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SECTION 8.00
STORMWATER DESIGN

8.01 GENERAL

This section outlines the design and construction requirements to obtain plan approvals associated with stormwater management which includes NPDES Phase II Post-Construction Management, Floodplain Development and general stormwater conveyance principals. Due to the location and nature of stormwater management it is the developer's responsibility to ensure that the project is in compliance with all applicable Federal, State and Town regulations when impacting streams, wetlands, riparian buffers, floodplain and creating impoundments. Consideration of avoiding and minimizing impacts should be taken into account with the entire project's design. However, when impacts to such features are unavoidable appropriate permitting shall be required prior to issuance of the Environmental Development Permit and a draft Preconstruction Notification Form to be included in the preliminary stormwater plan submittal which shall include all temporary and permanent impacts required for construction at each specific location.

8.02 STORMWATER PERMIT PROCESS

There are three general stages for stormwater projects: the Concept Stage, Construction Stage and Post-Construction Stage. Each has been outlined and summarized in this section. Subsequent chapters of Section 8 of this manual outline specific design and submittal requirements specific to each stage of the project's development.

A <u>Concept Stage</u>

The Concept Stage is the review process for the following plan review types outlined in the Unified Development Ordinance (UDO), (Major Residential Subdivision Plan, Master Plan, Special Exception Use, Development Plan or Planned Unit Development (PUD) Master Plan), hereafter referred to as "Preliminary Plan". The Town's stormwater staff will review preliminary engineering early in the development process in order to assist the developer with proper planning in accordance with stormwater management requirements. As a part of this review, Town staff will provide comments to the developer. Additional developer guidance may be needed between this stage and the first Construction Drawing submittal to finalize conditions of preliminary plan approval.

Scoping and Concept Plan Review meeting will be held first with staff to discuss the items to be included in the first preliminary plan submittal package. The Scoping Meeting is an optional meeting that is recommended for applicants to attend prior to the required Concept Plan Review Meeting to discuss submittals and general project information. Applicants shall bring a sketch plan and a Natural Resource Inventory,

(NRI) with supporting documentation to the Concept Plan Review Meeting to determine stormwater, floodplain and other environmental regulations that the project will be subject to.

The preliminary stormwater plan submittal minimally includes preliminary documents to determine the existing environmental features in the project limits, proposed impacts to the environmental features, and permits from outside agencies required prior to the first Construction Drawing Submittal. It will also identify the general location, size and type of stormwater conveyances and Stormwater Control Measures (SCMs) required to meet stormwater quality, quantity and infrastructure regulations. For projects where it has been determined that a new or updated flood study will be required, projects shall determine flood limits by performing preliminary analysis outlined in Section 8.07 of this document.

B Construction Stage

The Construction Stage consists of Construction Drawing, Stormwater and Environmental Plan Review, plan approval, permitting and actual construction. This is the step in the review process where the preliminary stormwater plans are enhanced as needed for constructability and demonstration of compliance with all applicable TOHS design requirements. The developer must also incorporate any approval stipulations included as part of the Preliminary Plan approval.

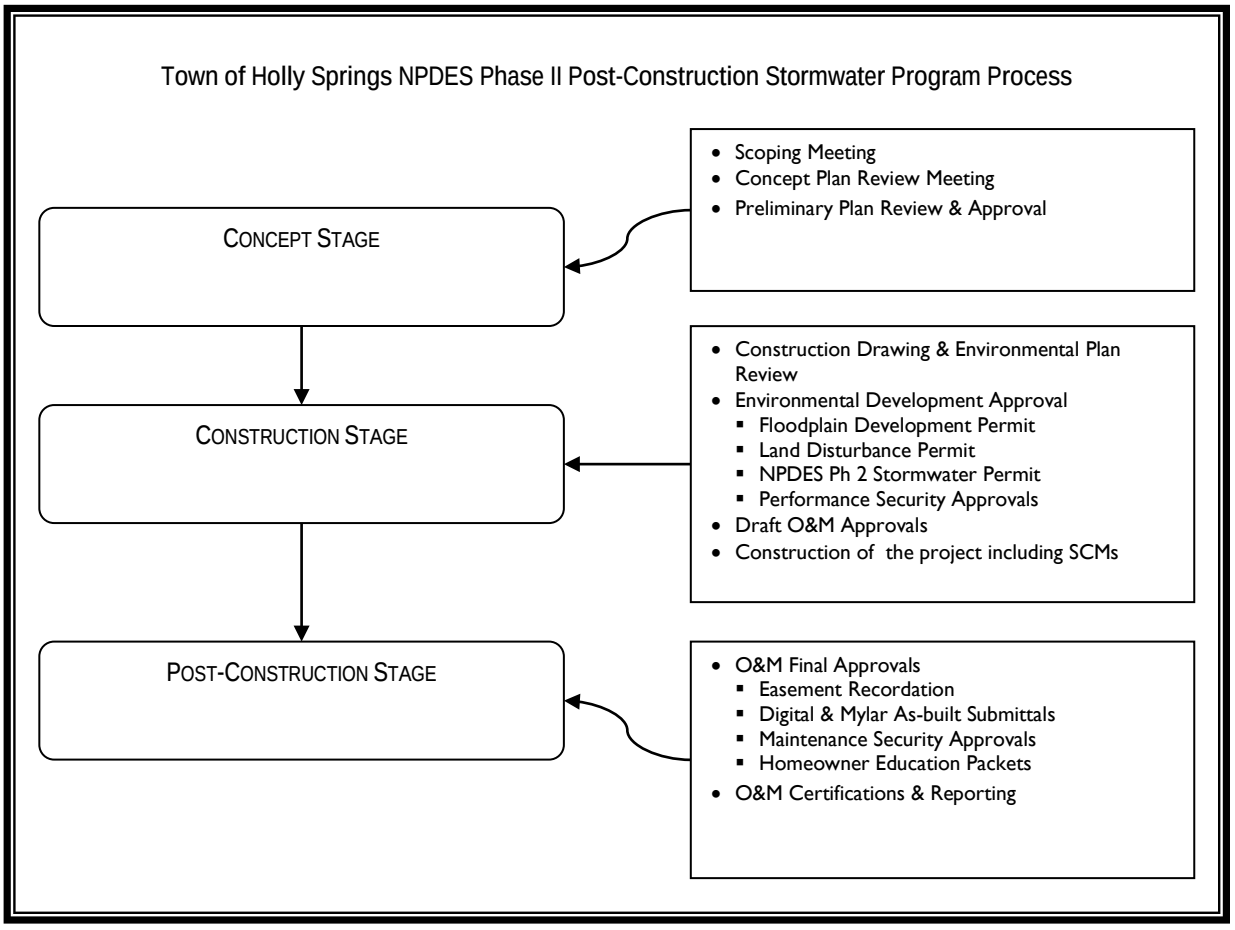
As part of the Construction Stage process, it is advisable to contact the TOHS Engineering Department prior to submittal to determine if a pre-submittal meeting may be appropriate. After submittal, TOHS staff will review the submittal package for compliance with the Holly Springs Engineering Design and Construction Standards and other Town policies, ordinances, checklists, and standards. Submittal requirements are outlined in Section 8.04 of this document and will minimally include applicable 401/404 permits, stormwater infrastructure plan, grading and erosion control sheets, the Stormwater Management Report and calculations, flood study and draft Post-Construction Stage documents.

Once all of the environmental plan review requirements have been met, an Environmental Development Permit will be issued for the project which will include the applicable approvals: NPDES Phase II Stormwater Permit, Floodplain Development Permit and Land Disturbance Permit (erosion control plan approval). This permit will be issued at the preconstruction meeting upon receipt of six sets of Construction Drawings, final stormwater management and flood study reports and payment of development fees for the project, the storm drainage infrastructure can be installed once the permit and the Certificate of Compliance for installation of Erosion Control Measures has been issued. SCMs that are planned in the same location as the erosion control measures must be installed once the Projects Development Inspector has approved the removal of the temporary erosion control devices.

C Post-Construction Stage

The Post-Construction Stage begins once all permits have been acquired and construction activities have commenced. This stage has two main components, acceptance of infrastructure and long term operation and maintenance. The acceptance requirements of the Post-Construction Stage are related to verification that the project has been constructed in substantial accordance with the approved plans and specifications and that all appropriate easements and financial securities have been secured. The long term operation and maintenance portion of this stage will consist of the property owner's implementation of the project's recorded Operations and Maintenance (O&M) Agreement and Town's enforcement of its ordnance. Section 8.03 of this document outlines specific requirements for all stages of the project's development. Chart 8.02a outline this process.

Chart 8.02a Post-Construction Stormwater Process



8.03 POST-CONSTRUCTION STORMWATER MANAGEMENT

A. Introduction

Development can dramatically alter the hydrologic response of an area and, ultimately, an entire watershed. As the TOHS continues to develop, the impervious surfaces that are created will increase the proportion rainfall that is runoff during rain events, disrupting the natural hydrologic cycle. Without controls in place, the increased runoff can erode stream channels, increase pollutant loadings, cause flooding, and prevent groundwater recharge. The contaminants involved in urban stormwater runoff are primarily sediment, nutrients, and to a lesser extent, toxics, such as heavy metals and hydrocarbons. Protecting waters is vital for a number of reasons, including the protection of fish and wildlife habitat, human health, recreation, and drinking water supplies.

Stormwater Control Measures (SCMs) andBest Management Practices, (BMPs), are structural and nonstructural practices, or a combination of practices, designed to act as effective, practicable means of minimizing the impacts of development on surface water quality and quantity. SCMs operate by trapping stormwater runoff and detaining it until unwanted nutrients, sediment, and other harmful pollutants are allowed to settle out or be filtered. These trapped pollutants must be managed or disposed of through periodic maintenance as prescribed in this manual.

B. Purpose

The purpose of this manual is to establish minimum standards for the design and implementation of measures to prevent and control peak stormwater runoff rates, stormwater volume, erosion, sedimentation and other forms of stormwater pollution. This section of the TOHS Engineering Design and Construction Standards is intended to assist developers, engineers, contractors, inspectors and property owners in the selection of SCMs for the design of new or existing facilities to improve the environmental quality of stormwater and attenuate increases in the rate of stormwater runoff resulting from new development.

The most current NCDEQ Minimum Design Criteria (MDC) shall be used for design standards and specifications for post-construction SCMs that will meet the water quality objectives required by the Town of Holly Springs NPDES Phase II Stormwater Permit and Chapter 8, Article VI Post-Construction Stormwater of the Holly Springs NC Town Code of Ordinance.

The Engineering Department reserves the right to accept or reject designs (whole or in part) from the NCDENR Manual, based on policy, site conditions or other factors deemed appropriate by the Town. This document shall supplement the NCDENR manual where additional information is required for a project to comply with the Town regulations.

C. Regulations

The TOHS, like many towns and cities across the United States, is required by the Clean Water Act to have a National Pollutant Discharge Elimination System (NPDES) permit to discharge stormwater from the municipal separate storm sewer system (MS4). Because development activity may significantly increase the discharge of pollutants, the NPDES permit requires that the Town encourage, promote and require implementation of certain practices and procedures for the purpose of reducing or limiting discharge to stormwater channels.

To achieve this goal, the Town has implemented a Stormwater Ordinance which requires SCM installation, inspection and maintenance as part of land development activities. Development of this Design Manual is also required by the Town's NPDES Phase II Stormwater Permit NCS000495 effective December 1, 2005.

This section of the TOHS Engineering Design and Construction Standards also addresses State mandates for watershed management in the Neuse and Cape Fear River basins.

When alternative standards are shown to conform to applicable policies and regulations, the Town may accept such alternative standards in lieu of the standards herein. Similarly, where a particular site is characterized by substantial impediments to development in compliance with existing policies and standards, or where technological changes provide for practices and techniques that better ensure compliance, the Town itself may modify or substitute additional standards for the design standards contained herein.

D. Applicability

Development and re-development within the TOHS Planning Jurisdiction, Town Limits and Extraterritorial Jurisdiction (ETJ), must manage stormwater in accordance with the Town of Holly Springs Phase II Post-Construction Stormwater Ordinance, (November 6, 2007), hereafter referred to as "Ordinance".

The Ordinance requires that development and re-development activities properly manage and control stormwater runoff rate, volume, and pollutants as necessary to protect and safeguard the environment, property, health, safety and welfare of citizens within the Town's jurisdiction. This section of the TOHS Engineering Design and Construction Standards provides information on the design and application of acceptable SCMs to comply with the requirements of the Ordinance. Post-construction stormwater management is part of the Preliminary, Construction Drawing and Environmental Review Process' which is outlined in various sections of the TOHS Development Procedures Manual (DPM).

Acceptable stormwater management practices include those found in this Design Manual, the UDO and in the DPM. Additionally, methods described in the latest version of the NCDENR Stormwater Best Management Practices Manual. (Considerations for selecting and using stormwater management SCMs for a specific development will include, but are not limited to: site applicability, public safety,

spatial requirements, soil characteristics, hydrologic benefits, slope, existing land use conditions, maintenance requirements, location within the watershed, overlay districts, buffer requirements, tree protection, and easements. In addition to the items listed above, it is the Town's goal to make stormwater features amenities for projects and assets to the overall aesthetics of the development project and the Town.

As a part of the development permit application process, conceptual methods, calculations, and designs must be presented to the Engineering Department at the concept plan, construction drawing review, and post construction review stages of the permitting process for comprehensive review, evaluation, optimization and approval. Revisions to the preliminary plan may be necessary to obtain Town Construction Drawing and Environmental Plan approvals.

In addition to standard Holly Springs' submittal requirements, there are specific development permit application requirements for stormwater features outlined in Section 8.04 of this manual.

