NCTCOG
North Central Texas Council of Governments

i SWM

iSWM Criteria Manual for Site Development and Construction

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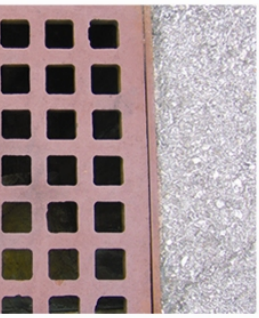

Overview of the iSWM Program

The iSWM Program for Construction and Development is a cooperative initiative that assists municipalities and counties to achieve their goals of water quality protection, streambank protection, and flood mitigation, while also helping communities meet their construction and post-construction obligations under state stormwater permits.

Development and redevelopment by their nature increase the amount of imperviousness in our surrounding environment. This increased imperviousness translates into loss of natural areas, more sources for pollution in runoff, and heightened flooding risks. To help mitigate these impacts, more than 60 local governments are cooperating to proactively create sound stormwater management guidance for the region through the *integrated* Stormwater Management (iSWM) Program.

The success of the iSWM Program provides persuasive evidence that the quality and quantity issues associated with urban environment are among the top priorities for our member local governments. The focus of iSWM has followed the development of stormwater regulations and rulemaking on site development, but also acknowledges that the impact of linear projects like transportation and other infrastructure has on our communities.

The iSWM Program is comprised of four types of documentation and tools as shown in Figure 1. These are used to complement each other and to support the development process.

The four parts of iSWM are:

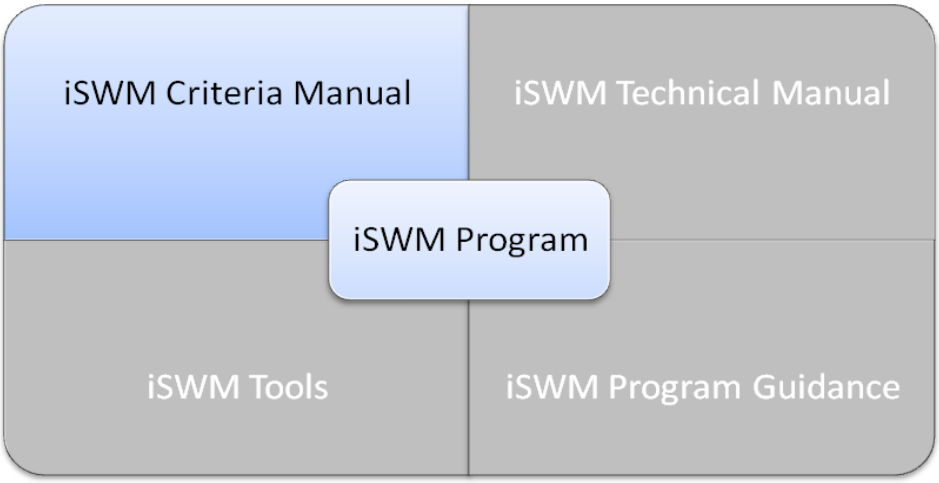

Figure 1: iSWM Program Support Documents and Tools

- iSWM Criteria Manual –This document provides a description of the development process, the iSWM focus areas and locally adopted design criteria allowing municipalities a flexible approach to apply at a local level. The Transportation *integrated* Stormwater Management (TriSWM) Appendix is provided for use by cities, counties, and transportation agencies for the planning and design of stormwater management systems associated with the construction of public transportation infrastructure (streets, roads, and highways).
- iSWM Technical Manual – This set of document provides technical guidance including equations, descriptions of methods, fact sheets, etc. necessary for design.
- iSWM Tools – This includes web-served training guides, examples, design tools, etc. that could be useful during design.
- iSWM Program Guidance – This includes reference documents that guide programmatic planning rather than technical design.

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1.0 Overview of iSWM Criteria Manual

This Chapter discusses the criteria aspects of iSWM and lays out the framework and specific requirements. Local governments may modify this section to meet any local provisions.

1.1 Introduction

The purpose of this manual is to provide design guidance and a framework for incorporating effective and environmentally sustainable stormwater management into the site development and construction processes and to encourage a greater regional uniformity in developing plans for stormwater management systems that meet the following goals:

- Control runoff within and from the site to minimize flood risk to people and properties;
- Assess discharges from the site to minimize downstream bank and channel erosion; and
- Reduce pollutants in stormwater runoff to protect water quality and assist communities in meeting regulatory requirements.

Following criteria provided in the manual will help to meet sustainable development goals. There are many ways that sustainable development may be achieved while following these criteria. For example, a development that reduces individual lot imperviousness and a development that has high lot density in one area and a large open space in another can both meet sustainable requirements.

Chapter Summary

The iSWM Criteria Manual consists of five chapters:

Chapter 1 – Introduction and Summary

Chapter 2 – *integrated* Development Process

Chapter 3 – *integrated* Design Criteria

Chapter 4 – *integrated* Construction Criteria

Chapter 5 – Additional Local Provisions

Transportation *integrated* Stormwater Management (TriSWM) Appendix[1]

1. The Transportation *integrated* Stormwater Management (TriSWM) Appendix is for use by cities, counties, and transportation agencies for the planning and design of stormwater management systems for public infrastructure projects including streets, roads, and highways. When utilized, the TriSWM Appendix is used in place of certain chapters or sections of the iSWM Criteria Manual as indicated in the appendix. Note that the TriSWM Appendix does not apply to local or residential classified streets within residential subdivisions, unless required by the local jurisdiction. Typically, runoff from residential streets is managed as part of the stormwater management system for the entire development and designed in accordance with Chapters 1 through 5 of the iSWM Criteria Manual. However, when a city or county cooperates with a developer in the construction of a collector or arterial street for access, the local government may require use of the TriSWM Appendix for that portion of the project.

Local Provisions:

Note: “Local Provisions” boxes may be used by a local government to add, delete, or modify sections of the criteria and specify the options allowed and/or required by the local government. Additional local information may be found in Chapter 5 (if used).

