Appendix 6-A

Site Plan Preparation and Submission as Part of the Land Development Process

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6-A.1.0. INTRODUCTION

This Handbook discusses the selection, design and implementation of a wide range of stormwater control measures. To encourage and ensure that local stormwater guidelines and requirements are implemented, communities should implement a formal site plan preparation, submittal, and review procedure that facilitates open communication and understanding between the involved parties. As a practical matter, this process should fit reasonably into the normal site development process.

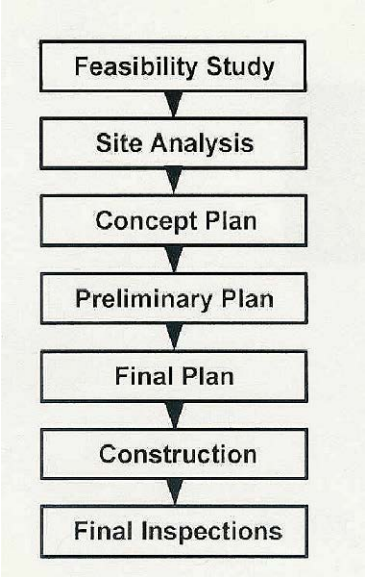

Figure 6-A.1. Typical Site Development Flow Chart

Figure 6-A.1 depicts a typical site development process from the perspective of the land developer. After an initial site visit the developer assesses the feasibility of the project. If the project is deemed workable, a survey is completed. The design team prepares a concept plan (often called a sketch plan) for consultation with the local review authority. A preliminary plan is then prepared and submitted for necessary reviews and approvals. Federal, state and local permits are applied for at various stages in the process.

After review by the local authority and possible public hearings, necessary revisions are made and a final construction plan is prepared. There may be several iterations between plan submittal and plan approval. Bonds are set and placed, contractors are hired, and construction of the project takes place. During and after construction numerous types of inspections take place. At the end of construction, there is a final inspection and a use and occupancy permit is issued for the structure itself.

Stormwater site planning and design is a subset of overall site development and must fit into the overall process if it is to be successful. **Table 6-A.1** on the next several pages shows how planning for the stormwater management system fits into the site development process from the perspective of the developer and site planner/engineer. For each step in the development process, the stormwater-related objectives are described, along with the key actions and major activities that are typically performed to meet those objectives.

Table 6-A.1. Stormwater Planning in the Site Development Process

Feasibility Study

Description:

A feasibility study is performed to determine the factors that may influence the decision to proceed with the site development, including the basic site characteristics, local and other governmental requirements, area information, surrounding developments, etc.

Stormwater-Related Objectives:

- Understand major site constraints and opportunities
- Understand local and other requirements

Key Actions:

- Initiate discussions with the local review authority
- Pre-consultation between the developer and the plan reviewer
- Determine local stormwater management requirements

Major Activities:

- Base map development
- Review of project requirements
- Review of local development and stormwater management requirements
- Review of local stormwater master plans or comprehensive land use plans
- Joint site visit with local review authority
- Collection of secondary source information
- Determination of other factors or constraints impacting feasibility

Site Analysis

Description:

A site analysis is used to gain an understanding of the constraints and opportunities associated with the site through identification, mapping and assessment of natural features and resources. Potential conservation and resource protection areas are identified at this stage.

Stormwater-Related Objectives:

- Identify key site physical, environmental, and other significant resources
- Develop preliminary vision for the stormwater management system

Key Actions:

- Site evaluation and delineation of natural feature/resource protection areas

Major Activities:

- Mapping of natural resources: soils, vegetation, streams, topography, slope, wetlands, floodplains, aquifers, etc.
- Identification of other key cultural, historic, archaeological, or scenic features, orientation and exposure
- Identification of adjacent land uses
- Identification of adjacent transportation and utility access
- Identification of natural feature protection and conservation areas

Table 6-B.1. continued

- Mapping of easements and utilities
- Integration of all layers – a map overlay
- Other constraints and opportunities

Concept Plan

Description:

A concept plan is used to provide both the developer and reviewer a preliminary look at the development and stormwater management concept. Based on the site analysis, a concept plan should take into account the constraints and resources available on the site. Several alternative "what if" concept plans can be created.

Stormwater-Related Objectives:

- Develop a concept for the stormwater management system
- Gain approval of the concept plan from the developer and local review authority

Key Actions:

- Develop a site layout concept using environmental site design techniques where possible
- Perform an initial runoff characterization based on the site layout concept
- Determine necessary site design and/or structural controls needed to meet stormwater management requirements

Major Activities:

- Prepare sketches of functional land uses including conservation areas
- Perform a "what if" analysis of different design concepts
- Conduct preliminary calculations based on applicable unified stormwater sizing criteria
- Use environmental site design concepts in the site layout concept
- Conduct a preliminary selection and siting of structural stormwater controls
- Identify the location of drainage/conveyance facilities

Preliminary and Final Plan

Description:

A preliminary site plan is created for local review, which includes roadways, building and parking locations, conservation areas, utilities, and stormwater management facilities. Following local approval, a final set of construction plans are developed.