E. Structural & Non-structural Best Management Practices

1. Performance Standards

a. Peak Discharge: There shall be no increase in stormwater runoff peak discharge rate leaving the project site between the pre- and post- development conditions for, at a minimum, the 1-Year, 24-Hour Storm (2.83 inches). Runoff volume drawdown time shall be a minimum of twenty-four (24) hours, but not more than one hundred and twenty (120) hours.

b. Total Nitrogen: The total nitrogen (TN) export limitations, per the Neuse Basin Rules, 15A NCAC 2B.0233, will be required throughout the Town and extra territorial jurisdiction. The Town Council shall establish Fee in Lieu and may amend and update the fees and policies from time to time. Fee costs and policies will be outlined in Section 8.03 of this Design Manual.

c. 85% Average Annual TSS: A minimum of 85% average annual removal for Total Suspended Solids *(note: for most SCMs this will be based on the 1 inch run off volume, some specific SCMs may be based on alternative design criteria. On occasion NCDENR BMP Stormwater Manual will require 90% TSS removal.)*

d. General: General engineering design criteria for all projects shall be in accordance with 15A NCAC 2H .1008c, as explained in the Design Manual;

e. Stream Setback: All Built-Upon Area shall be at a minimum of 30-feet landward of all perennial and intermittent surface waters, as described in Section 7.06 of the UDO. "Where applicable, stormwater management facilities may be located within the outer 50' of the TOHS riparian buffer but are not permitted within the Neuse Riparian Buffers unless specifically approved in writing by the TOHS Director of Engineering or designee. SCMs outfalls are permitted in riparian buffers as consistent with NCDENR policies

and 401 approvals." Additionally, Section 8.03 of this manual outlines the TOHS Restored Riparian Buffer requirements for removed ponds.

The above performance standards shall apply to all projects within the TOHS jurisdiction. Note that the Town's Stormwater Ordinance is a performance based ordinance and does not specifically limit the amount of impervious cover or utilize high or low density development thresholds to control development intensity. Instead, all pertinent development must meet the above standards as applicable. Note that additional stormwater reviews, permitting, and impervious area limitations may be required by NCDENR for projects requiring 401/404 and riparian buffer approvals.

Each phase of development shall be designed to meet the performance standards upfront to eliminate the need for retrofitting. These performance standards apply to the parent parcel of the development at the time of the first phase of development for any new development project. The overall development must remain in full compliance with the stormwater performance standards with each phase. In special cases, the Director of Engineering may allow proposed development that will disturb only a small fraction of a larger parcel to phase the project with the understanding that all of the standards must still be met as the project is developed. For example, the first phase of development may include a limited amount of impervious cover. That first phase of development may not require TN treatment or buy-down at the time it is constructed but would likely require SCMs to address other stormwater performance standards such as TSS removal and peak flow attenuation. Further development of the parent tract will require that the first phase development be reconsidered for all performance criteria. In the event that nitrogen export thresholds for the overall parent parcel are exceeded, the first phase of development would be factored into the analysis. This may mean that the existing first phase of development would need to be retrofitted with nitrogen reduction measures or that the new development needs to remove additional nitrogen to compensate for a lack of nitrogen reduction in the first phase of development.

Some development sites may have impervious cover that was in-place prior to the enactment of the Ordinance. In such situations, this impervious cover may be considered on the pre-development side of the peak stormwater runoff calculations. Also, this impervious cover or an equivalent impervious area is exempt from 85% TSS removal and nitrogen removal requirements. However, in many cases, it may be more difficult and costly to by-pass this impervious cover around proposed SCMs. This is particularly true when the existing impervious cover is small relative to the impervious area associated proposed conditions.

Built-upon area shall be considered the portion of a development project that is covered by impervious or partially impervious coverage including buildings, pavement, gravel roads and parking areas, recreational facilities (e.g. tennis courts), etc. (Note: Wooden slatted decks and the water area of a swimming pool are considered pervious.) The design engineer shall use conservative assumptions when creating a stormwater management plan, allowing some consideration for

future individual lot or home improvement projects, such as a home addition or additional parking areas. In addition, the assumptions that were used during the design process should be incorporated and explained in the Homeowner Education Packet, in order to provide clear guidance for homeowners and homeowner associations with regarding to increasing impervious surface on the development site in association with post-development individual home improvement projects.

2. Stormwater Control Measures (SCMs)

SCMs should be designed according to the latest version of NCDEQ Minimum Design Criteria (MDC). Additional design requirements may be necessary for SCMs that are utilized as detention basins for flood control.

Because they are permanent features, choosing the correct SCMor group of SCMs for a site is an important decision that should be thoroughly and carefully considered at the outset. Because every site is unique and has its own challenges, there is no one SCM solution that is best suited for every site. When selecting a SCM for a site:

- Understand which SCMs will work within the physical constraints of the site,
- Evaluate how the possible SCMs address the regulatory requirements relevant to the site, including pollutant removal and water quantity control, and
- Consider other factors such as construction costs, maintenance and access, ownership issues, safety, aesthetic, and environmental factors at the site.

a. General Design, Operations, and Maintenance Requirements: Certain general design, operation, and maintenance requirements apply to all SCMs in the TOHS:

- Sizing shall take into account all runoff at ultimate build-out including off-site drainage that is not diverted.
- Pretreatment, or the removal of sediment or other suspended solids through velocity dissipating devices such as check-dams, forebays, sumps, vegetation, etc. is required for all SCMs.
- All structural SCMs shall be designed to be aesthetically pleasing (to the extent the SCM type allows, and defined by compliance with the UDO) and not include fencing (i.e. chain link or privacy) unless approved by the Engineering Department and under special circumstances where the public health and safety is a reasonable concern. All fences must meet UDO design requirements applicable for the specific project.
- All SCMs must be designed with an emergency bypass or overflow system, where applicable.
- All SCMs shall be located in a recorded drainage easement with a recorded access easement to a public right-of-way.

- Adequate access to the entire SCM structure is mandatory and must be provided for maintenance, access to forebay and outlet.
- All SCMs shall have an Operations and Maintenance Agreement signed by the responsible party or owner and recorded with the deed.
- Infiltration SCMs shall be designed and constructed with smooth walled perforated underdrains, unless the in-situ soils meet the required permeability standards. All underdrain systems shall have clean-outs.
- All underdrains installed for dewatering of SCMs will be smooth walled pipe. No sock pipe will be allowed for use as an underdrain,
- Infiltration SCMs shall be designed and constructed with soils (existing or engineered) that meet the specifications for texture and permeability, testing and certifications of the soils used in the construction of the SCM shall be submitted to the TOHS with the Engineer's Certification of the SCM installation.
- All SCMs shall be certified by a registered PE for SCM installation. SCMs that will be used as an erosion control device during construction shall be certified twice: 1.) to verify that the volume and surface area has been established and the outlet has been constructed in accordance with the approved plan. 2.) at the time of the final construction of the SCM. Mylar and digital as-builts and soil certifications shall be provided at the time of final construction with the PE certification.
- Due to the soils in the Triassic Basin SCM design may be subject to additional engineering requirements and/or may not be permitted for use in the Triassic Basin.
- Infiltration SCM construction shall avoid the use of heavy equipment on the bottom of the basin, or any areas of the SCM where infiltration is a design component.
- The entire system must be designed to safely pass the 10-year storm event without causing scour, rills, gulleys or other reasonably expected failure, unless otherwise indicated in the design manual or ordinance.
- Parking lots without curb and gutter that are designed to directly drain into a SCM must provide flat curb and gutter and a gravel verge at the edge of the parking lot to ensure sheet flow into the SCM. Flat curb and gutter shall be designed in accordance with section 3.02 of this document.
- Drought tolerant species of vegetation and warm weather grasses should be use on the SCMs.
- Trees/woody vegetation shall <u>not</u> be planted on the SCM dam, planting of trees/woody vegetation is allowable around other perimeter slopes of the SCM.
- Reference the most recent NCDENR BMP Manual and N.C. State University Cooperative Extension Office for further design considerations, specifically SCM plantings.
- Sand Filters must be designed as a "Closed-Basin" as described in the NCDENR BMP Manual.
- Both barrel and riser structure shall be concrete and the riser shall be located in or near the embankment.

- On-site disposal areas capable of receiving sediment from at least two clean-out cycles shall be reserved in adjacent open space if area is available. In the event that area is not available sediment must be taken to an approved off site location. Method and location of sediment removed from SCMs shall be outlined in the O&M document for the project.
- A one-time application of fertilizer shall be allowed for new construction to establish vegetation for the purpose of stabilization with regard to erosion control or establishment of plantings associated with Structural SCMs. Soil testing may be required for proper application rates of fertilizer for vegetation establishment. Fertilization f existing lawns should be preceded by soil testing and recommended application rates should be followed. Any Person(s) that is found to be over-fertilizing may be subject to penalty in accordance with the Illicit Discharge Detection and Elimination Ordinance.
- Cross sections of all SCMs will be required on Construction Drawings.
- Road widening associated with a development project will be considered Built upon Area (BUA) for the project.
- One foot minimum freeboard required from the top of riser to bottom of spillway.
- Aquatic shelf shall be at least 50% submerged at normal pool elevation.
- Stormwater wet pond shall utilize clay liner or documentation must be provided that SHWT intersects water level at normal pool.

1. Best Management Practices (BMPs)

Best Management Practices are passive or programmatic and tend to be source control or pollution prevention policies and programs that reduce pollution in runoff by reducing the opportunity for the stormwater runoff to be exposed to the pollutants. BMPs usually work by changing behavior through government regulation (e.g., planning and ordinances), and/or economic instruments (density, etc.). BMPs also include institutional, educational or pollution prevention practices.

a. Incentives: The TOHS has no existing non-structural incentives or credits, but this policy may change with future water quality practices.

b. Signage: The TOHS requires signage at development sites as a part of meeting the NPDES Phase II Public Education program requirement. Per the Stormwater Ordinance. All signs must meet UDO requirements for signage.

SCMs shall be posted with a conspicuous sign stating who is responsible for required maintenance and annual inspection and the SCMs purpose. The sign shall be maintained so as to remain visible and legible.

c. Homeowner Education Packets All residential developments must provide a Homeowner Education Packet to be distributed to each property owner

educating them on the environmental features, protection/ conservation measures and development regulations associated with their development; this may include but is not limited to floodplain, riparian buffers, streams, wetlands and land disturbance. The homeowner education packet should include language informing the homeowners of through the neighborhood development requirements may restrict impervious surface through the improvements to their property, proper disposal of pet waste, proper disposal of yard waste, including grass clippings and proper fertilization applications and soil testing.

d. Public Education and Participation: Public education can address a multitude of pollutant sources by raising the general level of understanding of how individual actions can contaminate surface runoff and downstream water bodies. Public education may be targeted at specific stakeholders, the general public, and/or TOHS Staff. Public education efforts can include conducting workshops, open houses, surveys, signage, and curb inlet markings ("dump no waste, drains to waterway"), and other means of educating and including the public in providing input into, participating in, and commenting on stormwater management efforts. This may be accomplished by distributing educational materials to the community, installing signage at SCM facilities, or by conducting equivalent outreach activities about the impacts of stormwater discharges on water bodies and the steps the public can take to reduce pollutants in urban stormwater runoff. All storm drain hoods and lids must have "dump no waste, drains to waterway" or similar language cast into each structure. Existing storm drain structures that are within the project limits shall be marked consistent with the Town's storm drain marker program and standard detail.

2. Stormwater Fee-In-Lieu Option

a. Purpose & Goal: The purpose of the TOHS Stormwater Fee-In-Lieu is to provide the development community with additional tools to meet the Town's nutrient offset requirements in both the Neuse and Cape Fear River Basins in a consistent and streamlined approach. Paying fees to offset nutrient requirements is a normal practice in jurisdictions where Nutrient Sensitive Water (NSW) Management Regulations are required (i.e. the Neuse Stormwater Regulations.) These nutrient offset payments are typically made to the North Carolina Ecosystem Enhancement Program (EEP). The Town has coordinated with the NC DWR and the EEP to set up its own Stormwater Fee-In-Lieu program to provide a nutrient offset program for development projects within the Town's jurisdiction. Payment to the Town's Stormwater Fee-in-lieu program will be required for all development projects that have requested and have been approved to use the stormwater fee-in-lieu to meet the Town's performance standards for nutrient reduction. Projects that are required to meet both the Town's performance standards and NC DWQ 401 Stormwater requirements may be required to make a payment to the EEP

rather than payment to the Town, this will be determined during on a case-by-case basis during the project's plan review and stormwater requesting process.

To meet this goal, the Town accepts payments of a Stormwater Fee-In-Lieu according to the approved Stormwater Fee-In-Lieu request with the development projects approved Stormwater Management Plan. The payment carries out Stormwater Management Projects within the Town to provide for mitigation on behalf of the projects that pay into the Fee-In-Lieu program. By providing the Fee-In-Lieu program the Town is able to implement both small and large-scale watershed projects that will enhance the water quality of the Town's watersheds and will predominantly focus on nutrient reduction. The Town will identify and implement Stormwater projects on an annual basis through the Capital Improvement Project (CIP) process. These projects will be selected and designed for construction, maintenance and conservation.

b. Administration: The TOHS Stormwater Fee-In-Lieu is administered by the Department of Engineering and is implemented by staff that approves the Stormwater Management Plans and the NPDES Phase II Stormwater Program within the Town limits and ETJ. It is a voluntary program that was established by the Town to give developers who needed mitigation an option of paying a specified fee, or "buying down" their nutrient requirements where their project's Stormwater Control Measures (SCMs) have been not met a portion of the nutrient removal requirements for the proposed project.

c. Stormwater Project Process: With fees collected and accumulated from Holly Springs permitted development projects permitted by the TOHS the Town can design and construct both SCMsl and BMPs that could include but is not limited to construction of a specific SCM like a constructed wetlands or a riparian buffer restoration project. It can also provide maintenance to stormwater structures; provide watershed planning, education and participation projects to benefit the overall water quality of the Town's watersheds with a goal of restoring and maintaining ecosystem functions such as water quality and habitat throughout the Town. The Town will report annually and as requested by the N.C. Division of Water Quality on the status of the program including fees collected on future and proposed projects. Payments made to Town are based on a fee schedule approved by the Holly Springs Town Council. Developers have two mitigation options available to comply with nutrient-reduction requirements:

1. Load reductions eligible for Stormwater Fee-in-lieu credit shall not including reductions used to satisfy other requirements under the same nutrient strategy.

2. Construct an adequately sized on-site device or series of devices, often called SCMs. Examples of SCMs include retention ponds and stormwater wetlands.