Applicability

iSWM is applicable under the following conditions for development and redevelopment that will ultimately disturb one or more acres as illustrated below and in Figure 1.1:

Table 1.1 iSWM Applicability

Applicable for iSWM Site Design:	Applicable for iSWM Construction:
Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger.	Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger.

A common plan of development consists of construction activity that is completed in separate stages, separate phases, or in combination with other construction activities.

Development and redevelopment are not specifically defined in this manual. The applicability is based on land disturbance activities. If an existing site has been cleared and graded, but not developed, within five years of the date of the developer's initial application submittal, the developer must consider the land conditions prior to the clearing and grading to be the existing site conditions.

New development or redevelopment in critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria as specified by the local government. Furthermore, these sites may need to utilize certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area or watershed.

Site Design below Applicable Criteria

Site developments that do not meet the applicability requirements are not subject to the regulatory water quality or streambank protection requirements. However, it is recommended that these criteria still be used and that temporary controls be provided during construction. Flood mitigation and conveyance criteria still apply. The planning process is also simplified for sites below the applicable criteria to an optional pre-development review before the final submittal of the engineering plans.

Local Provisions:

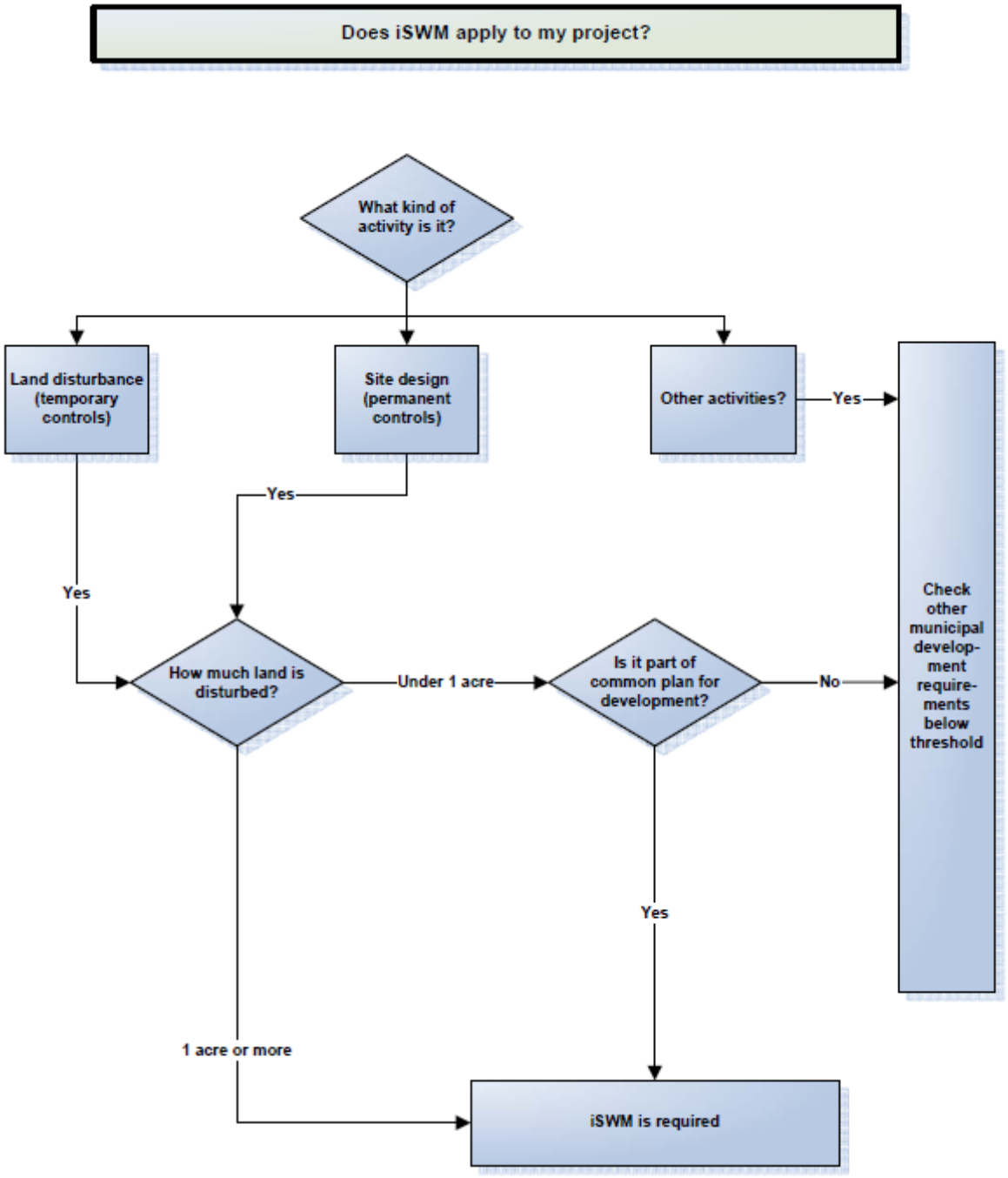

Figure 1.1 iSWM Applicability Flowchart

1.2 *integrated* Development Process

Chapter 2 of this manual presents details for completing the full iSWM development process which consists of five steps. Each of the steps builds on the previous steps to result in Final iSWM Plans and Construction Plans.

Step 1 – Review Local Requirements and Municipality's Processes

Step 2 – Collect Data and Perform Site Analysis

Step 3 – Prepare Concept/Preliminary iSWM Plans

Step 4 – Prepare Final iSWM Plans and iSWM Construction Plan

Step 5 – Prepare Operation and Maintenance Plans

Local Provisions:

1.3 *integrated* Design Criteria

Chapter 3 of this manual presents an *integrated* approach for meeting stormwater runoff quality and quantity management goals by addressing the key adverse impacts of development on stormwater runoff. Its framework consists of three focus areas, each with options in terms of how the focus area is applied.