Stormwater-Related Objectives:

- Assure soils and geotechnical issues are understood and resolved at this point
- Prepare preliminary and final stormwater management site plans
- Secure local and non-local permits

Key Actions:

- Perform runoff characterization based on the preliminary/final site plan
- Design structural stormwater controls and conveyance systems
- Perform a downstream analysis

Table 6-B.1. continued

Major Activities:

- Develop preliminary and final site layout plans
- Conduct calculations based on the applicable unified stormwater sizing criteria
- Select, site and design structural stormwater controls
- Design drainage and conveyance facilities
- Develop an erosion and sediment control plan and a site landscaping plan
- Apply for needed permits and waivers

Construction

Description:

During the construction stage, the site must be inspected regularly to ensure that all elements are being built according to plan, and that all resource or conservation areas are suitably protected during construction.

Stormwater-Related Objectives:

- Ensure that stormwater management facilities and site design practices are built as designed

Key Actions:

- Hold a pre-construction meeting at the site
- Inspect the site and stormwater management facilities during construction

Major Activities:

- Execute performance bonds
- Inspect during key phases or key installations
- Protect structural stormwater controls
- Protect conservation arease
- Control erosion and sedimentation
- Properly sequence construction

Final Inspection

Description:

After construction, the site must be inspected to ensure that all elements are completed according to plan. Long-term maintenance agreements should be executed.

Stormwater-Related Objectives:

- Ensure that stormwater management facilities and site design practices are built and operating as designed
- Ensure the long-term maintenance of structural stormwater controls and conveyances
- Ensure the long-term protection of conservation and resource protection areas

Key Actions:

- Conduct maintenance inspections
- Conduct a final inspection and submit record (as-built) drawings

Table 6-B.1. continued

Major Activities:

- Conduct final site stabilization
- Conduct an as-built survey
- Execute maintenance agreements
- Conduct a final site inspection
- Obtain a use permit/certificate of occupancy

6-A.2.0. THE STORMWATER MANAGEMENT PLAN

It is important for the designer to effectively communicate the rationale, design, and maintenance requirements to several audiences including the facility owner, regulatory reviewers, and maintenance personnel. It is critical so that all parties fully understand the need for the specified BMPs and the how they are expected to function in the future, to foster agreement regarding their selection and approval of their design.

This communication is typically accomplished through development of a stormwater pollution prevention plan, or SWPPP, which is required by the General Virginia Stormwater Management Program (VSMP) Permit for Discharges of Stormwater from Construction Activities. The SWPPP is composed of three components:

- An Erosion and Sediment Control Plan for the *construction* process
- A Pollution Prevention Plan for the construction site/process (more of a source control plan)
- A (*post-construction*) stormwater management plan

The stormwater management plan is a comprehensive document that describes the potential water quality and quantity impacts associated with a development project both during and after construction. The stormwater management plan also identifies selected source controls and treatment practices to address the potential impacts, the engineering design of the control measures, and maintenance requirements that enable the proper performance of the selected practices over time. Finally, the stormwater management plan contains the technical information and analysis to allow a local plan review authority to determine whether a proposed new development or redevelopment project meets the local stormwater regulatory requirements. This Appendix discusses the typical contents of a stormwater management site plan and the recommended review and consultation checkpoints between the local government staff and the site developer/permittee.

The procedures and guidelines for the preparation of a stormwater management plan should, be explicitly stated in the local stormwater management ordinance. The ordinance, in turn, may refer to a design guidance document for additional detail. Ideally, stormwater management site plans are developed with open lines of communication between the developer (and the developer's design consultants) and the plan reviewer. Stormwater management plans involve more than just the preparation of a document and maps. Beyond that, they should reflect the

entire development process, from planning through construction and continuing after build-out via regular inspection and maintenance of the site's stormwater management system.

6-A.3.0. SITE PLANNING AND DESIGN PROCESS

The first step in addressing stormwater management begins with the site planning and design process. The kinds of projects for which stormwater management plans are required and those that are exempt from plan requirements are set forth in § 62.1-44,15:34 of the Code of Virginia.

The information presented in this Appendix presents an idealized model of the stormwater management and site planning process from the land developer's perspective. Those who follow these steps to develop an environmentally-friendly site plan and stormwater management plan are much more likely to receive a timely approval by the local plan approval authority. The Department encourages local governments to provide opportunities for collaboration, as described below, in the structure of the local program's administration and review process.

In order to most effectively address stormwater management objectives, consideration of stormwater runoff needs to be fully integrated into the site planning and design process. This involves a more comprehensive approach to site planning and a thorough understanding of the physical characteristics and resources of the site. The purpose of this Appendix is to provide a framework for involving effective and environmentally sensitive stormwater management planning *early* – during the feasibility study and in the site layout and planning and process – and to encourage a greater uniformity in stormwater management plan preparation.

When designing the stormwater management system for a site, a number of questions need to be answered by the site planners and design engineers, including:

- How can the site's stormwater management system be designed to most effectively meet the stormwater management minimum standards (and any additional needs or objectives)?
- What are the opportunities for using Environmental Site Design (ESD) practices to minimize the need for structural stormwater controls?
- What are the development site constraints that preclude the use of certain structural controls?
- What structural controls are most suitable and cost-effective for the site?