3. Purchase approved reduction credits from the TOHS or other approved entity. The developer may opt to pay a fee to the Town based on the amount of nitrogen needing to be offset over the 30-year period for all or a portion of their project.

   Before a developer can receive final Stormwater Management Plan approval, the anticipated nutrient reduction requirement for nitrogen in pounds above a certain threshold over a 30-year period is calculated by the developer and verified by the Town's stormwater staff. The calculated amount of nutrient reduction must then be offset by the developer. If the developer chooses to pay a fee to the Town, the developer makes the payment, and it is then issued a receipt by the Town which allows the developer to receive final Stormwater Management Plan approval from the Town. Upon receiving the payment the Town assumes the responsibility for the mitigation requirement including mitigation site construction and monitoring for success.

d. Design Criteria: Projects shall use a nitrogen export standard of 3.6 lbs/ac/yr. However, before using offset payments, the development must attain, at a minimum, a nitrogen export that does not exceed 6.0 lbs/ac/yr for residential development and 10.0 lbs/ac/yr for multi-family, commercial or industrial development. The total nitrogen (TN) export limitations, in a manner consistent with the Neuse Basin Rules, 15A NCAC 2B.0233, will be required throughout the Town and extra territorial jurisdiction.

e. Fees

- Neuse River Basin In-Lieu fee for projects will be $18/.49 / lbs of nitrogen. The per pound rate listed above is then multiplied by the total number of pounds of offset required for the total area of the development for a 30-year period this amount is consistent with the current Ecosystem Enhancement Program Fee at the time of development of the Town's Stormwater In-Lieu fee program.

- Cape Fear River Basin In-Lieu fee for projects will be $14.00 / lbs of nitrogen. The per pound rate listed above is then multiplied by the total number of pounds of offset required for the total impervious area of the development for a 30-year period. This amount was determined at a lower rate than the Neuse River Basin since NCDENR does not have mandatory nutrient sensitive waters management regulations in the Town's sub-basin of the Cape Fear River Basin. In the future, if Nutrient Sensitive Water Management is required by NCDENR in the Cape Fear River Basin the Town will update their fees for the Cape Fear River Basin to be consistent with House Bill 859 and rules adopted by the Environmental Management Commission (EMC).

f. Required Information: The project developer or their agent (design consultant) will calculate the amount of the payment to be made by the development. For each submittal the development will provide the following information on the TOHS Stormwater Fee-In-Lieu Request Form during the Stormwater Management Review Process. Once reviewed and approved the TOHS can accept the payment and issue a receipt (payments based on letters not including this information will not be accepted). The Stormwater Fee-In-Lieu Request Form requires general contact and project information as well as the Total Site Area, Existing Impervious Area, Proposed Impervious Area, Pre-Development Nitrogen Load, Post-Development Nitrogen Load, Nitrogen removed by SCM(s), Total Nitrogen Offset by fee, Fee Amount to be paid to the TOHS, Supporting calculations for determining fee amount Operation & Maintenance Agreement.

- **Neuse River Basin** In-Lieu fee for projects will be $18/.49 / lbs of nitrogen. The per pound rate listed above is then multiplied by the total number of pounds of offset required for the total area of the development for a 30-year period this amount is consistent with the current Ecosystem Enhancement Program Fee at the time of development of the Town's Stormwater In-Lieu fee program.

- **Cape Fear River Basin** In-Lieu fee for projects will be $14.00 / lbs of nitrogen. The per pound rate listed above is then multiplied by the total number of pounds of offset required for the total impervious area of the development for a 30-year period. This amount was determined at a lower rate than the Neuse River Basin since NCDENR does not have mandatory nutrient sensitive waters management regulations in the Town's sub-basin of the Cape Fear River Basin. In the future, if Nutrient Sensitive Water Management is required by NCDENR in the Cape Fear River Basin the Town will update their fees for the Cape Fear River Basin to be consistent with House Bill 859 and rules adopted by the Environmental Management Commission (EMC).

g. Required Information: The project developer or their agent (design consultant) will calculate the amount of the payment to be made by the development. For each submittal the development will provide the following information on the TOHS Stormwater Fee-In-Lieu Request Form during the Stormwater Management Review Process. Once reviewed and approved the TOHS can accept the payment and issue a receipt (payments based on letters not including this information will not be accepted). The Stormwater Fee-In-Lieu Request Form requires general contact and project information as well as the Total Site Area, Existing Impervious Area, Proposed Impervious Area, Pre-Development Nitrogen Load, Post-Development Nitrogen Load, Nitrogen removed by SCM(s), Total Nitrogen Offset by fee, Fee Amount to be paid to the TOHS, Supporting calculations for determining fee amount Operation & Maintenance Agreement.

3. Operations and Maintenance

a Operations and Maintenance Requirements

SCMs are crucial in protecting water quality from the impacts of development projects. If designed correctly, SCMs can also be an aesthetic asset to the development. However, no matter how well they are designed and constructed, SCMs will not function correctly nor look attractive unless they are properly maintained. Most maintenance problems with SCMs are less costly to correct when they are caught early.

This section details operations, inspections and maintenance procedures for all SCMs. Inspection and Maintenance of each SCM is required through an Operation and Maintenance Agreement attached to the property deed. An example Operation and Maintenance Agreement is provided in Appendix D.

b Inspection Procedures

Regular inspection and maintenance is an ongoing legal requirement after the SCM is constructed. Inspections must be completed quarterly and annually (certified by a qualified professional engineer) throughout the year and inspection records must be made available to the TOHS upon request and PE certifications shall be submitted to the Town annually.

Tables in this section provide the following information for each SCM type:

- Components of the SCM to be inspected,
- Types of problems possible with each component, and
- Appropriate remedies.

These tables provide a starting point; additional components or problems may arise with certain SCMs, the position of the SCM in the landscape, and/or individual circumstances.

During each inspection, the inspector shall consult the appropriate Operations and Maintenance Table as described in this section and note which problems are seen and which remedies are recommended. The resulting inspections report will include any of the listed remedies required, as well as a narrative describing special circumstances and schedule for that individual SCM that needs to be addressed.

1. Schedule

Recommended inspection frequencies for SCM types are described in Table 8.03d below. Specific schedules for individual SCMs may be required and will be documented as a part of the Inspection and Maintenance Agreement.

Table 8.03d Inspection Frequency for SCMs in the Town of Holly Springs

Inspection Frequency	Inspection Type
Quarterly and within 24 hours after every water quality storm (greater than 1.0 inch)	Inspection must be conducted by a trained, qualified party. These inspections are intended to identify obvious maintenance needs early in order to prevent more extensive corrective actions.
Annual Certification	Inspection must be conducted by a Professional Engineer. These inspections are intended to provide a more thorough assessment of the facility. Annual inspection reports (sealed by the PE) must be submitted to the TOHS Engineering Department. Field survey calculations to confirm storage volume and embankment stabilization, etc. may be required on a case by case basis.

2. Operation and Maintenance Log and Reporting

Quarterly Operation and Maintenance Logs will be kept on file by the Owner or Responsible Party for each Structural SCM.

Forms to be used to create Inspection and Maintenance Logs for each SCM are provided in the Appendix to this SCM Manual. The tables in this section provide a listing of the minimum criteria to be considered in the inspection of each SCM feature.

Annual inspection and maintenance certifications must be filed with the TOHS. A digital photograph must be taken at the time of inspection and after maintenance for each SCM. These must be kept on file, with a hard copy filed in the Inspection and Maintenance Log.

There are various training, qualification and certification programs for available for SCM inspectors, it is recommended that all parties filling out quarterly operation and maintenance logs to be trained appropriately for each SCM inspected.

c Maintenance Procedures

1. Initial Maintenance

Initial maintenance, to complete the construction of the SCM and monitor until plants are established, is needed for certain SCM features, and includes activities such as:

- After the first time fertilization to establish grass or other plants in SCMs, fertilizer will not be applied.
- Other final maintenance measures to ensure proper functioning

I. Emergency Maintenance

Emergency maintenance will often be required immediately after storms and other emergencies. This may include the following, as needed:

- Replanting and repairs to structures.
- Vegetation is likely to need at least minor repairs.
- Mosquito control should be considered if standing water poses health risks because of mosquitoes.
- Obstructions and debris deposited during storm events should be removed immediately. Exceptions include debris that provides habitat and does not damage vegetation or divert currents to, from, or in the SCM. Because of the high quality habitat that can be found in woody debris, careful re-positioning rather than complete removal may be desirable. There may be instances where debris is even added. Such locations should be noted so that this debris is not accidentally removed.
- If the basin of a SCM must be drained for an emergency or to perform maintenance, the flushing of sediment through the emergency or to perform maintenance, the flushing of sediment through the emergency drain should be minimized to the maximum extent practical.

II. Corrective Maintenance

Regular maintenance is critical to the continued function of SCMs. The Operations and Maintenance Logs for all SCMS shall include descriptions of the corrective actions and maintenance required for each item, as noted in the inspection. If possible, inspections should occur during wet weather to verify that the facility is maintaining desirable retention times. One important purpose of inspections is to ascertain the operational condition and safety of the facility, particularly the condition of embankments, outlet structures, and other safety-related features. Other general objectives are to prevent clogging of any outlets, development of standing water, and growth of weeds and noxious plants.

All maintenance must adhere to the following:

- All maintenance needs cited at quarterly, semi-annually and annual certification inspections must be addressed within 60 days of each inspection report unless noted circumstances dictate that it be done in a shorter timeframe.
- All corrective actions involving structural repairs or use of heavy equipment shall be coordinated and approved by the TOHS Engineering Department through notification prior to and following the corrective actions(s).

- Minor repairs do not require prior TOHS approval.

6. Operations and Maintenance Guidelines for Specific SCM Types shall meet the criteria outlined in the most current version of the most current NCDEQ Minimum Design Criteria (MDC).

7. Performance & Maintenance Guarantees (Stormwater Sureties)

a Performance Surety for Installation is Required

Town requires the submittal of a performance security or bond with surety, cash escrow, or a letter of credit prior to issuance of the Post-Construction Stormwater Permit for development projects or as a part of the other Completion Bonds required by the development in order to ensure that the SCMs are installed by the permit holder. Bonds shall be placed either prior to issuance of the Stormwater Permit or with the establishment of the other completion bonds required for the project as determined by staff during the Construction Drawing Review Process. Documentation to put the security in place will be reviewed during the Construction Stage, document submittal requirements are outlined in Section 8.04 of this manual. This surety will be released after all check-list items have been received and approved by Engineering Department Staff and the Maintenance Security has been put in place.

b Maintenance Surety for long term Operation & Maintenance is Required

Town requires a cash payment to the Stormwater Facility Replacement Fund (SFRF) as described in The Post-Construction Stormwater Ordinance, for the purpose of operation and maintenance of SCMs approved in the permit by the property owner or HOA. Documentation to put the surety in place will be reviewed during the Construction Stage and then revised as necessary prior to the payment into the SFRF, document submittal requirements are outlined in Section 8.04 of this manual. This surety will be kept in place in perpetuity and may be updated on an annual basis.

8. Easements & Access

Private drainage easements are required for all SCMs by the Post-Construction Stormwater Ordinance. These easements shall be shown on the final plat and recorded with the Wake County Register of Deeds as outlined in Chapter 8, Article VI of the Holly Springs, NC Town Code of Ordinances. The final plat shall reference all applicable Operation and Maintenance Agreements, also to be recorded with the Wake County Register of Deeds, pertaining to each SCM associated with the project. All easements associated with the SCMs shall include access to the public right-of-way and shall be demonstrated to provide adequate coverage for access and maintenance for the SCM and outlet works. Access roads shall be provided and deeded as open space and not located on private property. Easement and access sizing and alignment must take into consideration the existing and design grades as well as the equipment needed to maintain the SCM. SCMs that impound water such as bio retention areas, constructed wetlands, dry extended detention basins, and wet detention ponds require an easement at least

ten feet from the toe of slope of the dam. Such easements shall not encroach into any undisturbed or Neuse Riparian Buffers unless otherwise permitted by NCDENR. See also Section 8.06 of this document for private storm drainage easements. An Engineers Certification will be required on the Recorded Plat as described in the Final Plat Packet, Appendix A.18 of the DPM.

9. Covenants

Town requires the review and approval of HOA covenants to allow for the establishment of easements, the operation, maintenance and enforcement of SCMs outlined in the Ordinance. The covenants shall reference the recorded easement plats as well as the recorded Operation and Maintenance Agreements for the project. Appendix D. of this document has an outline of submittal requirements and documents to be filled out by the permit holder. This documentation will be reviewed during the Construction Stage and approved and recorded prior to the Post-Construction Stage of development.

10. Construction Sequence

The basic construction sequence for conversion of an erosion control device to a structural stormwater SCM shall be outlined as in the Town's Standard Details. Note that a more detailed construction sequencing may be required for site conditions that have environmental features on or adjacent to it, downstream citizen concerns, or site constraints. Corresponding erosion control and stormwater management plans shall be provided in addition to the construction sequence.

8.04 DOCUMENTATION AND SUBMITTAL REQUIREMENTS

As part of the review process, the developer must provide documentation to the Town that each stage of the development plan's stormwater design is consistent with the Town's policies and requirements at each stage of the review process. This section includes general lists of required items to be provided to the Town at each development review stage. See Section 8.00 for a detailed description of each review stage and the Appendixes for additional submittal information.