Design Focus Areas

The stormwater management focus areas and goals are:

- **Water Quality Protection:** Remove pollutants in stormwater runoff to protect water quality
- **Streambank Protection:** Regulate discharge from the site to minimize downstream bank and channel erosion
- **Flood Mitigation and Conveyance:** Control runoff within and from the site to minimize flood risk to people and properties for the conveyance storm as well as the 100-year storm.

Each of the Design Focus Areas must be used in conjunction with the others to address the overall stormwater impacts from a development site. When used as a set, the Design Focus Areas control the entire range of hydrologic events, from the smallest runoff-producing rainfalls up to the 100-year, 24-hour storm.

Local Provisions:

Design Storms

Integrated design is based on the following four (4) storm events.

Table 1.2 Storm Events

Storm Event Name	Storm Event Description
"Water Quality"	Criteria based on a volume of 1.5 inches of rainfall, not a storm frequency
"Streambank Protection"	1-year, 24-hour storm event
"Conveyance"	25-year, 24-hour storm event
"Flood Mitigation"	100-year, 24-hour storm event

Throughout the manual the storms will be referred to by their storm event names.

Local Provisions:

Design Focus Area Application Options

There are multiple options provided to meet the required criteria for water quality protection, streambank protection, and flood mitigation. These design options are summarized in Table 1.3.

Design criteria for streambank protection and flood mitigation are based on a **downstream assessment**. The purpose of the downstream assessment is to protect downstream properties and channels from increased flooding and erosion potential due to upstream development. A downstream assessment is required to determine the extent of improvements necessary for streambank protection and flood mitigation. Downstream assessments shall be performed for streambank protection, conveyance, and flood mitigation storm events. More information on downstream assessments is provided in Section 3.3.

If a development causes no adverse impacts to existing conditions, then it is possible that little or no mitigation would be required.

Table 1.3 Summary of Options for Design Focus Areas			
Design Focus Area	**Reference Section**	**Required Downstream Assessment**	**Design Options**
Water Quality Protection	3.2	no	**Option 1:** Use *integrated* Site Design Practices for conserving natural features, reducing impervious cover, and using the natural drainage systems
			Option 2: Treat the Water Quality Protection Volume (WQ_V) by reducing total suspended solids from the development site for runoff resulting from rainfalls of up to 1.5 inches (85^{th} percentile storm)
			Option 3: Assist in implementing off-site community stormwater pollution prevention programs/activities as designated in an approved stormwater master plan or TPDES Stormwater permit
Streambank Protection	3.4	yes	**Option 1:** Reinforce/stabilize downstream conditions
			Option 2: Install stormwater controls to maintain or improve existing downstream conditions
			Option 3: Provide on-site controlled release of the 1-year, 24-hour storm event over a period of 24 hours (Streambank Protection Volume, SP_V)
Flood Mitigation and Conveyance	3.5 and 3.6	yes	**Flood Mitigation** **Option 1:** Provide adequate downstream conveyance systems
			Option 2: Install stormwater controls on-site to maintain or improve existing downstream conditions
			Option 3: In lieu of a downstream assessment, maintain existing on-site runoff conditions
			Conveyance Minimize localized site flooding of streets, sidewalks, and properties by a combination of on-site stormwater controls and conveyance systems

Local Provisions:

1.4 *integrated* Construction Criteria

Chapter 4 of this manual presents an *integrated* approach for reducing the impact of stormwater runoff from construction activities on downstream natural resources and properties. The purpose is to provide design criteria for temporary controls during construction that protect water quality by:

- Preventing soil erosion;
- Capturing sediment on-site when preventing erosion is not feasible due to construction activities; and
- Controlling construction materials and wastes to prevent contamination of stormwater.

Temporary controls to protect water quality are known as Best Management Practices (BMPs). The design of the BMPs is to be coordinated with and done at the same time as the Preliminary and Final iSWM Plans. Construction BMPs complement and work with the site grading and drainage infrastructure.

Erosion Control BMPs are designed to minimize the area of land disturbance and to protect disturbed soils from erosion. Protection can be accomplished by diverting stormwater away from the disturbed area or by stabilizing the disturbed soil. Erosion control BMPs are most important on disturbed slopes and channels where the potential for erosion is greatest. The design of erosion control BMPs must be coordinated with related grading, drainage and landscaping elements. (e.g. channel armoring, velocity dissipaters, etc.)

Sediment Control BMPs are temporary structures or devices that capture soil transported by stormwater. The BMPs are designed to function effectively with the site drainage patterns and infrastructure. An effective design ensures that the sediment control BMPs do not divert flow or flood adjacent properties and structures. Some types of permanent drainage structures, such as retention basins, can also be designed to function as a sediment control BMP during construction.

Material and Waste Control BMPs prevent construction materials and wastes from coming into contact with and being transported by stormwater. These BMPs consist of a combination of notes to direct contractor and temporary construction controls.

The iSWM Construction Criteria are the minimum requirements for temporary controls during construction. The state permit and requirements for stormwater discharges associated with construction activities must also be followed. More information on state requirements is provided in Section 4.2.

Local Provisions:

1.5 Transportation *integrated* Stormwater Management (TriSWM) Criteria

The TriSWM Appendix presents an *integrated* approach for reducing the impact of stormwater runoff associated with public linear transportation infrastructure projects. The TriSWM Appendix has been incorporated as an expansion of the iSWM Criteria Manual for Site Development and Construction for use by cities, counties, and transportation agencies (and in some cases private developers) in the planning and design of stormwater management systems for public streets, roads, and highways.

Transportation design, construction and operation practices are unique when contrasted with site/parcel development and require equally unique approaches to stormwater management. New public roadway, street, and highway projects are distinct from private site development and they require some specific strategies to more fully integrate stormwater design. In the larger context, the interrelation between

parcel development and transportation projects represent important challenges and opportunities to truly integrate stormwater management in urban areas and infrastructure.

The process of coordinating more effective stormwater management for new public transportation infrastructure projects, as well as significant expansion projects, starts with a full integration into the project planning and design process. This involves a comprehensive planning approach and a thorough understanding of the physical characteristics and natural resources in proximity to the proposed route.

