process that may take a long period of time for implementation. The Division's approach in this process will be to allow entities to develop a recovery plan that is effective and that is also reasonable. Over time we anticipate that management alternatives in these areas will increase/improve and we anticipate that implementing agencies will effectively adapt their management strategies to utilize the most effective approaches. While the TMDL confers no additional authority to local entities for implementation, we do feel that there are authorities available that allow local entities to select and prioritize stormwater management practices today that can begin this process. This could include identifying public lands for stormwater controls, looking at stormwater provisions for redevelopment or utilizing innovative approaches to reuse or otherwise reduce stormwater runoff.

One commenter stated that on page 6, the TMDL watershed area is reported to be 11 square miles (or 306,662,400 square feet). Our understanding of the TMDL is that if the impervious cover in the watershed is reduced to 306,662,240 square feet or less, then water quality standards will be achieved as measured by a Not Impaired, Good-Fair or better benthic macroinvertebrate bioclassification. It is our further understanding that the maximum allowable impervious cover in the watershed allocated to point and nonpoint sources (WLA+LA) is equal to 27,599,616 square feet (9% of 306,662,400 s.f.) Is our understanding of the draft Perry Creek TMDL correct and are our calculations correct? If not, please provide clarification and corrections to our calculations.
Response: The current imperious cover is 17% and the mitigation is aimed at achieving the equivalent of 9% through stormwater management.

One commenter suggested that more specific stressors be identified.
Response: There is a list of stressors in the TMDL since the impairment cannot be attributed to a specific pollutant, impervious cover (IC) was used as a surrogate measure of the complex array of stressors associated with stormwater. The TMDL report does contain site-specific information referenced from two stressor studies conducted by DWQ in 2004.

One commenter stated that more research is needed to determine a proven, definitive course of action that will restore the biological integrity of streams in North Carolina prior to TMDL implementation.
Response: The implementation plan is not a required component of the TMDL. The TMDL language and permitting approach attempt to recognize that there may be multiple ways for entities to meet the intent of the TMDL, not just one single approach. Through the development of your plan in your stormwater permit, you will have the opportunity to work with the Division to target the most appropriate approach for your jurisdictional area.

Two commenters stated that it is not clear from the draft report which MS4 permittees have been assigned a WLA?
Response: The WLA portion of the TMDL applies to the Phase I NPDES stormwater permits. EPA recommends expressing the wasteload allocation in the TMDL as either a single number for all NPDES-regulated storm water discharges, or when information allows, as different WLAs for different identifiable categories. In this case, information was not available to establish separate WLA numbers.

One commenter stated that Wake County has no land use regulatory authority in the Perry Creek watershed, the TMDL is not applicable to Wake County. It is requested that all references to unincorporated Wake County be removed from the TMDL.
Response: A TMDL must include a load allocation for all nonpoint sources. Not all of this TMDL watershed is covered by a NPDES permit.

Two commenter asked if future permit applications for new construction will be denied by DWQ if a proposed project increases impervious cover in the watershed? If the answer is No, then what requirements related to this TMDL will be a condition of permit application approval for future construction projects in the watershed that add new impervious cover?
Response: The DWQ Stormwater Permitting Unit will work with permitees to access the need for any potential modifications or clarifications in the permit language.

One commenter asked if in the future, will either DWQ or EPA a 9% impervious cover limitation in the Perry Creek watershed?
Response: The goal of the TMDL is to mitigate for the effects of stormwater runoff through stormwater management, not documenting the current or future extent of impervious cover. The studies done in this particular watershed clearly indicate that stormwater runoff from impervious areas is having an adverse impact on the biological community.

One comment stated that NCDOT-owned impervious cover in this watershed is approximately 3.2%. Assuming the accuracy of this figure, is NCDOT currently in compliance with the draft TMDL? At what percent impervious cover would NCDOT be out of compliance with the draft TMDL?
Response: It is not clear what the 3.2% refers to from the commenter. All MS4 permits include a requirement to implement an approved TMDL and strongly encourage adjoining jurisdictions to work together in this process. We also realize that individual entities will be interested in their specific compliance and the Division anticipates that for each permitee adherence to their final recovery plan will establish their compliance.

One commenter stated that under the "SUMMARY" heading (pg 3) - the document summary specifies hydromodification (impoundments), nutrient and organic loading, and low DO as primary stressors. In order to avoid distraction from the primary focus of stormwater (and the surrogate IC) as the stressor, I would suggest removing the nutrient and organic loading from the summary.
Response: The text has been changed for clarification.

One commenter requests that the classification of impairment and application of the TMDL be limited to the lower portion of the watershed from US 1 to the Neuse until additional sampling establishes an accurate and objective assessment of the remainder of the watershed.
Response: Percent impervious cover appears to be uniform across this watershed regardless of the type of development. The DWQ study indicated strong pressures from suburban and urban development. In implementing the TMDL and developing the Water Quality Recovery Program through the NPDES Stormwater permit local governments t will be able to target the areas they believe will result in meeting the narrative water quality standard of a Good-Fair bioclassification.

One commenter stated that under the "WATERSHED DESCRIPTION" heading (pg 6) - reference is made to the Perry Creek watershed (study area) which appears to be an 11 square mile subset of the entire 31.6 square mile watershed. Does the TMDL apply to the entire Perry Creek watershed or just the "study area"?
Response: The TMDL applies to the entire 11 square mile watershed. The text has been revised for clarification.

One commenter stated that under the "POLLUTANT SOURCE ASSESMENT" heading (pg 8) - in the 5th paragraph the document indicates low DO may be a stressor due to nutrient enrichment and algal activity. Since there is no evidence presented to support this hypothesis and local staff have traditionally not found low DO to be a problem in urban streams, we would request that this assumption be removed.
Response: The text has been clarified.

One commenter stated that the document fails to discuss Load Allocation (LA) for those portions of the watershed not subject to NPDES permits such as discharges to waters of the state from systems not owned or operated by an NPDES permit holder (direct discharges from private land into waters of the state) which qualify as non-point sources.
Response: This TMDL includes a Load Allocation of 9% impervious cover.