A. <u>Concept Stage</u>

1. Scoping Meeting

- This is highly recommended but an optional meeting that is requested by the applicant to discuss and obtain the information listed below.
  - Exchange of general information about the project between the developer and TOHS staff

- TOHS Engineering Department staff will provide guidance to the developer for critical items to consider prior to the Concept Plan Review Meeting

2. Concept Plan Review Meeting

- Sketch Plan: showing general site layout and proposed stormwater concepts
- Completed Natural Resources Inventory: This document will assist staff in determining if a Flood Study will be required by the Town, applicable environmental regulations in the development such as but not limited to riparian buffers and possible locations and types of SCM may be appropriate for the development. This form is located in Appendix A of the Design Manual

3. Preliminary Plan
   - Preliminary Stormwater Submittal Checklist: checklist includes a detailed description of the requirement for the items described below. If items included on the submittal checklist have not been received with each submittal, plans will be rejected and will not be able to return until the next review cycle until all submittal requirements have been provided for review. This form is located in Appendix B of the Design Manual.
   - Preliminary Stormwater Infrastructure Plans: (included as part of the plan set) shall include but not necessarily be limited to the items shown below. Note that in some cases, it may be acceptable to combine the plans shown below onto a single Preliminary Stormwater Infrastructure Plan.
     - Preliminary Grading Plan: Existing and proposed grades shall be shown at a minimum of two foot contour intervals along with existing and proposed building finished floor elevations. Also, all other related information such as existing FEMA or TOHS floodplains and draft TOHS floodplains shall be shown.
     - Preliminary Stormwater Conveyance Plan: Existing and proposed drainage features including streams, open channels, pipe networks, storm piping, etc. Plans should indicate approximate sizing of such features.
     - Preliminary Stormwater Quality Plan: Proposed SCMs including type, size, and location in relation to pertinent site features such as riparian buffers, proposed site improvements, and stormwater conveyance systems.
   - Preliminary Stormwater Management Report and Calculations: shall be a bound document and include at a minimum the following items:
     - Cover Sheet: Name of project, name of developer, name of engineering firm, date of first issuance, all subsequent revision dates, and seal/signature of a registered professional engineer.
     - Project Narrative: Narrative with a brief description of existing drainage patterns, environmental features, topography, proposed improvements,

proposed drainage patterns, stormwater management objectives, and proposed stormwater management approach.

- Stormwater Design Executive Summary: Insert completed form found in Appendix C of the Design Manual.
- Unless otherwise critical to other approvals such as 401/404 approvals (by-pass channel from SCM for instance) full SCM design/routing calculations and stormwater conveyance calculations are not typically required for the Preliminary Stormwater Management Report and Calculations.
- Existing and Proposed Drainage Area Maps: Maps showing and labeling land cover conditions, sub-shed drainage areas, proposed SCMs, time of concentration segments, drainage patterns/pipe networks, and interconnectivity of sub-shed areas. Separate maps maybe needed for stormwater management and storm drainage design purposes.
- Preliminary Sizing Calculations: Basic sizing calculations only to demonstrate compliance with required footprint (square feet) or length and DWQ sizing forms found at http://h2o.enr.state.nc.us/su/bmp_forms.htm .
- Preliminary Nitrogen Export Calculations: Nitrogen Export Calculations based upon methodologies outlined in Section 8.03 and included in the Stormwater Design Executive Summary found in Appendix C of the Design Manual.
- TSS Removal Calculations: In many situations, this will simply be a statement of how 85% TSS is being removed. However, if impervious area is being bypassed from proposed SCMs or SCMs in series are being utilized to achieve 85% TSS, then calculations demonstrating compliance shall be provided.
- Soils Information: Site boundary overlay on USGS Quadrangle Maps and USDA Soils Maps.

- Preliminary Stormwater Fee-In-Lieu Request Form: Projects desiring to utilize the Stormwater Fee-In-Lieu to offset TN for the project must complete this form and provide it with supporting documentation in the preliminary stormwater report. Staff will conditionally approve or deny the request based on the site plan and preliminary calculations. This form will be finalized during the construction stage and is found in Appendix C of the Design Manual.
- Preliminary Flood Study or Stormwater Impact Analysis:
  - Flood Study Narrative: Narrative with a brief description of existing drainage patterns, hydrologic/hydraulic conditions, environmental features, topography, proposed improvements, proposed drainage patterns, stormwater management objectives, and proposed stormwater management approach.

- Flood Study Schematic: Graphic schematic of the reach or reaches in the study with all cross-sections delineated, existing/proposed buildings with finished floor elevations, and existing/proposed water surface elevations.
- Drainage Basin Map: Map showing the drainage area used for the model. Show location for existing studies as appropriate. Show existing and proposed floodplain limits.
- Digital copy of HEC-RAS or HEC-HMS model
- Hard Copy of hydrology Calculations
- Approved Land Use Map (8.5"x11"): Obtain from www.hollyspringsnc.us

- PE Certification: For matching the last applicable submittal
- Draft Preconstruction Notification (PCN), Supporting Documentation, Wetlands determinations, and Buffer/Stream Determinations: Obtain PCN form from http://h2o.enr.state.nc.us or http://www.saw.usace.army.mil

B. Construction Stage

- Stormwater Submittal Checklist: This checklist includes a detailed description of the requirement for the items described below. If items included on the submittal checklist have not been received with each submittal, plans will be rejected and will not be able to return until the next review cycle until all submittal requirements have been provided for review. This form is found in Appendix C of the Design Manual.
- Final Stormwater Infrastructure Plans: Shall include but not limited to the following items.
  - Final Grading Plan: Existing and proposed grades shall be shown at a minimum of two foot contour intervals along with existing and proposed building finished floor elevations. Also, all other related information such as existing FEMA or TOHS floodplains and final TOHS floodplains per the Final Flood Study shall be shown. Include spot elevations as required for constructability and to ensure stormwater goals are met.
  - Stormwater Conveyance Plan: Existing and proposed drainage features including streams, open channels, pipe networks, storm piping, etc. Plans must include final design of all stormwater conveyance features including detailed information pertaining to the construction of pipe systems such as structure type, top elevations, invert elevations, pipe material, and pipe slope. Open channel systems shall include grading and appropriate design details as needed for construction including dimensions, appropriate lining, and energy dissipation as needed.
  - Stormwater Quality Plan: Final SCM design including type, size, grading, location, section through outlet control structure, typical cross-section, pretreatment systems, level spreaders, by-pass structures, maintenance access, sub-drainage, spillways, easements/buffers, notes, and SCM planting (including source for nursery plants). Plans shall cross-reference

Erosion Control Plans as necessary, especially for the construction sequence. Plans shall also include a table showing key design information with blanks for the contractor to verify this information during construction. Refer to the Sample SCM As-built Table located in Appendix C of the Design Manual.

- Final Stormwater Management Report and Calculations: Shall be a bound document and include at a minimum the following items:
  - Cover Sheet: Name of project, name of developer, name of engineering firm, date of first issuance, all subsequent revision dates, and seal/signature of a registered professional engineer.
  - Project Narrative: Narrative with a brief description of existing drainage patterns, environmental features, topography, proposed improvements, proposed drainage patterns, stormwater management objectives, and proposed stormwater management approach.
  - Stormwater Design Executive Summary: Insert completed form found in Appendix C of the Design Manual.
  - Existing and Proposed Drainage Area Maps: Maps showing and labeling land cover conditions, sub-shed drainage areas, proposed SCMs, time of concentration segments, drainage patterns/pipe networks, and interconnectivity of sub-shed areas. Separate maps maybe needed for stormwater management and storm drainage design purposes.
  - Final Sizing Calculations: Basic sizing calculations only to demonstrate compliance with required footprint (square feet) or length and NCDEQ Minimum Design Criteria (MDC) sizing documents.
  - First Flush Volume Calculations: Calculations demonstrating the first flush volume.
  - Stormwater Management Routing Calculations: Calculations for routing of stormwater through each SCM. Include a system schematic, flow summaries for each node, design storm data used, Tc calculations, runoff coefficient calculations, hydrograph summaries or hydrographs, SCM volume calculations (elevation/area table), outlet structure design data, outlet structure flow calculations, and drawdown time calculations (first flush and 1-year storm).
  - Anti-floatation Calculations: Calculations for vertical stability of the riser/barrel systems at the most buoyant condition.
  - Preliminary Nitrogen Export Calculations: Nitrogen Export Calculations based upon methodologies outlined in Section 8.03 and included in the Stormwater Design Executive Summary found in Appendix C of the Design Manual.
  - TSS Removal Calculations: In many situations, this will simply be a statement of how 85% TSS is being removed. However, if impervious area is being bypassed from proposed SCMs or SCMs in series are being

utilized to achieve 85% TSS, then calculations demonstrating compliance shall be provided.

- Storm Drainage Design Calculations: Detailed calculations demonstrating compliance with TOHS storm system design and performance requirements. Typical storm drainage system design tables are located in Appendix C of the Design Manual. See also above for Drainage Area Map requirements.
- Erosion Control Calculations: Detailed calculations for all erosion control measures such as sediment basins, channels/diversion ditches, skimmers, etc.
- Soils Information: Site boundary overlay on USGS Quadrangle Maps and USDA Soils Maps. Where SCM design requires infiltration, provide appropriate geotechnical soils information such as infiltration testing.

- Stormwater Fee in Lieu Request Form: The preliminary form will be revised to reflect the final stormwater management plan and the Town's conditional approval. Payment must be received by the preconstruction meeting and prior to issuance of the stormwater permit. This form is located in Appendix D
- Final Flood Study
  - Flood Study Narrative: Narrative with a brief description of existing drainage patterns, hydrologic/hydraulic conditions, environmental features, topography, proposed improvements, proposed drainage patterns, stormwater management objectives, and proposed stormwater management approach.
  - Flood Study Schematic: Graphic schematic of the reach or reaches in the study with all cross-sections delineated, existing/proposed buildings with finished floor elevations, and existing/proposed water surface elevations.
  - Drainage Basin Map: Map showing the drainage area used for the model. Show location for existing studies as appropriate. Show existing and proposed floodplain limits.
  - Digital copy of HEC-RAS or HEC-HMS model
  - Paper copy of HEC-RAS or HEC-HMS model
  - Approved Land Use Map (8.5"x11"): Obtain from www.hollyspringsnc.us
  - CAD file: (dwg format) with floodplain, cross-section, 100-year water surface elevation and adjacent buildings with finished floor elevations.
- Preconstruction Notification (PCN), Supporting Documentation, Wetlands determinations, and Buffer/Stream Determinations: Provide documents and approvals received from outside agencies as appropriate. Please note that permit modifications may result due to changes made during the plan review process. All final permits must be received prior to issuance of the Land Disturbance Permit for the project.

- PE Certification: for applicable submittal & consistency with the approved preliminary plans
- Preliminary versions of Post-Construction Documents as appropriate such as:
  - Preliminary Operations & Maintenance Agreement: This agreement between the owner or HOA and the Town outlines the SCMs that exist on the project and the required O&M criteria for each SCM. A sample O&M documents and O&M log templates are located in Appendix D.
  - Preliminary Performance Guarantee submittal: Performance and Maintenance Securities will be required for each SCM, cost estimates and the SCM Summary Sheet shall be submitted. If a Performance Security is required prior to issuance of the Stormwater Permit rather than at Plat recordation or later in the construction process the preliminary forms must be finalized prior to issuance of the Stormwater Permit. See Appendix D for the Stormwater Bonding Checklist.
  - Preliminary Covenants: Covenants will be reviewed by the Town Attorney and staff to determine that all requirements of the HOA have been adequately outlined to meet O&M requirements for the project.

C. Post-Construction Stage

- Recorded Operations and Maintenance Agreement: Refer to Appendix D of the Design Manual for a Sample O&M Manual, SCM Maintenance Log Forms and Stormwater Bonding Checklist. Preliminary documents shall be updated, approved by the Town and recorded with the Wake County Register of Deeds.
- Recorded easements (plat or deed): Easements shall be reviewed by the Town and recorded with the Wake County Register of Deeds
- Record Drawings ("as-built drawings") of SCM(s) with Engineer's Certification: Provide in both digital (dwg format) and Mylar. Shall be submitted upon completion of construction of each SCM. Soils certifications shall be attached with this certification.
- Performance Guarantee:
  - Stormwater Bonding Checklist: found in Appendix D of the Design Manual. Preliminary documents required for starting the security will be updated, the Maintenance Security will be updated with actual construction costs. The Performance guarantee cannot be released until the Maintenance Security has been approved.
- Covenants (if applicable): Will be finalized, approved by the Town and recorded with the Wake County Register of Deeds
- Environmental Education Packet: Packet generally describing the Town's Environmental programs and how they directly relate to the project. These documents will provide general guidance to homeowners regarding their property

and common areas in respect to stewardship, maintenance, and development. See Appendix D for outline and sample document.

8.05 DESIGN METHODOLOGIES

A Hydrology Modeling

The objective of utilizing SCMs is to minimize the adverse effects of development by meeting the criteria established in the TOHS Stormwater Ordinance. The preferred stormwater management approach is to preserve the natural storage, infiltration, and pollutant-treatment functions of each drainage area where practical, and where not practical to construct SCMs that mimic those natural functions.

Stormwater calculations for discharge estimates for specified design storms shall be calculated assuming full development of the contributing watershed based on the most recent Land Use Plan or on existing development, whichever is greater. Routing of discharges through lakes, ponds, or other impoundments is not acceptable unless the impoundment is publicly owned and operated as a permanent discharge control structure. Additional calculations are required to design SCMs with appropriate treatment capacity and correctly sized outlet structures. Diversions of stormwater flow across drainage area boundaries are not acceptable due to the resulting change in the watershed. If no alternative to diversion is possible, then the development must evaluate the entire watershed to ensure no adverse effects in regards to water quantity and water quality.

The table below summarizes the stormwater calculations and allowable methods that will be presented in this chapter.

Table 8.05a Allowable Methods for Stormwater Calculations

Calculation Value	Section	Allowable Methods
Peak Flow	A.1	a) Rational Method b) NRCS (SCS) c) Regional Regression Equation Analysis (National Flood-Frequency Program)
Runoff Volume	A.2	a) Simple Method b) NRCS (SCS)
Storage Volume	A.3	Stage-Storage Table
Stage-Storage Discharge	A.4	Chainsaw Routing (upon pre-approval from TOHS Engineering Dept only), NRCS (SCS), HEC-HMS, WinTR-55, SWMM, other approved method or software

1 Peak Flow Calculations

a. Rational Method: The rational method provides a simple yet reliable way to determine peak runoff rates for drainage areas that do not exceed 20 acres and do not utilize any stormwater attenuation devices.