6-A.3.1. Principles of Stormwater Management Site Planning

The following principles should be considered in preparing a stormwater management plan for a development site:

1. The site design should utilize an integrated approach to deal with stormwater quantity, quality and streambank (channel) protection requirements. The stormwater management infrastructure for a site should be designed to integrate drainage and water quantity control, water quality protection, and downstream channel protection. Site design should be done in unison with the design and layout of stormwater infrastructure to attain stormwater management goals. Together, the combination of ESD practices (clustering, minimizing imperviousness, etc.)

and effective infrastructure layout and design can mitigate the worst stormwater impacts of most urban development while preserving stream integrity and aesthetic attractiveness.

2. The design should strive to protect and use existing site features, minimize land disturbance, and minimize the amount of impervious cover resulting from the proposed development. Chapter 6 discusses how to accomplish these objectives, including concepts of clustered and concentrated development, routing of drainage from impervious areas (i.e., disconnection), maximizing tree canopy over impervious features, and use of practices such as vegetated roofs, permeable pavements, and capturing rainwater (cisterns) for reuse on-site (irrigation, etc.).

3. Manage stormwater using a "systems" approach. Determine the level of control needed, using the following concepts to create a sensible, integrated management system (might include one or more "treatment trains"):

- **Stormwater management practices should strive to use the natural drainage system and require as little maintenance as possible.** Almost all sites contain natural features which can be used to help manage and mitigate runoff from development. Features on a development site might include the existing drainage network, depressions, permeable soils, wetlands, floodplains, and undisturbed vegetated areas that can be used to reduce runoff, provide infiltration and stormwater filtering of pollutants and sediment, recycle nutrients, and maximize on-site storage of stormwater. Site design should seek to improve the effectiveness of natural systems rather than to ignore or replace them. Furthermore, natural systems typically will continue to function for many years with little or no maintenance.
- **Structural stormwater controls should be implemented only after all site design and nonstructural options have been exhausted.** Operationally, economically, and aesthetically, stormwater-related ESD and the use of natural techniques offer significant benefits over structural stormwater controls. Therefore, all opportunities for using these methods should be explored before implementing structural stormwater controls such as wet ponds and sand filters.
- **Structural stormwater solutions should attempt to be multi-purpose and be aesthetically integrated into a site's design.** A structural stormwater facility need not be an afterthought or ugly nuisance on a development site. A parking lot, soccer field or city plaza can serve as a temporary storage facility for stormwater. In addition, water features such as ponds and lakes, when correctly designed and integrated into a site, can increase the aesthetic value of a development.

4. Consider operations and maintenance in the design of the stormwater management system and the individual practices chosen. Select and design practices so maintenance needs will be minimal. Design practices with convenient access for inspection and maintenance. Because a maintenance agreement will need to be executed with the local jurisdiction, prepare a document that includes a list of maintenance tasks and schedules that can be provided to appropriate post-construction property owner.

5. "One size does not fit all" in terms of stormwater management solutions. Although the basic problems of stormwater runoff and the necessity of managing it remain constant, each site,

project, and watershed presents different challenges and opportunities. For instance, an infill development in a highly urbanized town center or downtown area will require a much different set of stormwater management solutions than a low-density residential subdivision in a largely undeveloped watershed. Therefore, local stormwater management needs to take into account differences between development sites, different types of development and land use, various watershed conditions and priorities, the nature of downstream lands and waters, and community desires and preferences.

6-A.3.2. Preparation of Stormwater Management Site Plans

A stormwater management site plan is a comprehensive report that contains the technical information and analysis to allow a local review authority to determine whether a proposed new development or redevelopment project meets the local stormwater regulatory requirements and/or the minimum stormwater management standards contained in this Handbook.

This section describes the typical contents and general procedure for preparing a stormwater management site plan. The level of detail involved in the plan will depend on the project size and the individual site and development characteristics. The preparation of a stormwater site plan ideally follows these steps:

- Pre-consultation Meeting and Joint Site Visit
- Review of Local Requirements
- Perform a Site Analysis
- Prepare a Stormwater Concept Plan
- Prepare a Preliminary Stormwater Site Plan
- Complete the Final Stormwater Site Plan

6-A.3.3. Pre-Consultation Meeting and Joint Site Visit

The most important action that can take place at the beginning of the development project is a pre-consultation meeting between the local review authority and the developer and his/her team to outline the stormwater management requirements and other regulations, and to assist the developer in assessing constraints, opportunities, and potential for stormwater design concepts.

This recommended step helps to establish a productive relationship for the entire development process. A joint site visit, if possible, can yield a conceptual outline of the stormwater management plan and strategies. By walking the site, the two parties can identify and anticipate problems, define general expectations and establish general boundaries of conservation areas and natural features to be protected. A major incentive for pre-consultation is that permitting and plan approval requirements will become clear at an early stage, increasing the likelihood that the approval process will proceed faster and more smoothly.

6-A.3.4. Review of Local Requirements

The site developer should be made familiar with the local stormwater management and development requirements and design criteria that apply to the site. These requirements may include:

- The minimum standards for stormwater management included in the Virginia Stormwater Management Regulations and the local stormwater management ordinance
- Design storm frequencies
- Conveyance design criteria
- Floodplain criteria
- Buffer/setback criteria
- Wetland provisions
- Watershed-based criteria
- Offset mitigation opportunities
- Erosion and sedimentation control requirements
- Maintenance requirements
- Need for physical site evaluations (infiltration tests, geotechnical evaluations, etc.)