The information presented in the TriSWM Appendix provides design guidance and a framework for incorporating effective and environmentally sensitive stormwater management into the public street and highway project development process in order to meet the following goals:

- Provide safe driving conditions
- Minimize the upstream and downstream flood risk to people and properties
- Minimize downstream bank and channel erosion
- Reduce pollutants in stormwater runoff to protect water quality.

Note: Stormwater runoff from residential streets should be managed as part of the overall stormwater management system for the entire site. Chapters 1 through 5 of the iSWM Criteria Manual for Site Development and Construction should be used for the planning and design of stormwater management facilities for residential subdivisions and internal residential streets. The TriSWM Appendix does not apply to streets within residential subdivisions, unless required by the local jurisdiction. However, when a city or county cooperates with a developer in the construction of a collector or arterial street for access, the local government may require the use of the TriSWM Appendix for that portion of the project.

Local Provisions:

2.0 *integrated* Development Process

This Chapter discusses the five-step development process. Local governments will integrate these processes into their current process by the addition of local provisions.

2.1 Planning

A formal *integrated* Stormwater Management Development Process shall be implemented to meet the stormwater management goals and to see that local stormwater guidelines and requirements are implemented. The process shall include the steps, meetings, and documents that must be met by the developer. The five-step process described herein includes the following:

- The iSWM Plans: The iSWM Plans are the documents that summarize the data collected in steps 1 and 2 and are shown on the conceptual/preliminary and final plans that must be submitted to the municipality as part of steps 3, 4, and 5. Each submittal must follow the criteria outlined in Chapters 2 and 3. Submittals shall include information in accordance with the checklists that are included in Chapter 5.
- The iSWM Construction Plan: The iSWM Construction Plan is the document that uses data collected in steps 1 and 2 to protect water quality during construction. It is submitted to the municipality with the Final iSWM Plans in Step 4. An overview of the iSWM construction plan content is covered in Section 2.2. More detailed criteria for the iSWM Construction Plan are outlined in Chapter 4.

The iSWM Plans and iSWM Construction Plan are a subset of the overall development process that occurs throughout the planning and development cycle of a project and then continues after construction is completed via regular inspection and maintenance of the stormwater management system.

In addition to these plans, stormwater master plans are an important tool used to assess and prioritize both existing and potential future stormwater problems and to consider alternative stormwater management solutions. Local governments may have individual watershed plans, or several governments may work cooperatively to develop a unified approach to watershed planning, development controls, permit compliance, multi-objective use of floodplain and other areas, and property protection. Refer to the Local Provisions in Step 1 under Section 2.2 where regional approaches (if any) are identified.

2.2 Steps in the Development Process

This section describes the typical contents and general procedure for preparing iSWM Plans and the iSWM Construction Plan. The level of detail involved in the plans will depend on the project size and the individual site and development characteristics. Figure 2.1 lays out the five-step process. Each of the following steps builds on the previous steps to result in the Final iSWM Site and Construction Plans:

Step 1 – Review Local Requirements and Municipality's Processes

Step 2 – Collect Data and Perform Site Analysis

Step 3 – Prepare Concept/Preliminary iSWM Plans

Step 4 – Prepare Final iSWM Plans and iSWM Construction Plan

Step 5 – Prepare Operation and Maintenance Plans

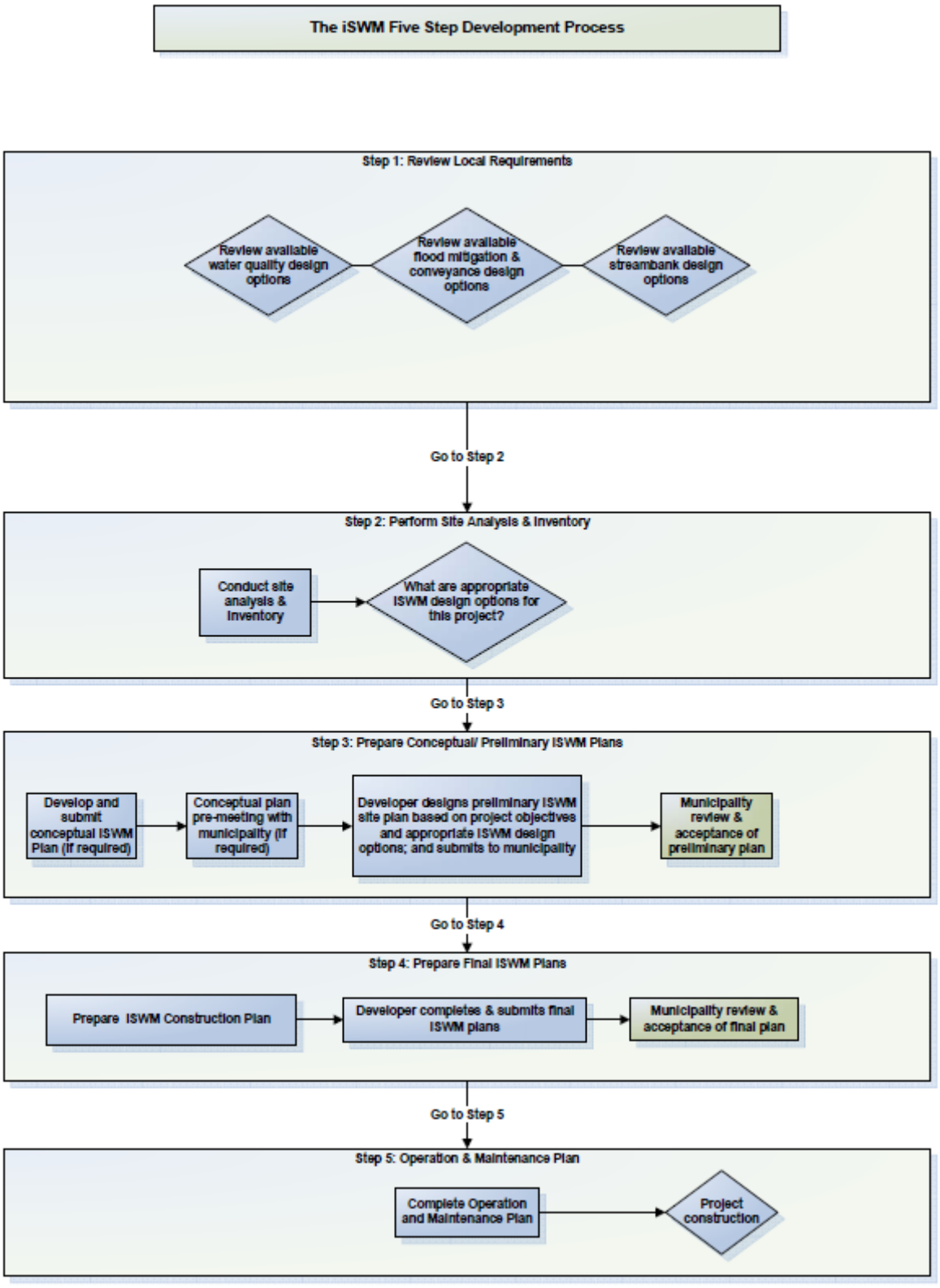

Figure 2.1 iSWM Flowchart

Step 1 – Review Local Requirements and Municipality Processes

The site developer shall become familiar with the local stormwater management, development requirements and design criteria that apply to the site. These requirements include:

- iSWM Criteria Manual for Site Development and Construction (this manual including all local provisions)
- Available online iSWM Program documents
  - iSWM Technical Manual
  - iSWM Tools
  - iSWM Program Guidance
- State and Federal Regulatory Requirements
- Other Local Municipal Ordinances and Criteria
  - Platting Procedures
  - Zoning Requirements
  - Development Codes and Procedures
  - Tree and Landscape Requirements
  - Special Use Permits
  - Drainage Master Plans and Watershed Plans
  - Erosion Control Plans
  - Floodplain Ordinances
  - Grading Plan Requirements
  - Construction/Building Permit Notifications and Requirements

Information regarding the above items can be obtained from this manual or at a pre-submittal (or similar) meeting with the municipality.

A critical part of any project involves the proposed development working closely with various departments within the municipality. Integrating the stormwater practices with other regulatory requirements will promote a sustainable development.

Opportunities for special types of development (e.g., clustering) or special land use opportunities (e.g., conservation easements or tax incentives) must be investigated. In addition, there may be an ability to partner with a local community for the development of greenways or other riparian corridor or open space developments.

All applicable State and Federal regulatory requirements must be met.

Local Provisions:

Step 2 – Collect Data and Perform Site Analysis

Using field and mapping techniques approved by the municipality, the site engineer shall collect and review information on the existing site conditions and map the following site features:

- Topography
- Drainage patterns and basins
- Intermittent and perennial streams on-site and off-site waters that will receive discharges from the proposed development
- Property lines, adjacent areas and easements
- Wetlands and critical habitat areas
- Boundaries of wooded areas and tree

- Soil types and their susceptibility to erosion
- Ground cover and vegetation, particularly unique or sensitive vegetation areas to be protected during development
- Existing development
- Existing stormwater facilities on-site and off-site facilities that will receive discharges from the proposed development
- clusters
- Floodplain boundaries
- Steep slopes
- Required buffers and setbacks along water bodies
- Proposed stream crossing locations
- Other required protection areas

The site analysis shall be summarized in the conceptual/preliminary iSWM Plans along with any other supporting documents. The data collected and analyzed during this step of the development process shall be used as the starting point for preparing the iSWM Plans and the iSWM Construction Plan.

Local Provisions:

Step 3 –Prepare Conceptual/Preliminary iSWM Plans

Conceptual iSWM Plan

Based on the review of existing conditions and site analysis, the design engineer shall develop and submit a Conceptual iSWM Plan for the project. The Conceptual iSWM 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 following steps shall be followed in developing the Conceptual iSWM Plan with the help of the Checklist for Conceptual iSWM Plans found in Chapter 5 of this manual:

1. Use *integrated* Site Design Practices (Section 3.2.2) 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
   - Reducing impervious surface area through various techniques
   - Preserving and utilizing the natural drainage system wherever possible
2. Determine the credits for *integrated* Site Design (Section 3.2.2) and water quality volume reduction (Section 3.2.3) as applicable, to be accounted for in the design of structural and non-structural stormwater controls on the site.
3. Calculate conceptual estimates of the locally required focus area design requirements for water quality protection, streambank protection, and flood mitigation (Sections 3.2, 3.4, 3.5) based on the conceptual plan site layout.
4. Perform screening and conceptual selection of appropriate temporary and permanent structural stormwater controls (Section 3.8 and Section 4.0) and identification of potential site locations.

It is extremely important at this stage that stormwater system design is integrated into the overall site design concept in order to best and most cost-effectively reduce the impacts of the development as well as provide for the most cost-effective and environmentally sensitive approach. Using hydrologic calculations, the goal of mimicking pre-development conditions can serve a useful purpose in planning the stormwater management system.

Local Provisions:

Preliminary iSWM Plans

The Preliminary iSWM Plan ensures that requirements and criteria are complied with and opportunities are taken to minimize adverse impacts from the development. This step builds on the data developed in the Conceptual iSWM Plan by refining and providing more detail to the concepts identified. If no Conceptual Plan is submitted, it shall be part of the Preliminary iSWM Plan. The checklist for Preliminary iSWM Plan in Chapter 5 outlines the data that shall be included in the preliminary iSWM Plan.

The Preliminary iSWM Plan shall consist of maps, plan sheets, narrative, and supporting design calculations (hydrologic and hydraulic) for the proposed stormwater management system. The completed Preliminary iSWM Plan shall be submitted to the local review authority for review and comment.

Local Provisions:

Step 4 – Prepare Final iSWM Plans and iSWM Construction Plan

The Final iSWM Plans and iSWM Construction Plan shall be prepared together and submitted to the local review authority for approval prior to any soil disturbance or other construction activities on the development site. The Final iSWM Plans add further detail to the Preliminary iSWM Plan and reflect changes that are requested or required by the local review authority.