The Rational equation is given as:

$$Q = C * I * A$$

Where:

Q = Estimated design discharge (cfs)
C = Composite runoff coefficient (unit less) for the watershed. See Table 8.05d for C values based upon soil type.
I = Rainfall intensity (in/hr) for the designated design storm. *Please refer to the following Table 8.05c for rainfall intensity, I.
A = Watershed area (acres)

Although there is no conversion factor, the units are resolved because one acre-inch per hour is about the same as one cubic foot per second.

Please note that the precipitation intensity can be calculated either by equation as shown below or by interpolating values from Table 8.05c:

$$I = g / (h+T)$$

Where:

I = Precipitation intensity (in/hr)

g and h = empirically derived constants (See Table 8.05b for values)

T = Time of concentration (minutes, 5 minutes min.)

Table 8.05b: Values for g and h

Return Period (years)	g	h
1	104	18
2	132	18
5	169	21
10	195	22
25	232	23
50	261	24
100	290	25

Table 8.05c: Intensity-Duration Frequency Table

Duration	1-Year (in/hr)	2-Year (in/hr)	5-Year (in/hr)	10-Year (in/hr)	25-Year (in/hr)	50-Year (in/hr)	100-Year (in/hr)
5 minutes	4.52	5.76	6.58	7.22	8.19	8.96	9.72
10 minutes	3.71	4.76	5.54	6.13	7.01	7.71	8.40
15 minutes	3.15	4.04	4.74	5.25	6.03	6.64	7.24
30 minutes	2.17	2.70	3.28	3.71	4.32	4.80	5.28
60 minutes	1.33	1.70	2.12	2.41	2.84	3.17	3.50
2 hours	0.75	0.95	1.20	1.37	1.62	1.81	2.00
3 hours	0.53	0.71	0.89	1.02	1.21	1.35	1.50
6 hours	0.28	0.44	0.56	0.65	0.77	0.86	0.96
12 hours	0.14	0.26	0.33	0.39	0.46	0.52	0.57
24 hours	0.07	0.15	0.19	0.22	0.27	0.30	0.33

Time of Concentration, T_c:

Time of concentration for the rational method may be calculated by the Kirpich equation as described below or by using Kinematic Wave Equation. The Kirpich Equation is best used in areas of low development intensities. Kinematic wave equation may also be used but is not described in this manual. Time of concentration shall be calculated using a segmented approach as reasonable based upon changes in slope, land cover conditions, or flow type.

Kirpich T_c Equation (Applicable to Rational Method only): Kirpich's equation (1940) was developed for small, agricultural watersheds. It was derived by examining the required time for the stream to rise from low to maximum stage during a storm. The time of concentration was then assumed equal to that time.

$$T_c = \frac{[L^3/H]^{0.38}}{128}$$

where:

T_c = Time of concentration in minutes

L = Longest flow path in feet

H = Elevation of difference along L in feet

The above equation was developed for overland flow on bare earth. For overland flow on grassy earth T_c should be multiplied by 2.0. On concrete and asphalt surface it should be multiplied by 0.4.

Table 8.05d Curve Numbers and Rational C

Cover Description	SCS Curve Number				Rational C				Percent Impervious
	HSG A	HSG B	HSG C	HSG D	HSG A	HSG B	HSG C	HSG D	
Fully developed urban areas									
Open space									
Poor condition (<50% grass)	68	79	86	89	0.36	0.58	0.72	0.78	
Fair condition (50 -75% grass)	49	69	79	84	0.15	0.38	0.58	0.68	
Good condition (>50% grass)	39	61	74	80	0.15	0.22	0.48	0.60	
Impervious areas									
Pavement, roofs	98	98	98	98	0.96	0.96	0.96	0.96	
Gravel	76	85	89	91	0.52	0.70	0.78	0.82	
Dirt	72	82	87	89	0.44	0.64	0.74	0.78	
Urban districts									
Commercial and business	89	92	94	95	0.78	0.84	0.88	0.90	85
Industrial	81	88	91	93	0.62	0.76	0.82	0.86	72
Residential areas (by lot size)									
1/8 acre (town houses, condos)	77	85	90	92	0.54	0.70	0.80	0.84	65
1/4 acre	61	75	83	87	0.22	0.50	0.66	0.74	38
1/3 acre	57	72	81	86	0.15	0.44	0.62	0.72	30
1/2 acre	54	70	80	85	0.15	0.40	0.60	0.70	25
1 acre	51	68	79	84	0.15	0.36	0.58	0.68	20
2 acres	46	65	77	82	0.15	0.30	0.54	0.64	12
Agricultural areas									
Pasture, grassland									
Poor	68	79	86	89	0.36	0.58	0.72	0.78	
Fair	49	69	79	84	0.15	0.38	0.58	0.68	
Good	39	61	74	80	0.15	0.22	0.48	0.60	
Meadow (mowed)	30	58	71	78	0.15	0.16	0.42	0.56	
Brush					0.15	0.15	0.15	0.15	
Poor	48	67	77	83	0.15	0.34	0.54	0.66	
Fair	35	56	70	77	0.15	0.15	0.40	0.54	
Good	30	48	65	73	0.15	0.15	0.30	0.46	
Woods and grass (orchard)									
Poor	57	73	82	86	0.15	0.46	0.64	0.72	
Fair	43	65	76	82	0.15	0.30	0.52	0.64	
Good	32	58	72	79	0.15	0.16	0.44	0.58	
Woods									
Poor	45	66	77	83	0.15	0.32	0.54	0.66	
Fair	36	60	73	79	0.15	0.20	0.46	0.58	
Good	30	55	70	77	0.15	0.15	0.40	0.54	
Row crops, straight, good	67	78	85	89	0.34	0.56	0.70	0.78	
Row crops, contoured, good	65	75	82	86	0.30	0.50	0.64	0.72	
Small grain, good	63	75	83	87	0.26	0.50	0.66	0.74	
Farmsteads	59	74	82	86	0.18	0.48	0.64	0.72	

In the table values of Rational C were computed from $C = 0.020\ CN - 1.0$

Source: Malcom 2003, Supplement to Elements of Urban Stormwater Design

b. NRCS (SCS) Method: See Section 8.5.A.2 for both peak flow and volume calculations.

c. Regional Regression Equation Analysis: Regression equations for rural and urban areas in North Carolina for various return periods are listed in the documents WRIR 96-4114 and WRIR 96-4084, The National Flood-Frequency Program—Methods for Estimating Flood Magnitude and

Frequency in Rural and Urban Areas in North Carolina, 2001, otherwise known as USGS Fact Sheet 007-00, January, 2002. Fact sheets can be found at the following USGS website http:// water.usgs. gov/osw /programs/ nffpubs.html.

A typical North Carolina Rural Regression Equation:

$Q_T = K * (DA)^X$

Where:

Q_T = Peak discharge in cubic feet per second for a storm event of recurrence interval T
T = Recurrence interval that ranges from 2 to 500 years
DA = Drainage Area in Square Miles
K, X = Empirical Constants (Vary with equation. Refer to WRIR 96-4112)

A typical North Carolina Urban Regression Equation:

$U_T = L * (DA)^X * (IA)^Y$

Where:

U_T = Peak discharge in cubic feet per second for a storm event of recurrence interval T
T = Recurrence interval that ranges from 2 to 100 years
DA = Drainage Area in Square Miles
IA = Percentage of drainage area covered by impervious surfaces
L, X ,Y= Empirical Constants (Vary with equation. Refer to WRIR 96-4084)

The Regional Regression Analysis shall be used for flood analysis only as approved by the TOHS Engineering Department. This method shall not be used for SCM routing or analysis.

2. Runoff Volume

a. Simple Method: The Simple Method (1" first flush volume) uses a minimal amount of information such as watershed drainage area, impervious area, and design storm depth to estimate the volume of runoff associated with the water quality storm (first flush volume). The Simple Method was developed by measuring the runoff from many watersheds with known impervious areas and curve-fitting a relationship between percent imperviousness and the fraction of rainfall converted to runoff (the runoff coefficient). The Simple Method shall be used for calculating first flush volumes only and shall not be used for any other purpose.

This relationship is presented below:

$R_V = 0.05 + 0.9 * I_A$

Where:

R_V = Runoff coefficient [storm runoff (in)/storm rainfall (in)], unitless
I_A = Impervious fraction [impervious portion of drainage area (ac) / drainage

area (ac)], unitless.

Once the runoff coefficient is determined, the volume of runoff that must be controlled is given by the equation below:

$V = 3630 * R_d * Rv * A$

Where:

V = Volume of runoff that must be controlled for the design storm (ft3)
RD = Design storm rainfall depth = 1" for water quality treatment
A = Watershed area (ac)

b. NRCS (SCS) Method: The SCS method (SCS, 1985; NRCS, 1986) is an alternative method for calculating the volume of stormwater runoff that is generated from a given amount of rainfall. It may not be used for calculating the water quality volume, but should be used for SCM routing/analysis and low impact development projects. First flush volumes for water quality treatment shall be based upon the Simple Method as described above. The following is a brief summary of the SCS Method. Refer to Technical Release 55 for a full description of this calculation methodology. This method should not be used on drainage areas exceeding 640 acres.

The SCS runoff equation is given below:

$$Q^* = \frac{(P-0.2S)^2}{P+0.8S}$$

Where:

Q* = Runoff depth (in)
P = Rainfall depth (in)
S = Potential max. retention after rainfall begins (in)

S is related to the soil and surface characteristics of the drainage area through the curve number (CN) by the following equation:

$S = (1000/CN) - 10$

The curve number, CN, describes the characteristics of the drainage area that determine the amount of runoff generated by a given storm: hydrologic soil group and ground cover. Soils are classified into four hydrologic soil groups (A, B, C, and D) based on their minimum infiltration rate, with A having the highest infiltration potential and D having the lowest. Refer to Technical Release 55 (TR-55) for a detailed list of soil names and associated hydrologic soil groups. Curve numbers should be prorated based upon actual land cover conditions in the event that land use is not homogenous. The four soil groups are summarized in the table below:

Table 8.05e – Hydrologic Soil Groups

Soil group	Characteristics
Group A	A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr). The textures of these soils are typically sand, loamy sand, or sandy loam.
Group B	B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr). The textures of these soils are typically silt loam or loam.
Group C	C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr). The texture of these soils is typically sandy clay loam.
Group D	D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr). The textures of these soils are typically clay loam, silty clay loam, sandy clay, silty clay, or clay.

As described in 8.6.A.1.a, the time of concentration shall be based upon a segmented approach. Although not needed to calculated runoff volumes, the time of concentration is important for both peak flow analysis and SCM routing. For the SCS method, the time of concentration segments may include sheet flow, shallow concentrated flow, and open channel flow. All calculations in the TOHS shall be based upon a Type II, 24-hour rainfall distribution. Again, refer to Technical Release 55 for more detailed information on this methodology.

Table 8.05f: Local Rainfall Depth

Precipitation Frequency Estimates (inches)																		
ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.39	0.63	0.79	1.08	1.34	1.56	1.65	2.00	2.37	2.83	3.26	3.63	4.21	4.79	6.39	7.92	10.12	12.16
2	0.46	0.74	0.93	1.28	1.61	1.86	1.98	2.39	2.84	3.42	3.92	4.35	5.02	5.69	7.54	9.32	11.84	14.16
5	0.53	0.85	1.07	1.52	1.95	2.29	2.44	2.95	3.52	4.27	4.86	5.35	6.10	6.82	8.90	10.83	13.55	15.98
10	0.59	0.94	1.19	1.72	2.24	2.65	2.83	3.44	4.11	4.93	5.58	6.13	6.95	7.72	9.98	12.00	14.87	17.38
25	0.65	1.03	1.31	1.93	2.58	3.08	3.33	4.06	4.89	5.83	6.55	7.19	8.10	8.92	11.45	13.54	16.59	19.17
50	0.69	1.10	1.39	2.09	2.83	3.43	3.74	4.57	5.56	6.54	7.30	8.02	9.01	9.86	12.61	14.72	17.91	20.53
100	0.73	1.15	1.46	2.23	3.08	3.76	4.15	5.09	6.22	7.26	8.07	8.87	9.93	10.81	13.78	15.89	19.19	21.83
200	0.76	1.20	1.52	2.36	3.31	4.09	4.56	5.62	6.93	8.00	8.84	9.73	10.88	11.77	14.96	17.06	20.47	23.09
500	0.79	1.25	1.58	2.51	3.60	4.51	5.10	6.33	7.88	8.99	9.88	10.89	12.15	13.06	16.57	18.62	22.14	24.70
1000	0.82	1.29	1.62	2.62	3.82	4.84	5.55	6.92	8.69	9.77	10.68	11.79	13.14	14.05	17.81	19.80	23.39	25.90

Raleigh-Durham Airport Data
Reference: NOAA

3. Storage Volume

Volume control for peak flow attenuation is typically provided through detention structures with volume above the water operating level and below the required freeboard. Some SCMs do not have the capability to provide this volume control due to their design, and others can include storage volume within the media of the SCM. Each individual SCM chapter discusses the specific calculations for meeting the volume control requirements. However, since many of the SCMs use storage volume in a detention structure, this section will discuss an acceptable method of calculating that volume. Storage volume within a detention structure shall be calculated using a stage-storage method. A table shall be provided showing incremental elevations of the SCM with square footage values at the listed elevations. The elevation increments shall be no more than 1 foot. Columns can then be produced showing the incremental volume and cumulative volume of storage provided. The drainage areas used in this analysis shall not exceed that allowed by the methodology used to generate the runoff volumes being analyzed.

a. Stage-Storage Table: This method can be used for basin shapes as simple as a rectangle or as intricate as a curved, landscape designed wetland

feature. It can also be used to calculate sediment storage volume and operating volume within SCMs. Below is an example of a Stage-Storage volume calculation table.