Much of this guidance can be obtained at the pre-consultation meeting with the local review authority and should be detailed in various local ordinances (e.g., subdivision codes, stormwater and drainage codes, etc.). Current land use plans, comprehensive plans, zoning ordinances, road and utility plans, watershed or overlay districts, and public facility plans should all be consulted to determine the need for compliance with other local and state regulatory requirements.

Opportunities for special types of development (e.g., clustering) or special land use opportunities (e.g., conservation easements or tax incentives) should be investigated. There may also be opportunities to partner with a local community for the greenway development or other riparian corridor or open space enhancements.

6-A.3.5. Perform a Site Analysis and Inventory

Using approved field and mapping techniques, the site engineer should collect and review information on the existing site conditions, then document and map the following (9 VAC 25-870-55 B 8):

Analysis of Existing Conditions:

- Topography of the existing (pre-development) site showing drainage area or basin boundaries (ideally showing 2-foot contour intervals)
- All contributing drainage areas and existing drainage patterns, showing direction of flow and discharge points from the site
- Hydrologic analysis of runoff provided by off-site areas upstream of the project site
- Identification of intermittent and perennial streams, wetlands and other receiving waters, including karst features, into which stormwater may be discharged
- Soil types and underlying geologic formations (e.g., karst, etc.)

- Forest cover and other vegetative areas
- Current land use and land cover, including existing structures, roads, and locations of known utilities and easements
- Existing stormwater management facilities and conveyances
- Sufficient information regarding adjacent parcels to assess the impacts of stormwater runoff from the site
- Limits of clearing and grading and the proposed drainage patterns on the site
- Proposed buildings, roads, parking areas, utilities, and stormwater management facilities
- Proposed land use and land cover, with a tabulation of the percentage of surface area to be adapted to various land uses, including but not limited to planned locations of utilities, roads and easements
- Methodologies, assumptions, site parameters and supporting design calculations used in analyzing the existing conditions of the project site hydrology

Analysis of Post-Development Hydrology:

- Topography of the developed site conditions showing drainage area or basin boundaries (ideally showing 2-foot contour intervals)
- Total area of post-development impervious surfaces and other land cover areas for each sub-basin affected by the project
- Unified stormwater sizing criteria runoff calculations for water quality, channel protection, and overbank flooding protection for each sub-basin
- Location and boundaries of proposed natural feature protection areas
- Documentation and calculations for any applicable site design credits that are being used
- Methodologies, assumptions, site parameters and supporting design calculations used in analyzing the proposed conditions of the project site hydrology

In addition, in order to effectively coordinate stormwater management planning with other relevant regulatory requirements, the site engineer should identify and map all previously unmapped natural and other pertinent features such as:

- Wetlands
- Critical habitat areas
- Boundaries of wooded areas
- Floodplain boundaries
- Utility easements
- Steep slopes
- Required buffers
- Proposed stream crossing locations
- Other required protection areas (e.g., wellhead protection or drainfield setbacks)

Some of this information may be available from previously performed studies or from the previous feasibility study. For example, if a development site requires a permit under the Erosion and Sediment Control Law, most of the resource protection features will likely have been mapped as part of the land disturbance activity plan. Other recommended site information to map or obtain includes utilities information, seasonal groundwater levels, and geologic mapping.

Individual map or geographic information system (GIS) layers can be designed to facilitate an analysis of the site through what is known as map overlay, or a composite analysis. Each layer (or group of related information layers) is placed on the map in such a way as to facilitate comparison and contrast with other layers. A composite layer is often developed to show all the layers at the same time (see **Figure 6-A.2**). This composite layer can be a useful tool for defining the best buildable areas and delineating and preserving natural feature conservation areas.

6-A.3.6. Prepare a Stormwater Concept Plan

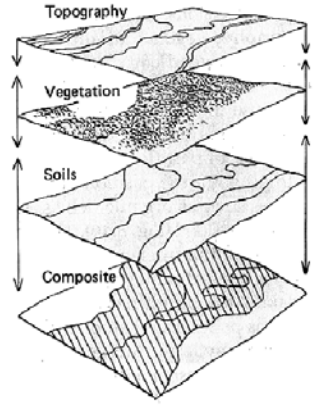

Figure 6-A.2. Composite GIS Analysis
(Source: Marsh, 1983)

Based upon the review of existing conditions and site analysis, the design engineer should develop a concept site layout plan for the project. During the concept plan stage the site designer will perform most of the layout of the site including the preliminary stormwater management system design and layout. The stormwater concept plan allows the design engineer to propose a potential site layout and gives the developer and local review authority a "first look" at the stormwater management system for the proposed development. The stormwater concept plan should be submitted to the local plan reviewer before detailed preliminary site plans are developed. The following steps should be followed in developing the stormwater concept plan:

(1) Use ESD approaches as applicable to develop the site layout, including:

- Preserving the natural feature conservation areas defined in the site analysis
- Fitting the development to the terrain and minimizing land disturbance
- Using various techniques to reduce impervious surface areas
- Preserving and using the natural drainage system, wherever possible

(2) Calculate preliminary estimates of the unified stormwater sizing criteria requirements for water quality, channel protection, overbank flooding protection and extreme flood protection based on the concept plan site layout.