The Final iSWM Plans and iSWM Construction Plan, as outlined in the final iSWM Plan checklist in Chapter 5, shall include all of the revised elements of the Preliminary iSWM Plans as well as a landscape plan, operation and maintenance plan, and any permits/waiver requests.

Local Provisions:

Step 5 – Complete Operations and Maintenance Plan

An Operations and Maintenance Plan shall be developed in accordance with this section. The plan shall be included in the Final iSWM Plan. It needs to clearly state which entity has responsibility for operation and maintenance of temporary and permanent stormwater controls and drainage facilities to ensure they function properly from the time they are first installed.

The Operations and Maintenance Plan shall include but is not limited to:

- Responsible party for all tasks in the plan
- Inspection and maintenance requirements
- Maintenance of permanent stormwater controls and drainage facilities during construction
- Cleaning and repair of permanent stormwater controls and drainage facilities before transfer of ownership

- Frequency of inspections for the life of the permanent structures
- Funding source for long-term maintenance
- Description of maintenance tasks and frequency of maintenance
- Access and safety issues
- Maintenance easements
- Reviewed and approved maintenance agreements
- Testing and disposal of sediments
- Life span of structures and replacement as needed

Guidance for development of Operations and Maintenance Plans has been provided with each temporary and permanent Best Management Practice (BMP) included in the *Stormwater Controls Technical Manual* sections.

Local Provisions:

3.0 *integrated* Design Criteria

This chapter gives details on criteria to meet the three focus areas of water quality, stream bank protection and flood mitigation, as well as information supportive of hydrology and stormwater conveyance.

3.1 Hydrologic Methods

3.1.1 Types of Hydrologic Methods

There are a number of empirical hydrologic methods available to estimate runoff characteristics for a site or drainage sub basin. However, the following methods have been selected to support hydrologic site analysis for the design methods and procedures included in this manual:

- Rational Method
- SCS Unit Hydrograph Method
- Snyder's Unit Hydrograph Method
- USGS & TXDOT Regression Equations
- iSWM Water Quality Protection Volume Calculation
- Water Balance Calculations

Table 3.1 lists the hydrologic methods and the circumstances for their use in various analysis and design applications. Table 3.2 provides some limitations on the use of several methods.

In general:

- The Rational Method is acceptable for small, highly impervious drainage areas, such as parking lots and roadways draining into inlets and gutters.
- The U.S. Geological Survey (USGS) and Texas Department of Transportation (TXDOT) regression equations are acceptable for drainage areas with characteristics within the ranges given for the equations shown in Table 3.2. These equations should not be used when there are significant storage areas within the drainage basin or where other drainage characteristics indicate general regression equations are not appropriate.

Local Provisions:

Table 3.1 Applications of the Recommended Hydrologic Methods

Method	Rational Method	SCS Method	Modified Rational	Snyder's Unit Hydrograph	USGS / TXDOT Equations	iSWM Water Quality Volume Calculation
Water Quality Protection Volume (WQ_v)						✓
Streambank Protection Volume (SP_v)		✓		✓		
Flood Mitigation Discharge (Q_f)		✓		✓	✓	
Storage Facilities		✓	✓	✓		
Outlet Structures		✓		✓		
Gutter Flow and Inlets	✓					
Storm Drain Pipes	✓	✓		✓		
Culverts	✓	✓		✓	✓	
Bridges		✓		✓		
Small Ditches	✓	✓		✓		
Open Channels		✓		✓	✓	
Energy Dissipation		✓		✓		

Table 3.2 Constraints on Using Recommended Hydrologic Methods

Method	Size Limitations[1]	Comments
Rational	0 – 100 acres	Method can be used for estimating peak flows and the design of small site or subdivision storm sewer systems.
Modified Rational[2]	0 – 200 acres	Method can be used for estimating runoff volumes for storage design.
Unit Hydrograph (SCS)[3]	Any Size	Method can be used for estimating peak flows and hydrographs for all design applications.
Unit Hydrograph (Snyder's)[4]	1 acre and larger	Method can be used for estimating peak flows and hydrographs for all design applications.
TXDOT Regression Equations	10 to 100 mi^2	Method can be used for estimating peak flows for rural design applications.
USGS Regression Equations	3 – 40 mi^2	Method can be used for estimating peak flows for urban design applications.
*i*SWM Water Quality Protection Volume Calculation	Limits set for each Structural Control	Method can be used for calculating the Water Quality Protection Volume (WQ_v).

[1] Size limitation refers to the drainage basin for the stormwater management facility (e.g., culvert, inlet).
[2] Where the Modified Rational Method is used for conceptualizing, the engineer is cautioned that the method could underestimate the storage volume.
[3] This refers to SCS routing methodology included in many readily available programs (such as HEC-HMS or HEC-1) that utilize this methodology.
[4] This refers to the Snyder's methodology included in many readily available programs (such as HEC-HMS or HEC-1) that utilize this methodology.

Local Provisions:

3.1.2 Rainfall Estimation

Rainfall intensities are provided in *Section 5.0 of the Hydrology Technical Manual* for the nine (9) counties within the North Central Texas Council of Governments. The intensities are based on a combination of data from Hydro-35 and USGS. These intensities shall be used for all hydrologic analysis within the applicable county.

Local Provisions:

3.2 Water Quality Protection

3.2.1 Introduction

iSWM requires the use of *integrated* Site Design Practices as the primary means to protect the water quality of our streams, lakes, and rivers from the negative impacts of stormwater runoff from development. The *integrated* Site Design Practices shall be designed as part of the iSWM Plans. In addition to the *integrated* Site Design Practices, required water quality protection can be achieved by two additional options: (1) by treating the water quality protection volume and (2) assisting with off-site pollution prevention activities. These three approaches are described below.