Table 8.05g. Stage Storage Volume Table

Elevation	Surface Area (sf)	Incremental Volume (cf)	Cumulative Volume (cf)
less than 725	operating volume	0	0
725	10,000	0	0
726	13,000	11,500	11,500
727	16,500	14,750	26,250
728	21,500	19,000	45,250
729	26,000	23,750	69,000
Over 729	freeboard	0	69,000

4. Stage-Storage-Discharge Model

Creating a stage-storage-discharge model is crucial for SCMs that involve detention of stormwater, particularly stormwater wetlands and wet detention basins. These SCMs provide volume control for the specified storm (for example, the 1-inch storm) in a temporary pool that is above the permanent pool.

a. Models: The following models may be used to assist in determining stage-storage-discharge through a detention SCM. These models include:

- HEC-HMS, developed by the U.S. Army Corps of Engineers, provides a variety of options for simulating precipitation-runoff processes. This model can simulate unit hydrograph and hydrologic routing options. The latest version also has capabilities for continuous soil moisture accounting and reservoir routing operations. http://www.hec.usace.army.mil/software/hec-hms/download.html.
- WinTR-55, develop by the NRCS, can be used to analyze the hydrology of small watersheds. A final version (including programs, sample data, and documentation) is now complete. http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-intr55.html.
- SWMM, developed by the EPA, can be used to analyze stormwater quantity and quality associated with runoff from urban areas. Both single-event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations. http://www.epa.gov/ceampubl/swmm.htm.
- Other programs may be used upon approval from the TOHS Engineering Department.

b. Chainsaw Routing: The Chainsaw Routing method is appropriate for the routine design of some small systems. Chainsaw routing is not appropriate for

many applications and shall only be used upon pre-approval from the TOHS. Three sets of source data are needed to apply the Chainsaw Routing method:

- The inflow hydrograph
- The size and shape of the storage basin
- The hydraulics of the outlet device.

The application of the Chainsaw Routing method is described in detail in Elements of Urban Stormwater Design (Dr. H. Rooney Malcom, P.E. 1989).

B Hydraulics Modeling

1. Channel Geometry: The Manning Equation is the equation of choice for determining the cross-section for a trapezoidal stormwater channel. It is applicable where (Malcom 1989):

- Stormwater is flowing under the influences of gravity, and
- Flow is steady – it does not vary with time (Although discharge does vary during the passage of a flood wave, it is essentially steady during the time around the peak, the time of interest in channel design.)

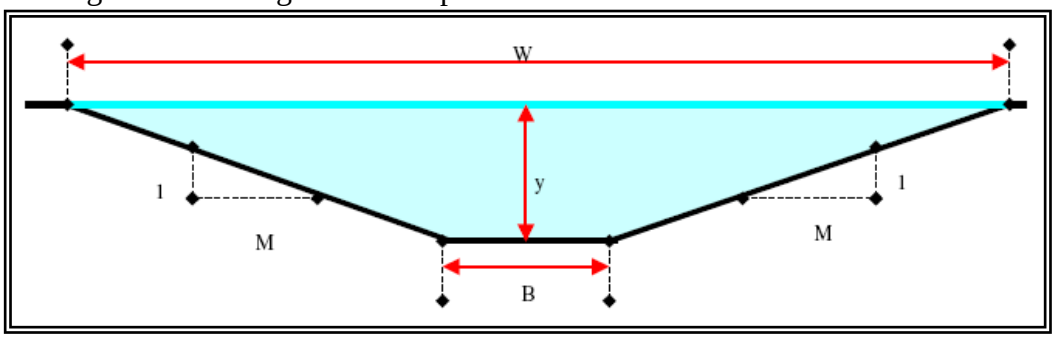
The Manning Equation can be stated as:

$$Q = \frac{1.489}{n} A R^{0.667} S^{0.5}$$

Where:

Q = Peak discharge to the channel (cfs)
n = Manning roughness coefficient (dimensionless)
A = Cross-sectional area of flow (sq ft), the area through which flow takes place
(see below)
R = Hydraulic radius (ft), found by dividing cross-sectional area, A (sq ft), by wetted perimeter, P (ft) (see below)
S = Longitudinal slope of the invert of the channel (ft fall/ft run).

Figure 8.04a Diagram of a trapezoidal channel



The Manning roughness coefficient is an experimentally determined value that is a function of the nature of the channel lining.

Table 8.05h Rational runoff coefficients (Munson, et al., 1990 and Chow et al., 1988)

Channel lining	Manning roughness coefficient, n
Asphalt	0.016
Concrete, finished	0.012
Concrete, unfinished	0.014
Grass	0.035
Gravel bottom with riprap sides	0.033
Weeds	0.04

The cross-sectional area of flow, A, can be determined by the following equation:

$A = By + My^2$

The wetted perimeter, P, is the distance along the cross section against which the water is flowing. It does not include the free water surface. P can be determined by the following equation:

$P = B + 2y\,(1 + M^2)^{0.5}$

The hydraulic radius, R, can be determined by the following equation:

$R = \frac{A}{P}$

For the three equations above, the variables have the following meanings:

A = Cross-sectional area of flow (sq ft)
B = Bottom width of the channel (ft)
M = Side slope ratio (ft horizontal/ft vertical)
P = Wetted perimeter (ft)
R = Hydraulic radius (ft)
y = Depth of flow (ft)

The tractive force for a channel flowing at a specific depth can be calculated as:
T = y x S x W, where W is the unit weight of water (62.4 #/cf). The tractive force experienced in the channel must be less than the resistance provided by the channel surface or channel lining for the design storm (10-year event, typical).

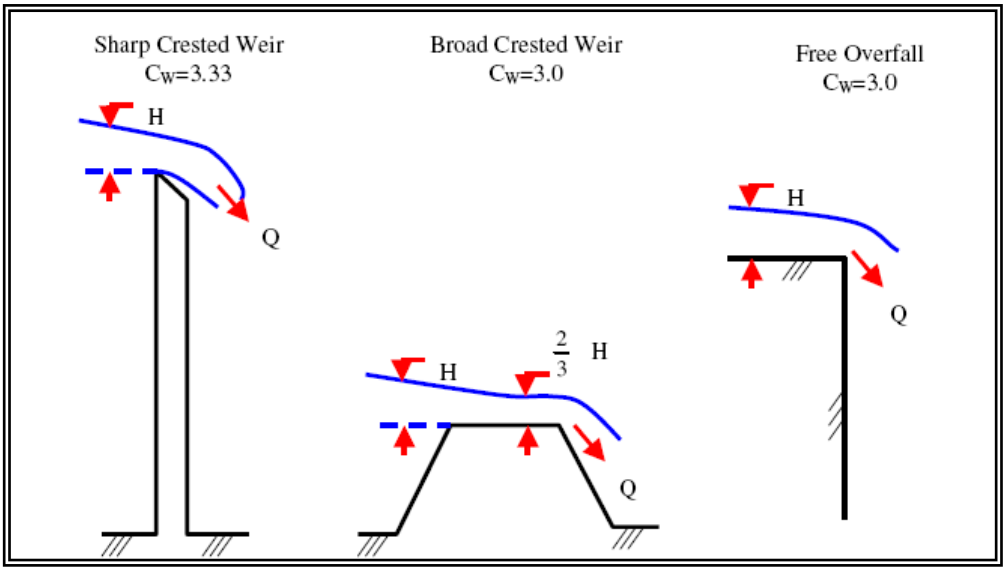
2. Weir Equations: Three kinds of weirs are typically used: sharp-crested, broad-crested and v-notch. For sharp-crested and broad-crested weirs, the basic equation is:

$$Q = C_w L H^{1.5}$$

Where:

Q = Discharge (cfs)
C_w = Coefficient of discharge (dimensionless) – see below
L = Length of weir (ft), measured along the crest
H = Driving head (ft), measured vertically from the crest of the weir to the water surface at a point far enough upstream to be essentially level.

Figure 8.05b: Schematic sections through weirs (Malcom 1989)

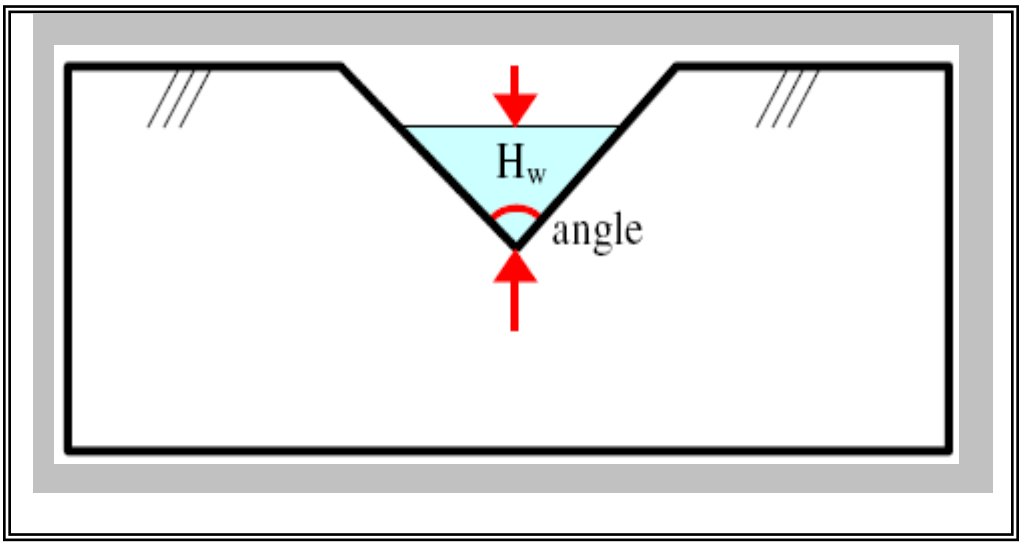


For v-notch weirs, the basic equation is:

$$Q = C_v H_w^{5/2}$$

Where:

Q = Discharge (cfs)
C_w = Weir flow coefficient for V-notch weirs
2.50 for 90 degrees
1.44 for 60 degrees
1.03 for 45 degrees
H = Difference between pool elevation and notch (ft)



3. Orifice Equation

The basic equation for orifices is:

$$Q = C_o\ A\ (2gH_o)^{0.5}$$

Where:

Q = Discharge (cfs)
C_o = Coefficient of discharge (dimensionless) – see below
A = Cross-sectional area of flow at the orifice entrance (sq ft)
g = Acceleration of gravity (32.2 ft/sec^2)
H_o = Driving head (ft), measured from the centroid of the orifice area to the water surface – Note: Usually use H_o /3 to compute drawdown through an orifice to reflect the fact that head is decreasing as the drawdown occurs. Alternatively, designer may use a incremental falling head calculation to better simulate actual performance.

Figure 8.05d: Schematic section through an orifice

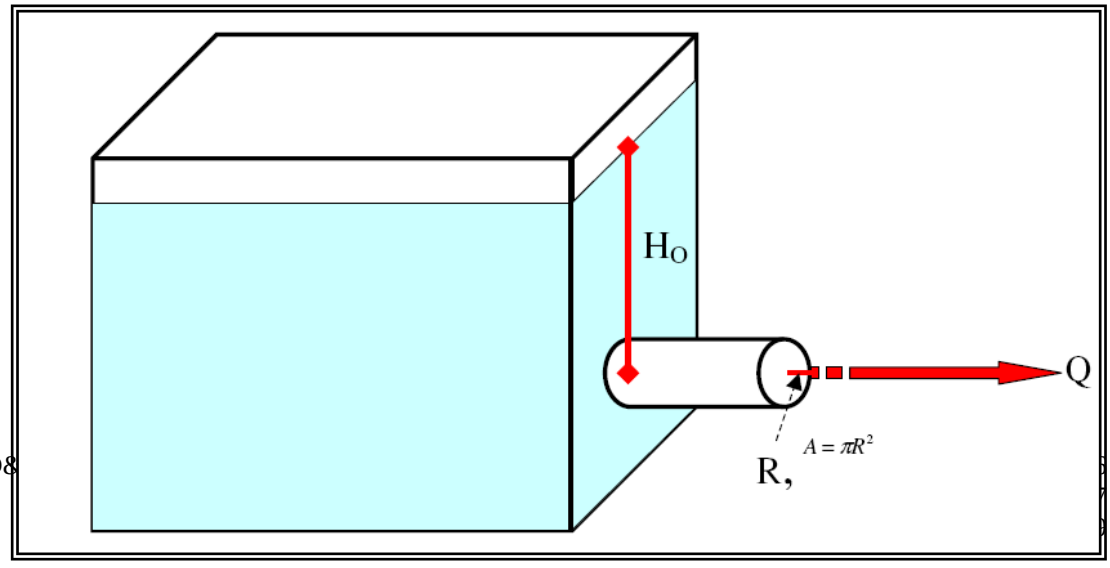


Table 8.05i: Values of Coefficient of Discharge, Co (Malcom, 1989)

Entrance Condition	CD
Typical default value	0.6
Square-edged entrance	0.59
Concrete pipe, grooved end	0.65
Corrugated metal pipe, mitred to slope	0.52
Corrugated metal pipe, projecting from fill	1

4. Pipe Systems: HEC-22. Nomograph, Inlet control, outlet control or other method approved by the Town Engineer.

8.06 STORM DRAINAGE DESIGN

When development of an area changes the flow regime from existing to developed or redeveloped flow conditions, drainage systems shall be designed according to the following standards:

A Applicability

The following design standards apply to all development within the TOHS corporate limits or ETJ, except for storm drainage systems constructed within the NCDOT right-of-way. Storm drainage facilities constructed in the NCDOT right-of-way shall be reviewed and approved by NCDOT and shall be in compliance with NCDOT standards and specifications, unless otherwise stated. Storm drainage facilities constructed within NCDOT right-of-way shall be subject to all applicable NCDOT's design requirements.

B Private Drainage Easements

Private drainage easements are required for any development which accepts or conveys stormwater runoff. Exemptions may be permitted by the Director of Engineering in instances where it can be proven that the storm drainage system on non-residential parcel(s) has been designed to serve lands only internal to the property. Drainage easements are intended to provide access, inspection, maintenance, and repair of structural portions of storm drainage conveyance systems. In addition to SCMs, all other portions of the storm drainage systems shall be maintained by the property owner, unless otherwise dedicated to and accepted by the Town of Holly Springs. In the event that privately-owned storm drainage systems are not maintained by the property owner, and are causing an emergency situation, the

Town of Holly Springs may take corrective action and charge the property owner for all costs associated with the corrective action. All private drainage easements shall be recorded after construction but prior to certificate of occupancy.