(3) Determine the site design stormwater credits to be accounted for in the design of structural stormwater controls handling the water quality volume.

(4) Perform screening and preliminary selection of appropriate structural stormwater controls and identification of potential siting locations.

It is extremely important at this stage that stormwater design is integrated into the overall site design concept in order to (1) reduce the impacts of the development and (2) provide for the most cost-effective and environmentally sensitive design. The hydrology calculations for the site

provide a key reference for the designer to use in planning a stormwater management system that, as much as is feasible, mimics the pre-development site hydrology.

For local review purposes, the stormwater concept plan should include the following elements:

(1) Applicant name, legal address, and contact information (i.e., telephone and FAX numbers and email address).

(2) Common address and legal description of the site

(3) Vicinity map

(4) Project narrative (see additional explanation below)

(5) Preliminary Calculations (see additional explanation below)

(6) Existing conditions and proposed site layout mapping and plans (recommended scale of 1" = 50'), which illustrate at a minimum:

- Existing and proposed topography (minimum of 2-foot contours recommended)
- Perennial and intermittent streams
- Mapping of predominant soils from USDA soil surveys, including the locations of bore hole investigations
- Boundaries of existing predominant vegetation and proposed limits of clearing and grading
- Location and boundaries of other natural feature protection and conservation areas such as wetlands, lakes, ponds, floodplains, Resource Protection Areas (RPAs), stream buffers and other setbacks (e.g., drinking water well setbacks, septic setbacks, etc.)
- Location of existing and proposed roads and roadway easements, buildings, parking areas and other impervious surfaces
- Existing and proposed utilities (e.g., water, sewer, gas, electric) and easements
- Preliminary estimates of unified stormwater sizing criteria requirements
- Identification and calculation of stormwater site design credits
- Preliminary selection and location, size, and limits of disturbance of proposed structural stormwater controls (treatment practices, flood control facilities, stormwater diversion structures, etc.)
- Location of existing and proposed conveyance systems such as grass channels, swales, and storm drains
- Final landscaping plans for structural stormwater management practices and site revegetation
- Locations of pollution source controls
- Flow paths

- Location of floodplain/floodway limits and relationship of site to upstream and downstream properties and drainages
- Preliminary location and dimensions of proposed channel modifications, such as bridge or culvert crossings

(7) Concept Design Drawings and Specifications

(8) Conceptual Erosion and Sediment Controls

(9) Supporting Documents and Studies

(10) Operations and Maintenance Plans

(11) Other Required Permits

(12) Identification of preliminary waiver requests

6-A.3.7. Project Narrative

Projects that require a stormwater management plan must include documentation that adequately describes the proposed improvements or alterations to the site. In particular, it is necessary to describe any alterations to surface waters, including wetlands and waterways, removal of vegetation, and land disturbing operations. The project scope and objective must identify, in summary, the potential water quality impacts to receiving waters during construction and the post-construction water quality and quantity impacts that may occur as a result of the intended use(s) of the property. In describing the project, alternative designs or construction methods should be evaluated to address the goal of impact minimization through the use of site design practices such as providing "green" parking areas, and preserving natural buffers or open spaces. The purpose of evaluating project alternatives is to achieve a final design that allows an appropriate, legal use of the property while minimizing impacts to surface water quality and stream system integrity caused by stormwater runoff.

The project narrative should consist of:

- **Project Description and Purpose.** Provide a general description of the project in adequate detail such that reviewers will have a sense of the proposed project and potential impacts. This section should describe existing and proposed conditions, including:
  - Natural and manmade features at the site including, at a minimum, wetlands, karst, watercourses, floodplains, and development (roads, buildings, and other structures)
  - Site topography, drainage patterns, flow paths, and ground cover
  - Impervious area and site runoff coefficients
  - Site soils as defined by USDA soil surveys including soil names, map unit, erodibility, permeability, slope, depth, texture, and soil structure
  - Stormwater discharges, including the quality of any existing or proposed stormwater discharges from the site and known sources of pollutants and sediment loadings

- Critical areas, buffers, and setbacks established by the local, state, and federal regulatory authorities
- Water quality classification of on-site and adjacent water bodies and identification of any on-site or adjacent water bodies included on the Virginia 303(d) list of impaired waters or having assigned waste load allocations in conformance with an established and EPA-approved TMDL

- **Potential Stormwater Impacts.** Describe the project's potential for stormwater impacts affecting water quality, peak flow, and groundwater recharge. The elements that should be included in this section are:
  - Description of all potential pollution sources such as erosive soils, steep slopes, vehicle fueling and/or washing, etc.
  - Identification of the types of anticipated stormwater pollutants and the relative or calculated load of each pollutant
  - A summary of calculated pre- and post-development peak flows
  - An analysis of potential downstream flooding and channel erosion

- **Critical On-site and Off-Site Resources.** Describe and identify the locations of on-site resources and off-site resources (typically downstream of the site) that could potentially be impacted by stormwater runoff. These resources may include:
  - Wells
  - Aquifers
  - Wetlands
  - Streams
  - Ponds
  - Karst
  - Public drinking water supplies
  - Neighboring land uses

- **Proposed Stormwater Management Practices.** Describe the proposed stormwater management practices and why they were selected for the project. Stormwater management practices that should be described in this section are:
  - Source controls and pollution prevention
  - Environmental site design
  - Runoff volume control practices
  - Stormwater treatment practices
  - Flood control and peak runoff attenuation management practices

- **Construction Schedule.** Describe the anticipated construction schedule, including the construction sequence and any proposed phasing of the project.