Local Provisions:

3.2.2 Option 1: integrated Site Design Practices and Credits

The *integrated* Site Design Practices are methods of development that reduce the "environmental footprint" of a site. They feature conservation of natural features, reduced imperviousness, and the use of the natural drainage system. In this option, points are awarded for the use of different Site Design Practices. A minimum number of points are needed to meet the iSWM requirements for Water Quality. Additional points can be gained to qualify for development incentives.

List of *integrated* Site Design Practices and Techniques

Twenty *integrated* Site Design Practices are grouped into four categories listed below. Not all practices are applicable to every site.

- **Conservation of Natural Features and Resources**
  1. Preserve Undisturbed Natural Areas
  2. Preserve Riparian Buffers
  3. Avoid Floodplains
  4. Avoid Steep Slopes
  5. Minimize Siting on Porous or Erodible Soils
- **Lower Impact Site Design Techniques**
  6. Fit Design to the Terrain
  7. Locate Development in Less Sensitive Areas
  8. Reduce Limits of Clearing and Grading
  9. Utilize Open Space Development

10. Consider Creative Designs

- **Reduction of Impervious Cover**
  11. Reduce Roadway Lengths and Widths
  12. Reduce Building Footprints
  13. Reduce the Parking Footprint
  14. Reduce Setbacks and Frontages
  15. Use Fewer or Alternative Cul-de-Sacs
  16. Create Parking Lot Stormwater "Islands"
- **Utilization of Natural Features for Stormwater Management**
  17. Use Buffers and Undisturbed Areas
  18. Use Natural Drainageways Instead of Storm Sewers
  19. Use Vegetated Swale Instead of Curb and Gutter
  20. Drain Rooftop Runoff to Pervious Areas

More detail on each site design practice is provided in the *integrated* Site Design Practice Summary Sheets in *Section 2.2 of the Planning Technical Manual*.

Local Provisions:

Integration of Site Design Practices into Site Development Process

During the site planning process described in Chapter 2, there are several steps involved in site layout and design, each more clearly defining the location and function of the various components of the stormwater management system. To be most effective and easier to incorporate, *integrated* Site Design Practices should be part of this overall development process as outlined in Table 3.3.

Table 3.3 Integration of Site Design Practices with Site Development Process	
Site Development Phase	**Site Design Practice Activity**
Site Analysis	• Identify and delineate natural feature conservation areas (natural areas and stream buffers) • Perform site reconnaissance to identify potential areas for and types of credits • Determine stormwater management requirements
Conceptual Plan	• Preserve natural areas and stream buffers during site layout • Reduce impervious surface area through various techniques • Identify locations for use of vegetated channels and groundwater recharge • Look for areas to disconnect impervious surfaces • Document the use of site design practices
Preliminary and Final Plan	• Perform layout and design of credit areas – integrating them into treatment trains • Ensure *integrated* Focus Areas are satisfied • Ensure appropriate documentation of site design credits according to local requirements
Construction	• Ensure protection of key areas • Ensure correct final construction of areas needed for credits • Inspect and maintain implementation of BMPs during construction
Final Inspection	• Develop maintenance requirements and documents • Ensure long term protection and maintenance • Ensure credit areas are identified on final plan and plat if applicable

Point System

All sites that meet iSWM applicability must provide on-site enhanced water quality protection. Under the *integrated* Site Design Practice option, sites that accumulate a minimum number of points by incorporating *integrated* Site Design Practices are considered to have provided enhanced water quality protection.

The point system is made up of three components:

1. The initial percentage of the site that has been previously disturbed sets the minimum requirement. This is shown in the left-hand column of Table 3.4.
2. A minimum required total of Water Quality Protection (WQP) points is needed to meet the basic water quality criteria. This minimum is shown in the center column of Table 3.4.
3. Optional additional points can be accumulated through additional use of Site Design Practices to be eligible for developer incentives. Each developer incentive attained requires ten (10) additional Site Design Practice points above the minimum required points as shown in the right-hand column of Table 3.4.

As shown in Table 3.4, the initial percentage of site disturbance sets the minimum required points necessary to meet Water Quality Protection criteria. If a developer wishes to go beyond this minimum then the number of additional points required to attain specific development incentives is also given.

Table 3.4 *integrated* Site Design Point Requirements

Percentage of Site(by Area) with Natural Features Prior to Proposed Development	Minimum Required Points for Water Quality Protection (WQP)	Additional Points Above WQP for Development Incentives
> 50%	50	10 points each
20 - 50%	30	10 points each
< 20%	20	10 points each

The minimum number of points required to achieve WQP, as shown in the center column of Table 3.4, depends on the proportion of undisturbed natural features that exist on the site before it is developed. It is assumed that disturbing a site that has little previously disturbed area will cause more relative environmental impact than a site that has already incurred significant site disturbance. Therefore, disturbing a "pristine" site carries a higher restoration/preservation requirement.

For the purpose of this evaluation, undisturbed natural features are areas with one or more of the following characteristics:

- Unfilled floodplain
- Stand of trees, forests
- Established vegetation
- Steep sloped terrain
- Creeks, gullies, and other natural stormwater features
- Wetland areas and ponds

The number of points credited for the use of *integrated* Site Design Practices is shown in Table 3.5. To determine the qualifying points for a site, the developer must reference Table 3.5 and follow the guidance for each practice in the *Planning Technical Manual*.

Using the area of the site that is eligible for a practice as a basis, points are given for the percent of that area to which the *integrated* Site Design Practice is applied. For example, if a planned site has four (4) acres of riparian buffer and the developer proposes to preserve two (2) acres, then the site would qualify for 50 percent of the 8 credit points for iSWM Site Design Practice 2 (Preserve Riparian Buffers), because 50 percent of the site design practice was incorporated. The actual points earned for iSWM Site Design Practice 2 would be 4 points (0.50 * 8 pts = 4 pts). To comply with water quality protection and to apply for site design credits, the developer must submit the completed table and associated documentation or calculations to the review authority.