Private drainage easements shall be provided on all storm drainage and structures, including but not limited to:

- All drainage conveyance systems and structures, such as: pipes, channels, inlets, junction boxes, etc.
- All stormwater management SCMs, such as: ponds, wetlands, devices, etc.
- All new impoundments or existing impoundments on or adjacent to new development
- Streams, wetlands and other natural stormwater conveyances
- Other locations deemed appropriate by the TOHS Engineering Department
- Existing impoundments off site and adjacent to development must have a minimum 20-foot easement adjacent to the device and the property line.

Private drainage easements shall be indicated on the final plat, labeled and recorded as "Private Drainage Easement". Such easements shall be located on commonly owner property unless it is required for individual lot use. All private drainage easements shall be at least twenty (20) feet in width unless otherwise specified in the Town of Holly Springs Engineering and Design Construction Standards.

Easements widths shall be as follows:

1. Pipe Systems: Pipe systems shall be a minimum of 20' or 10' + 2 times the invert depth rounded to the nearest 5' (whichever is greater) and shall be centered on the pipe unless otherwise approved by the TOHS Engineering Department. Multiple culverts will be reviewed on a case-by-case basis but should generally have easements no less than the outside dimensions plus 40'.

2. Open Channel Systems: Easement widths shall be provided (unless an engineering study is provided to and approved by the TOHS Engineering Department that demonstrates that a lesser width will allow for proper construction, access, and maintenance) as follows as measured from top of bank or centerline of channel if there is no discernable top of bank:

Table 8.06a: Required easement widths for channels based on drainage areas

Drainage Area, ac	Easement Width, ft
<10 ac	10' on each side
10 - <25 ac	20' on each side
25 - <50 ac	30' on each side
50 - <100 ac	40' on each side
> 100 ac	The greater of the floodway width or 50'

The owners of real estate containing drainage features shall ensure that actions performed on the owned property do not negatively impact upstream or downstream neighbors, including other uses included in a common development. Any changes to existing natural drainage ways or other stormwater conveyance systems shall be subject to TOHS review as needed to evaluate potential impacts to upstream or downstream neighbors.

Structures are not permitted on/in private drainage easements with the exception of the following:

1. Pipe Systems: Structure cannot be placed over piped systems contained in a private drainage easement with the exception of fences, landscaping, and driveways that may encroach into the private drainage easements in a manner that will not impede the flow of stormwater or damage the storm drainage pipe in anyway or block access to a SCM.

2. Open Channel Systems: Structures cannot be placed in an open channel system such as ditches swales or natural drainage features contained in private drainage easements with the exception of fences or landscaping that is installed in a manner that is above the bank-full elevation and does not impede flow of the stormwater or damage the storm drainage system in anyway or block access to a structure stormwater SCM.

3. Retaining walls are not permitted within private drainage easements regardless if it is a piped or open channel system. Retaining walls maybe permitted on a case by case basis by the Director of Engineering in areas adjacent to the structural SCMs.

C Gutter Spread

The horizontal width of stormwater runoff conveyed along a curb system is known as gutter spread. Gutter spread requirements apply only to public roadways to be owned and maintained by the TOHS. The following is a list of required design criteria:

Table 8.06b: Required Design Criteria

Hydraulic Analysis	HEC – 12 or HY – 22
Hydrology	Rational Method
Design Storm Intensity	5.76 IN/HR (2-year storm with 5 minute time of concentration)
Manning's 'N'	0.016
Inlet Clogging Factor	50% Clogging for sag inlets
By-Pass	Consider All By-Pass (No By-Pass Across Streets, Through Intersections, or Around Radius Allowed)

Required Inlet Locations	2 At Every Sag Point (one on each side of road if road is crowned) As Required For Accessibility Where no overflow outlet is available, double inlets must be used (4 total if road is crowned).
Allowable Spread: Roads without Roadside Parking Roads With Roadside Parking	Minimum of either ½ outermost travel lane or 8 feet from flow line of curb No Encroachment Into Travel Lanes

D Storm Drainage Piping

All storm drainage piping systems shall sized in accordance with Manning's equation and shall be in compliance with the following unless otherwise approved by the TOHS Engineering Department:

Table 8.06c Storm Drainage Piping Requirement

Materials (Town Right-of-Way or Property)	Class III RCP or Greater (15" Min.) as Required by Depth or Loading.
Materials (Private Property)	Designer's Discretion – specify rcp or hdpe. All pipe connections to the public right-of-way must be RCP. ADS N-12 High Density Polyethylene Corrugated Storm Sewer Pipe (with approval from TOHS Eng. Dept.) ADS pipe shall not be installed under any pavement or curb and gutter, and shall not be installed with Class I or Class II bedding to the spring line for the pipe. Pipe material shall meet the product specifications of ASTM F667 and shall have a smooth interior.
Hydraulic Grade Line (HGL) Analysis - Based on Full Buildout Conditions	HEC – 22 Energy Loss or Approved Alternative 10-Year HGL Inside Pipe 25-Year HGL 1' Freeboard to Inlet Grate or Lid
Min. Slope	0.5%
Max. Slope Concrete Pipes	10% Without Submittal of Structural Calculations and Supporting Documentation
Max. Flow Velocity at Outfall	20 fps for the 25-year storm, unless otherwise approved by the TOHS Engineering Dept.
Outfall Protection	Outfalls shall be protected by riprap as needed to meet NCDENR-DLQ standards (see also Section 4 of the TOHS Engineering Design and Construction Standards).
Outlets	Outlets less than 36" require Flared End Sections. Outlets 36" and Over require Endwalls (Endwalls must meet criteria specified in table 8.06e)
Flared End Sections Used as Inlets	Flared End Sections May Only Be Used as Inlets when: a) Drainage area is less than or equal to 3 lots or equivalent b) 3 CFS max.
Tailwater	Use Known Tailwater Conditions Where Appropriate, use 7/8 pipe diameter min. at outlet pipe
Analyze 100-Year Storm	>20 AC Cumulative Drainage Area or as required by the TOHS Engineering Department
Min. Cover (Town R/W or Property)	2' of cover to Subgrade
Min. Cover (Private/ non-load bearing)	1' of cover to Subgrade
Bedding Class	As Appropriate for Proposed Conditions
Deflection	True to Grade, No Vertical or Horizontal Deflection
RCP Joints	Ram-Nek, Butyl Rubber Sealant, or Approved Equal
Max. Distance Between Access	300 Feet (less than 48" diameter) 400 Feet (48" diameter Or Greater)
Pipe Separation	See sections 6.00 and 7.00 for these Standards for horizontal and vertical separation requirements between storm drainage pipe, water lines, and sanitary

	sewer lines.
Discharge on Residential Lots	Unless prevented by topographic constraints, storm sewer shall not discharge into front yards of lots, but shall extend within 20 feet of the rear property line in lots up to ½ acre in size shall extend a minimum of 150 feet from right of way in lots larger than ½ acre.

E Storm Drainage Structures

All storm drainage structures shall be in compliance with the following unless otherwise approved by the TOHS Engineering Department:

Table 8.06d: Storm Drainage Structure Requirements

Applicability	May Not Apply to SCMs or Private Systems
Allowable Structure Materials	Masonry Concrete Block Precast Concrete may be installed only to depths certified acceptable by the manufacturer. Waffle Boxes are NOT permitted
Structure Materials: Masonry (clay brick)	 ASTM C32, Grade MS Mortar Joints ≤ 3/8" (non-shrink mortar required) May not be appropriate for structures with large drops or high HGL's
Concrete Block or Brick	ASTM C139 ½" Mortar Joints (non-shrink mortar required) May not be appropriate for structures with large drops or high HGL's
Precast Manholes	ASTM C478 Eccentric Cone Joints Conforming to Federal Spec SS-S-00210 (Ram-Nek, Butyl Rubber, or Approved Equal) Shall not be used for curb inlets
Manhole Frames and Covers	Cast Iron or Ductile Iron Stamped "Storm Sewer - Flows Into Waterways, Do Not Dump Waste" (2) 1" Holes Continuous Bearing On Bottom Casting shall be grey iron made in the USA free of porosity and blowholes ASTM 48CL35B Solid Lids may be required in site specific locations
Catch Basins (Combination Inlets) Drop Inlets and Yard Inlets	NCDOT Standards - 840.03 Cast "Flows Into Waterways, Do Not Dump Waste" as Appropriate For New Structure, Weather Resistant Plaque For Existing Casting shall be grey iron made in the USA free of porosity and blowholes ASTM 48CL35B No stormwater inlets shall be placed within the travel lane areas of the roadway.
Structure Steps	10" Wide Min. Polypropylene w/ ½" Rebar 16" O.C. 4" Projection Steps In Precast By Manufacturer
Minimum Drop Inside Structure	0.1' (0<Ø<45°) 0.2' (45°≤Ø≤90°) Ø>90° Not Allowable w/o Approval of Town of Holly Springs Engineering Department

F Culverts

All culverts shall be in compliance with the following unless otherwise approved by the TOHS Engineering Department:

Table 8.06e: Culvert and Channel Requirements

Hydraulic Modeling	a) Consider cross-sectional area loss due to siltation. b) Consider inlet control and outlet control methods and use controlling method. c) Others as deemed appropriate by Town Engineer d) 25-yr. design storm for culverts required e) 25-yr. design storm for channels required
Allowable Materials	a) RCP (18" Min.) b) If weep holes used, non-clogging filter material around pipe is required
Design Storm Frequency/Duration: 1. Thoroughfare Roads 2. Collector Roads 3. Minor (Local) Roads 4. Streams with FEMA Floodplains 5. Temporary Culverts 6. Streams with TOHS 100-yr. Floodplain	 100 – Year, 24-hour 50 – Year, 24-hour 25 – Year, 24-hour 100 – Year, 24-hour Case-by-case See Section 8.7
100 – Year Analysis For All Culverts To Ensure:	a) Post-Developed Backwater Does Not Flood Upstream Properties, b) Roadway Embankment Remains Stable c) Proposed & Existing Utilities Are Not Inundated Due To Culvert
Backwater Analysis (If Applicable)	a) Free Outfall Critical Depth And Equivalent Hydraulic Grade Line b) Stage-Discharge Curve To Determine Flow Depths c) Consideration Of Actual Site Conditions Such As Other Culverts Or Water Bodies
Minimum Free Board (100yr-24hr storm): Culverts 18" – 36" Diameter Culverts > 36" Diameter	 1.0' 1.5'
Inlet/Outlet Conditions	a) Energy Dissipaters (10-year or largest required design storm min.) At All Discharge Points To Prevent Scour (See Also Section 4 of the TOHS Engineering Design and Construction Standards) b) Additional channel and channel stability analysis is required downstream of the culvert until either the next structure is encountered or a point representing 110% of the drainage area to the subject culvert, whichever is met sooner. c) Geotextile Filter Fabric Between Stone and Natural Ground d) Headwalls are Required on Driveway Pipes 24" and greater e) Precast Headwalls/Endwalls For Single Pipes Only f) Headwalls, Endwalls, or Flared End Sections Required At All Inlets/Discharges. Flared End Sections Are Not Permitted For Pipes 36" Or Greater. g) Headwalls and Endwalls are required at all locations where multiple discharges occur at the same point. h) Headwalls Required Where Skew Is Less Than 75° Or Greater Than 105° i) Wingwalls Recommended As Appropriate

	j) Headwalls and Endwalls must be made of solid poured concrete below and equal to the 100-year water surface elevation k) Headwalls and Endwalls 4 foot in height or taller must be engineered and obtain a building permit prior to construction.
Deflection	True To Grade, No Vertical Or Horizontal Deflection Unless Otherwise Approved
Allowable Depths	Depths Shall Not Exceed Those Certified By The Manufacturer For The Service Condition
Allowable Skew	45° Maximum As Measured Perpendicular To Roadway Without Approval From Town Engineer
Allowable Flow Velocity RCP Other	 a) No Maximum But Ensure Stability At Entrance And Outlet a) To Be Reviewed On A Case-By-Case Basis
3-sided or Bottomless Culvert	a) An estimate of potential Scour depth is required for all bridge sites. The procedure for this analysis is presented in HEC-18 reference (12) and HEC-20 reference (14). 100 yr. 24 hr. storm must be analyzed. b) Channel stability analysis is required; if channel is not stable downstream of the structure an energy dissipation device will be required. c) Hydraulic analysis of the structure, 100 yr. 24 hr. storm event must be analyzed. d) Headwall and endwalls are required. e) True to grade no vertical or horizontal deflection. f) Footing required to be attached to non-weathered crystalline rock, standard penetration test to refusal in accordance with ASTM D1586 shall be used to determine the location of rock. For the purposes of this provision, "Rock" is defined as a continuous intact natural material in which the penetration rate with a rock auger is less than 2 in (50mm) per 5 minutes of drilling at full crowd force. This definition excludes discontinuous loose natural materials such as boulders and man-made materials such as concrete, steel, timber, etc. g) All other requirements set forth for the culvert in section.
Debris Control Structures	Per USACE Hydraulic Engineer Circular No. 9
Roadways Used As Dams	Must Be $\leq$ 15 Feet In Height Measured From Upstream Inlet To Water Source Elevation Any dam determined to be high hazard must be permitted by NCDEQ
Pipe Separation	See sections 6.00 and 7.00 for these Standards for horizontal and vertical separation requirements between storm drainage pipe, water lines, and sanitary sewer lines.
Limitation Of Property Damage	a) Existing And Proposed Inhabited Areas, HVAC Equipment, And Other Significant Improvements Subject To Flooding Damage Shall Be 2' Above Elevation Established By Design Frequency Analysis, Unless Otherwise Approved By The Town Engineer b) Compliance With Flood Prevention Ordinances And Other Applicable State/Federal Regulations c) Upstream And Downstream Must Remain Stable. Use Aprons And Other Stabilization Methods As Needed

a. An estimate of potential Scour depth is required for all bridge and bottomless culvert sites. The procedure for this analysis is presented in HEC-18, reference,(12). And HEC-20, reference (14), 100 yr. 24 hr. storm must be analyzed.
b. Channel stability analysis is required, if channel is not stable downstream of the structure an energy dissipation device will be required.
c. Hydraulic analysis of the structure, 100 yr. 24 hr. storm event must be analyzed.
d. Headwall and end walls are required.
e. Bridge and bottomless culverts must be true to grade, no vertical or horizontal deflection.
f. Footing required to be attached to non-weathered crystalline rock, standard penetration test to refusal in accordance with ASTM D1586 shall be used to determine the location of rock. For the purposes of this provision, "Rock" is defined as a continuous intact natural material in which the penetration rate with a rock auger is less than 2 in (50 mm) per 5 minutes of drilling at full crowd force. This definition excludes discontinuous loose natural materials such as boulders and man-made materials such as concrete, steel, timber, etc.