- **Long-term Operation and Maintenance.** Identify the mechanisms/entities, including the identification of financially responsible parties, through which the stormwater management facilities will be operated and maintained during and after construction activity.

6-A.3.8. Calculations

The stormwater management plan should include calculations to demonstrate that the proposed project satisfies the stormwater management objectives and treatment practice sizing criteria described in **Chapter 11** and applicable hydroligic and hydraulic procedures of **Chapter 11** of this Handbook.

- **Groundwater Recharge Volume (R_v).** If the locality where the development will take place has established a groundwater recharge requirement, calculate the required groundwater recharge volume to maintain pre-development annual groundwater recharge on the site after the site is developed. The R_v should be calculated using the procedures described in **Appendix A of Chapter 10** or otherwise established by the locality. The R_v calculation should include the average annual groundwater recharge (i.e., stormwater infiltration) provided by the proposed stormwater management practices.

- **Pollution Reduction.**
  - **Treatment Volume (T_v).** Calculate the design treatment volume to be treated by the proposed stormwater treatment practices using the procedures described in **Chapter 11** and in the individual BMP specifications provided on the Stormwater BMP Clearinghouse web site (http://www.vwrrc.vt.edu/swc/). Design calculations should demonstrate that the proposed stormwater treatment practices meet the required Treatment Volume (T_v), detention time, and other practice-specific design criteria.
  - **Water Quality Flow.** Where necessary, calculate the design water quality flow, which is the peak flow rate associated with the T_v. The water quality flow is used to size flow-based treatment practices (i.e., manufactured treatment systems such as catch basin inserts, media filters, and hydrodynamic structures). The peak flow rates associated with larger design storms should also be evaluated to ensure that stormwater treatment practices could safely convey large storm events while providing the minimum rates of pollutant removal established in this Handbook.
  - **Pollutant Loads.** At the discretion of the local plan review authority, estimate pollutant loads found in post-development runoff. The Virginia Runoff Reduction Method can be used to accomplish this.

- **Peak Flow Control (Stormwater Quantity).** For new development projects, calculations should be provided to demonstrate that post-development peak flows do not exceed the stream channel protection criteria set forth in 9 VAC 25-870-66 B. For redevelopment projects, the bank condition and sensitivity of receiving waters may justify a reduction in peak flows and runoff volume from the site. Achieving a reduction in runoff from a redevelopment project may often be feasible with proper planning and implementation of detention or infiltration practices.

  A number of methods and models are available to calculate peak stormwater discharge rates, as discussed in **Chapter 11**. The designer must determine the most appropriate method for the project. The following information should be submitted with all stormwater management plans:

- **Hydrologic and Hydraulic Design Calculations.** Calculate the post-development peak runoff rates, volumes, and velocities at the site limits. The calculations shall be based on the following 24-hour duration design storm events to satisfy the sizing criteria described in **Chapter 11** and **Appendix 11-E** of this Handbook:

  - Stream Channel Protection: 1-year frequency ("over-control" of the 1-year storm)
  - Protection from Frequent Flooding: 10-year frequency
  - Peak Runoff Attenuation: 10-year, 25-year, and 100-year frequency (or other specified storm event), *if required by the local review authority*
  - Emergency Outlet Sizing: Safely pass the 100-year frequency or larger storm

  Provide the following information for each of the above design storms for pre-development and post-development conditions:
  - Description of the design storm frequency, intensity, and duration
  - Watershed map with locations of design points and watershed area (acres) for runoff calculations
  - Time of concentration (and associated flow paths)
  - Imperviousness of the entire site and each watershed area
  - NRCS runoff curve numbers or volumetric runoff coefficients
  - Peak runoff rates, volumes, and velocities for each watershed area
  - Hydrograph routing calculations
  - Culvert capacities
  - Infiltration rates, where applicable
  - Dam breach analysis, where applicable
  - Documentation of sources for all computation methods and field test results

- **Downstream Analysis.** Improperly placed or sized detention may adversely affect downstream areas by delaying the timing of the peak flows from the site. Delayed peaks can coincide with the upstream peak flow that naturally occurs later as the discharge travels from the upper portions of the watershed. If the site is in the middle to lower third of a watershed and detention is proposed, provide calculations of existing and proposed discharges at any critical downstream points using hydrograph analysis. Critical downstream points may be currently flooded properties or roadways, for example. As general guidance, routing calculations should proceed downstream to a confluence point where the site drainage area represents 10 percent of the total drainage area or according to other locally established procedures.