G Open Channels

All open channels shall be in compliance with the following unless otherwise approved by the Town Engineer:

Table 8.06f Open Channel Requirements

Hydraulic Analysis	Manning's Equation, HEC – RAS (Particularly For Non-uniform Flow Conditions) Or Other Methodology Approved By Town Engineer
Hydrology	Rational Method SCS Method Other As Approved By Town Engineer Use Full Build-Out Conditions
Channel Stability	Must Remain Stable Up To And Including 10 – Year Storm Un-reinforced Grass Swales Shall Have A Max. Velocity Of 4 fps For The 10 – Year Storm Full Vegetation Must be Established If Applicable
Capacity	10– Year Storm Within Banks 100 – Year Storm Must Be Analyzed To Determine Flood Impacts Based Upon Worst Hydraulic Condition Of Channel (Low Slope, High Weeds, Etc.)
Maximum Side Slopes	Vegetated 2:1 Stone 1.5:1 Grid Pavers 2:1 Gabions Vertical Retaining Wall Vertical

H Installation

1. All storm sewers shall be installed to provide a true line and grade between structures.
2. Structures shall be installed at each deflection of line and/or grade.
3. The maximum length between access points shall meet specifications outlined in Table 8.06c.
4. No inaccessible storm drainage structures shall be allowed.

5. Pipe may enter through the corner of all structure material types as long as it has been certified by a Professional Engineer.
6. A reinforced concrete slab, designed by a Professional Engineer, may be used at oversized structures to adjust an inlet to standard horizontal dimensions.
7. The minimum cover for storm sewer pipe shall meet specifications outlined in Table 8.06c. Trench excavation and backfilling shall be in accordance with Section 5.00 of these standards.
8. Pipe shall not project into a drainage structure but shall be finished flush with the inside of the structure.
9. Catch basins between 5 and 20 feet in depth shall have minimum interior dimensions of 4 feet by 4 feet, and those over 20 feet in depth shall have minimum interior dimensions of 5 feet by 5 feet.
10. Each drainage structure shall have a shaped invert constructed from concrete, and a bench with a maximum 5:1 slope. The bench shall begin at a height of one-half the pipe diameter for 15 to 24-inch pipe, one-third the pipe diameter for 30 to 48-inch pipe, and one-fourth the diameter for pipe greater than 48 inches in diameter.
11. Precast concrete structures may be installed only to depths certified as acceptable by the manufacturer.
12. All voids in structures shall use concrete brick and block with non-shrink mortar.

I Inspections & Testing

The contractor shall furnish all materials, labor, and equipment to perform inspections of storm drainage systems. Below is a summary of the Town inspections requirements:

1. Materials used must be approved by the Town Inspector prior to installation. Rejected materials shall be immediately removed from the construction site.
2. Town Inspector may require any materials installed without previous inspection or installed in a manner not consistent with the approved plans and specifications to be removed and reinstalled.
3. Storm drain lines shall be clean and free from obstructions and shall be visually inspected from every structure and opening.
4. All piping and structures must be approved by the inspector prior to paving.

J Retaining Wall Drainage

When subsurface of surface drainage is discharged, it shall be discharged in such a manner that it will not cause and increase hazard to the stability of any cut and fill slope or any building or structure. Drainage shall not be discharged in quantities or velocities above which existed prior to grading except in approved drainage system. Every yard shall be properly graded in order to obtain positive drainage and to prevent the ponding of stagnant water.

8.07 FLOOD STUDIES

There are two types of flood studies that a project may be subject to: a Town regulated flood study or a FEMA regulated flood study. Flood studies are required pursuant to the Post-Construction Stormwater Ordinance, Basin Models Required and as outlined in the Town of Holly Springs Policy Statement P-018, and the TOHS Flood Damage Prevention Ordinance. Drainage basins where a current flood study exist or established downstream finished floor elevations are within the basin, the existing flood study shall be updated and no-rise to the downstream 100 yr. water surface elevation will be allowed. Any new flood study required in areas with downstream drainage complaints or established downstream finished flood elevations shall demonstrate there is no-rise to existing downstream 100 year water elevations.

A Stages of Review

For each stage of the review process, there may be a flood study component depending on existing and proposed conditions. The following is a general description of the required submittal items for flood studies at various stages of review. See Section 8.04 and Appendices for a more detailed description of the overall development plan review process and submittal items referenced below.

1. Concept Stage

The first step for flood studies in the Concept Stage is attendance of the Scoping Meeting. At the scoping meeting, TOHS Engineering Department staff will review any information the developer has available regarding the proposed project area and share any information that the staff can at that point in time.

a. Concept Plan Review Meeting: Following the Scoping Meeting (if applicable), the next step is the Concept Plan Review Meeting. At the Concept Plan Review Meeting, the developer will present such items as a sketch plan for the proposed project along with general stormwater approach including general SCM information. The developer must bring a copy of the completed Natural Resources Inventory, Appendix A. The TOHS Engineering Department staff will use the Natural Resources Inventory to provide guidance to the developer on key considerations for development and how to proceed.

b. Preliminary Plan Review: The Preliminary Plan Stage represents the first formal development submittal to the Town. Along with the other submittal requirements at this stage as discussed in Section 8.04, a Preliminary Flood Study (AKA "Draft Flood Study" or "Draft Stormwater Impact Analysis") must be submitted. The Preliminary Flood Study may be based upon Wake County GIS topography. The flood plain established by the Preliminary Flood Study shall be represented on the Preliminary Plans.

2. Construction Stage

At the Construction Stage, the developer is responsible for finalizing the Flood Study. The final Flood Study shall be based upon surveyed cross-section data (GIS topography is NOT acceptable for use at the Construction Plan Review Stage.)

B. Types of Flood Studies

Depending on the location and nature of the proposed improvements, the TOHS has three different types flood studies. These include a Stormwater Impact Analysis (a more limited detail Town flood study), Town Flood Studies, and FEMA Flood Studies as described below. Where applicable, all flood studies must tie to existing flood studies based upon the same methodology.

1. Stormwater Impact Analysis

Stormwater Impact Analysis generally apply to areas where the receiving stream has five to 20 acres of drainage area at the analysis point and none of the following apply:

- History of upstream/downstream drainage complaints
- Existing Detailed Town Flood Study upstream or immediately downstream
- Existing unmapped residential or commercial structures with finished floors
- Existing topography or channel geometry indicates likely floodplain
- Existing Limited Detail Town Flood Study failed to verify no increase in the flow rates or failed to indicate that stormwater flows remain in existing drainage easements
- Study revisions as needed due to plan changes during the review process
- Hydraulic and hydrologic analysis for TOHS Flood Studies shall typically be taken to a point downstream of the site that represents 110% of the peak flow discharges generated by the undetained, post-developed conditions. The TOHS Engineering Department may require additional analysis especially where there are site specific concerns or existing downstream studies.

Stormwater Impact Analysis typically include the following (See also Appendices for other pertinent submittal data) and are used to establish natural and/or man-made drainage or backwater easements:

- Current Land Use Map (11”x17”)
- Drainage Area Map showing adjacent property grading, topography, property lines, proposed development, hydrology information, structures w/ finished floor elevations, reaches, etc.
- Stormwater Infrastructure Plan
- Hydrologic and Hydraulic Calculations with cross-sections (HEC-RAS, typical. HEC-HMS may be required in areas where current data exists, or as determined by the TOHS Policy Statement P-018). HEC-RAS to be used to determine water surface elevations. However, additional HEC-HMS modeling will also be required to determine peak flows for areas where current watershed models exist.
- Study revisions as needed due to plan changes during the review process

2. Town Flood Studies

Town Flood Studies are required for all drainage features with 20 acres or more of drainage area. Note that special consideration shall be made when studies are performed within or directly adjacent to existing mapped FEMA floodplains.

Town Flood Studies typically include the following (See also Appendices for other pertinent submittal data) and are used to establish the 100-year floodplain and drainage/backwater easements:

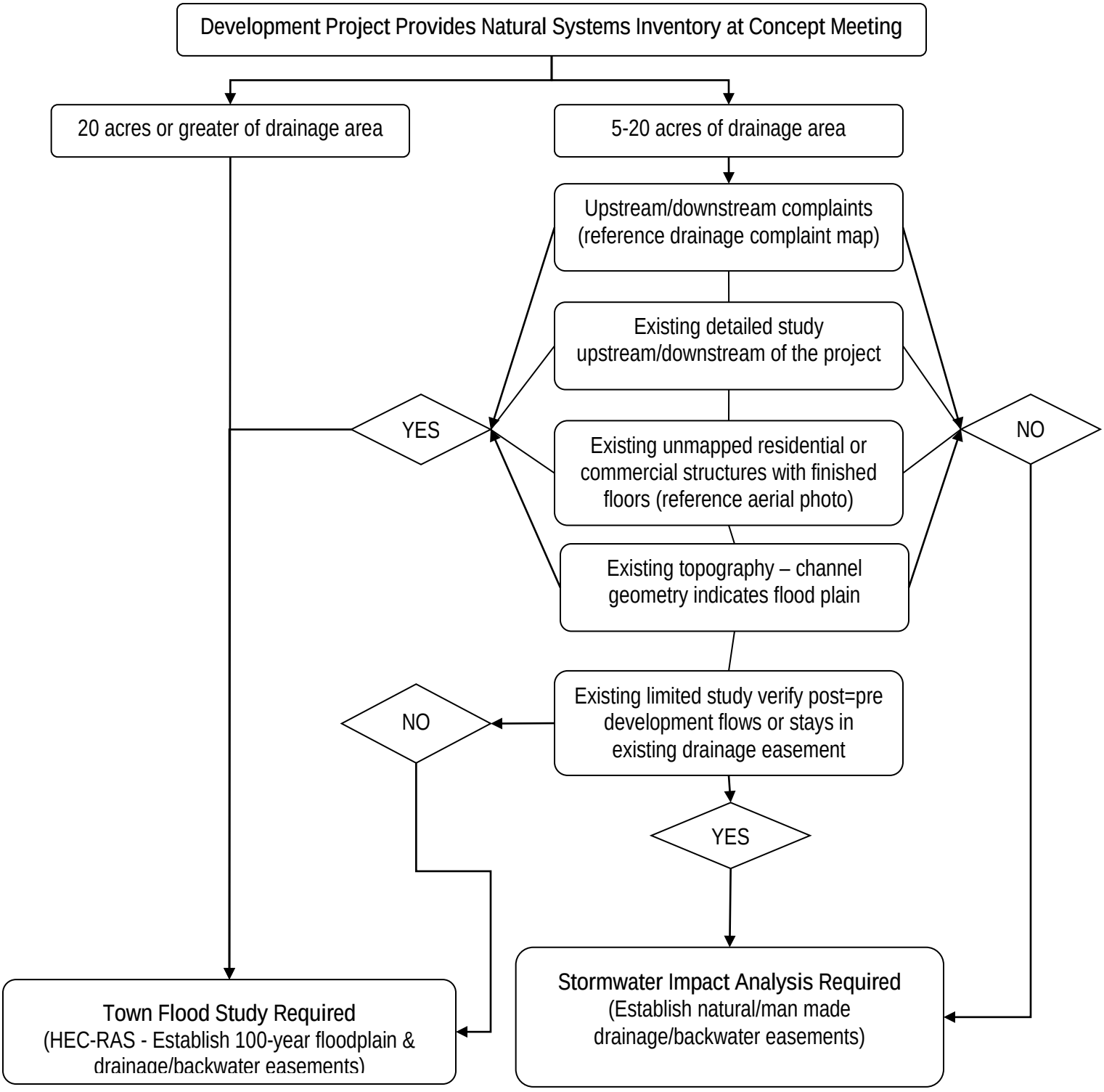
- Current Land Use Map (11"x17")
- Drainage Area Map showing adjacent property grading, topography, property lines, proposed development, hydrology information, structures w/ finished floor elevations, reaches, etc.
- Stormwater Infrastructure Plan
- Hydrologic and Hydraulic Calculations with cross-sections (HEC-RAS, typical. HEC-HMS may be required in areas where current data exists, or as determined by the TOHS Policy Statement P-018)
- Hydraulic and hydrologic analysis for TOHS Flood Studies shall typically be taken to a point downstream of the site that represents 110% of the peak flow discharges generated by the undetained, post-developed conditions. The TOHS Engineering Department may require additional analysis especially where there are site specific concerns or existing downstream studies.
- Surveyed cross-sections
- Study revisions as needed due to plan changes during the review process

3. FEMA Flood Studies

In areas where FEMA floodplain is present on or adjacent to the project Flood Studies, maps must be required in a manner consistent with Town's Flood Damage Prevention Ordinance, National Flood Insurance Program (NFIP) and the North Carolina Floodplain Mapping Program's regulations. Coordination will be required with Engineering Staff and regional representatives to determine the process required to update the maps and studies.

All residential development projects must take into consideration the Town's Flood Damage Prevention Ordinance requirements that prohibit residential development in the floodplain, this includes both fill and structures on residential lots and fill associated with the overall grading of the project unless associated with an approved perpendicular crossing location. The ordinance also requires that the lowest finished floor elevation must be at minimum 2-feet above the 100-year floodplain and a minimum buildable area on lots outside of the floodplain (100-year, 100-year future conditions and 500-year floodplain), based on the zoning of the lot. Both Preliminary Plans and Construction Drawings must identify the actual buildable area outside of the floodplain and the minimum finished floor elevation (Min. FFE) on all lots with floodplain on or adjacent to them.

Table 8.06a Flood Study Selection Flow Chart



* Note: FEMA Flood Studies & Town Basin Models may have additional requirements

END OF SECTION 8.00