- **Drainage Systems and Structures.** Provide design calculations for existing and proposed drainage systems and structures at the site. Based on the design storm for those structures, a hydrograph analysis should be used to analyze the storage and discharge for detention structures. Drainage system components should be designed according to the standards outlined in this Handbook, as well as other applicable local standards or requirements.

6-A.3.9. Prepare a Preliminary Stormwater Site Plan

The preliminary plan ensures that requirements and criteria are being complied with and that opportunities are being taken to minimize adverse impacts from the development. The preliminary stormwater management site plan should consist of maps, narrative, and supporting design calculations (hydrologic and hydraulic) and technical report data for the proposed stormwater management system, and should include the following sections:

(1) **Existing Conditions Hydrologic Analysis.** Provide an existing condition hydrologic analysis for stormwater runoff rates, volumes, and velocities, which includes:

- A topographic map of existing site conditions (minimum 2-foot contour interval recommended) with the basin boundaries indicated
- Acreage, soil types and land cover of areas for each sub-basin affected by the project
- All perennial and intermittent streams and other surface water features
- All existing stormwater conveyances and structural control facilities
- Direction of flow and exits from the site
- Analysis of runoff provided by off-site areas upstream of the project site
- Methodologies, assumptions, site parameters and supporting design calculations used in analyzing the existing conditions site hydrology

(2) **Post-Development Hydrologic Analysis.** Provide a post-development hydrologic analysis for stormwater runoff rates, volumes, and velocities, which includes:

- A topographic map of developed site conditions (minimum 2-foot contour interval recommended) with the post-development basin boundaries indicated
- Total area of post-development impervious surfaces and other land cover areas for each sub-basin affected by the project
- Unified stormwater sizing criteria (**Chapter 10**) runoff calculations for groundwater recharge (where applicable locally), water quality, channel protection, overbank flooding protection and extreme flood protection for each sub-basin
- Location and boundaries of proposed natural feature protection and conservation areas
- Documentation and calculations for any applicable site design credits that are being used
- Methodologies, assumptions, site parameters and supporting design calculations used in analyzing the existing conditions site hydrology

(3) Stormwater Management System. Provide drawings and design calculations for the proposed stormwater management system, including:

- A drawing or sketch of the stormwater management system including the location of nonstructural site design features and the placement of existing and proposed structural stormwater controls. This drawing should show design water surface elevations, storage volumes available from zero to maximum head, location of inlet and outlets, location of bypass and discharge systems, and all orifice/restrictor sizes.
- Narrative describing that appropriate and effective structural stormwater controls have been selected.

- Cross-section and profile drawings and design details for each of the structural stormwater controls in the system. This should include supporting calculations to show that the facility is designed according to the applicable design criteria.
- Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms (should include stage-storage or outlet rating curves, and inflow and outflow hydrographs).
- Documentation and supporting calculations to show that the stormwater management system adequately meets the unified stormwater sizing criteria.
- Drawings, design calculations and elevations for all existing and proposed stormwater conveyance elements including stormwater drains, pipes, culverts, catch basins, channels, swales and areas of overland flow.

(4) **Downstream Analysis.** Provide the assumptions and calculations from a downstream peak flow analysis (when required) to show safe passage of post-development design flows downstream.

(5) **Geotechnical Analysis.** Any geotechnical report that may be required due to the presence of karst or other unique geological features should be provided in the preliminary site plan. This gives the local review authority the opportunity to collaborate on solutions early enough to avoid significant cost impacts. This is also a good phase for detailed consideration of site soils, especially if site soils may not be suitable for embankments, basin liners, bioretention media mixes, etc., and imported soils will be needed.

In calculating runoff volumes and discharge rates, consideration may need to be given to any planned future upstream land use changes. Depending on the site characteristics and given design criteria, upstream lands should be modeled as "existing condition" or "projected build-out/future condition" when sizing and designing on-site conveyances and stormwater controls.

6-A.3.10. BMP Operation and Maintenance

Stormwater management plans should include pertinent information regarding the routine and non-routine procedures necessary to maintain treatment practices, including vegetation, in effective operating conditions. **Chapter 9** of this Handbook contains operation and maintenance guidelines and recommendations for individual stormwater treatment practices, including sample inspection and maintenance checklists. Over time, post-construction documentation should be kept by the qualifying local program to demonstrate compliance with maintenance activities. Operation and maintenance elements that should be included in the stormwater management plan include:

- An BMP Maintenance Agreement(s) executed with the local jurisdiction
- Detailed inspection and maintenance checklists, identifying requirements/ tasks
- Inspection and maintenance schedules
- Parties legally and financially responsible for maintenance (name, address, and telephone number)
- As-built plans of completed structures (see **Section 3.7** of Chapter 3; **Section 3-E.1.3** of Appendix E of Chapter 3; and **Section 9.3.10** of Chapter 9 of this Handbook).

6-A.3.11. Complete the Final Stormwater Site Plan

The final stormwater management site plan adds further detail to the preliminary plan and reflects changes that are requested or required by the local review authority. The final stormwater site plan should include all of the revised elements of the preliminary plan. In addition, the following items must be included:

(1) Erosion and Sedimentation Control Plan: The proposed Erosion and Sedimentation Control Plan should, at a minimum, demonstrate the methods and designs to be utilized during construction and stabilization of the site following completion of construction activity. All proposed erosion and sediment control measures must comply with the Virginia Erosion and Sediment Control Law (§ 62.1-44.15:51 et seq., Code of Virginia), Virginia Erosion and Sediment Control Regulations (9 VAC 25-840-30), *and the Virginia Erosion and Sediment Control Handbook*, 1992) and the local Erosion and Sediment Control ordinance.

- Erosion and sediment control measures must be included on the plans with sufficient detail to facilitate review of the design by regulatory officials, and proper construction of the measures.
- A description of the sequencing/phasing of construction and temporary stabilization measures must be included in the plans.
- If temporary E&S Control facilities are to be converted into permanent ("post-construction") BMPs, a description must be included regarding how and when to accomplish the conversion.

(2) Landscaping Plan

- Arrangement of planted areas, natural areas and other landscaped features on the site plan
- Information necessary to construct the landscaping elements shown on the plan drawings
- Descriptions and standards for the methods, materials and vegetation that are to be used in the construction

(3) Operations and Maintenance Plan

- Description of maintenance tasks, responsible parties for maintenance, funding, access and safety issues

(4) Evidence of Acquisition of Applicable Local and Non-local Permits

(5) Exception/Waiver Requests

Earlier conceptual designs and preliminary calculations should be refined for the completed design. The completed final stormwater site plan should be submitted to the local review authority for final approval prior to any construction activities on the development site.

6-A.3.12. Design Drawings and Specifications

Design drawings and specifications must be prepared by a professional engineer licensed to practice in the State of Virginia. The format of site plans and drawings should conform to the following:

- Drawings should be no larger than 24" x 36" and no smaller than 8-1/2" x 11".
- Plans and documents should not be pieced together or submitted with handwritten markings. Blue line prints or photocopies of original plans are acceptable.
- A scale should be used that adequately presents the detail of the proposed improvements for the project. A maximum scale of 1" = 40' is recommended, however larger scales up to 1" = 100' may be used to represent overall site development plans or for conceptual plans. Profiles and cross-sections should be prepared at a maximum scale of 1" = 4' vertical and 1"=40' horizontal.
- Design details including cross-sections, elevation views, and profiles needed to allow the proper depiction of proposed controls for review and permitting as well as to facilitate the proper construction of these controls.
- Specifications, which clearly indicate the materials of construction, the specific stormwater control product designations (if applicable), the methods of installation, and reference to applicable material and construction standards.
- Plans should contain a title block that includes the project title, location, owner, assessor's map and parcel number of the subject site(s), name of preparer, sheet number, date (with revision date, if applicable), and drawing scale.
- Legend defining all symbols depicted on the plans.
- A cover sheet with a sheet index for plan sets greater than two sheets. Multiple sheets should contain either match lines or provide an overlap of 1-inch with information on adjoining plan sheets.
- North arrow.
- Property boundary of the entire subject property and depicting the parcels, or portions thereof, of abutting land and roadways within one hundred (100) feet of the property boundary.
- Locus map of the site prepared at a scale of 1" = 1,000' with a north arrow. The map should adequately show the subject site relative to major roads and natural features, if any, so the site can be easily found using the locus map for guidance.
- The seal of a licensed professional should be affixed to all original design plans, calculations, and reports prepared by them or under their direct supervision.

6-A.3.13. Supporting Documents and Studies

Information used in the design of construction and post-construction stormwater controls for the overall site development must be included (or referenced, if appropriate) with reports, plans, or calculations to support the designer's results and conclusion. Pertinent information may include:

- Soil maps, borings/test pits
- Infiltration test results
- Groundwater impacts for proposed infiltration structures

- Reports on wetlands and other surface waters (including available information such as Maximum Contaminant Levels [MCLs], Total Maximum Daily Loads [TMDLs], 303(d) or 305(b) impaired waters listings, etc.)
- Water quality impacts to receiving waters
- Impacts on biological populations/ecological communities including fish, wildlife (vertebrates and invertebrates), and vegetation
- Flood study/calculations

6-A.3.14. Obtain Other Required Permits

Approval of a stormwater management plan does not relieve a property owner of the need to obtain other necessary permits or approvals from federal, state, and local regulatory agencies. The developer should obtain all applicable non-local environmental permits (e.g., §404 wetland permit, §401 water quality certification, VDOT entrance permit, VSMP General Permit for Stormwater Discharges from Construction Activities, etc.) or prior to or in conjunction with final plan submittal. In some cases, a non-local permitting authority may impose conditions that require the original concept plan to be changed. Developers and engineers should be aware that permit acquisition can be a long, time-consuming process. The stormwater management plan should include evidence of acquisition of all applicable federal, state, and local permits or approvals such as copies of permit registration certificates, local approval letters, etc.

Ideally, local governments should not issue a grading or building permit for any parcel or lot unless a stormwater management plan has been approved or officially waived. If requirements of federal, state, and local officials vary, the most stringent requirements should be followed.

6-A.4.0. REFERENCES

Atlanta Regional Commission (ARC). 2001. *Georgia Stormwater Management Manual*. Prepared by AMEC, the Center for Watershed Protection, Debo and Associates, Jordan Jones and Goulding, and the Atlanta Regional Commission. Atlanta, Georgia.