Table 3.5 Point System for *integrated* Site Design Practices				
***i*SWM Practice No.**	**Practice**	**Percent of Eligible Area Using Practice**	**Maximum Points**	**Actual Points Earned (% practice used * max. points)**
Conservation of Natural Features and Resources				
1	Preserve/Create Undisturbed Natural Areas		8	
2	Preserve or Create Riparian Buffers Where Applicable		8	
3	Avoid Existing Floodplains or Provide Dedicated Natural Drainage Easements		8	
4	Avoid Steep Slopes		3	
5	Minimize Site on Porous or Erodible Soils		3	
Lower Impact Site Design				
6	Fit Design to the Terrain		4	
7	Locate Development in Less Sensitive Areas		4	
8	Reduce Limits of Clearing and Grading		6	
9	Utilize Open Space Development		8	
10	Incorporate Creative Design (e.g. Smart Growth, LEED Design, Form Based Zoning)		8	
Reduction of Impervious Cover				
11	Reduce Roadway Lengths and Widths		4	
12	Reduce Building Footprints		4	
13	Reduce the Parking Footprint		5	
14	Reduce Setbacks and Frontages		4	
15	Use Fewer or Alternative Cul-de-Sacs		3	
16	Create Parking Lot Stormwater “Islands”		5	
Utilization of Natural Features				
17	Use Buffers and Undisturbed Areas		4	
18	Use Natural Drainageways Instead of Storm Sewers		4	
19	Use Vegetated Swale Design		3	
20	Drain Runoff to Pervious Areas		4	
Subtotal – Actual site points earned			**100**	
Subtract minimum points required (Table 3.4) -				
Points available for development incentives				
Add 1 point for each 1% reduction of impervious surface +				
Total Points for Development Incentives				

Local Provisions:

Development Incentives

The developer can use *integrated* Site Design Practice points in excess of the minimum required for water quality protection to qualify for development incentives provided by the municipality. Additional points can be earned for redevelopment sites. Each reduction of one (1) percent imperviousness from existing conditions qualifies for one (1) site design point. The total points available for development incentives shall be calculated per Table 3.5. Each incentive requires ten (10) additional points above the minimum point required to meet water quality criteria, as stated in Table 3.4.

A list of available development incentives includes:

1. Narrower pavement width for minor arterials
2. Use of vegetated swales in lieu of curb and gutter for eligible developments
3. Reduced ROW requirements, i.e. Sidewalk/Utility Easements
4. Increased density in buildable area, floor area ratios, or additional units in buildable area
5. Expedited Plans review and inspection
6. Waiver or reduction of fees
7. Local government public-private partnerships
8. Waiver of maintenance, public maintenance
9. Stormwater user fee credits or discounts
10. Rebates, local grants, reverse auctions
11. Low interest loans, subsidies, tax credits, or financing of special green projects
12. Awards and recognition programs
13. Reductions in other requirements

Local Provisions:

3.2.3 Option 2: Treat the Water Quality Protection Volume

Treat the Water Quality Protection Volume by reducing total suspended solids from the development site for runoff resulting from rainfall of 1.5 inches (85th percentile storm). Stormwater runoff equal to the Water Quality Protection Volume generated from sites must be treated using a variety of on-site structural and nonstructural techniques with the goal of removing a target percentage of the average annual total suspended solids.

A system has been developed by which the Water Quality Protection Volume can be reduced, thus requiring less structural control. This is accomplished through the use of certain reduction methods, where affected areas are deducted from the site area, thereby reducing the amount of runoff to be treated. For more information on the Water Quality Volume Reduction Methods see *Section 1.3 of the*

Water Quality Technical Manual.

Water Quality Protection Volume

The Water Quality Protection Volume (WQ_v) is the runoff from the first 1.5 inches of rainfall. Thus, a stormwater management system designed for the WQ_v will treat the runoff from all storm events of 1.5 inches or less, as well as a portion of the runoff for all larger storm events. For methods to determine the WQ_v, see *Section 1.2 of the Water Quality Technical Manual*.

Local Provisions:

Recommended Stormwater Control Practices

Below is a list of recommended structural stormwater control practices. These structural controls are recommended for use in a wide variety of applications and have differing abilities to remove various kinds of pollutants. It may take more than one control to achieve a certain pollution reduction level. A detailed discussion of each of the controls, as well as design criteria and procedures, can be found in the *Site Development Controls Technical Manual*. Refer to Table 3.6 for details regarding primary and secondary controls.

- Bioretention
- Enhanced swales (dry, wet, wetland)
- Alum treatment
- Detention
- Filter strips
- Sand filters, filter boxes, etc
- Infiltration wells and trenches
- Ponds
- Porous surfaces
- Proprietary systems
- Green roofs
- Rainwater harvesting
- Wetlands
- Submerged gravel wetlands

Local Provisions:

Using Other or New Structural Stormwater Controls

Innovative technologies will be allowed and encouraged. Any such system will be required to provide sufficient documentation as to its effectiveness and reliability. Communities can allow controls not included in this manual at their discretion. However, these communities shall require third party proof of performance, maintenance, application requirements, and limitations.

More specifically, new structural stormwater control designs will not be accepted for inclusion in the manual until independent performance data shows that the structural control conforms to local and/or State criteria for treatment, conveyance, maintenance, and environmental impact.

Suitability of Stormwater Controls to Meet Stormwater Management Goals

The stormwater control practices recommended in this manual vary in their applicability and ability to meet stormwater management goals:

Primary Controls

Primary Structural Stormwater Controls have the ability to fully address one or more of the Steps in the *integrated* Focus Areas if designed appropriately. Structural controls are recommended for use with a wide variety of land uses and development types. These structural controls have a demonstrated ability to effectively treat the Water Quality Volume (WQv) and have been shown to be able to remove 70% to 80% of the annual average total suspended solids (TSS) load in typical post-development urban runoff when designed, constructed, and maintained in accordance with recommended specifications. Several of these structural controls can also be designed to provide primary control for downstream streambank protection (SPv) and flood mitigation. These structural controls are recommended stormwater management facilities for a site wherever feasible and practical.

Secondary Controls

A number of structural controls are recommended only for limited use or for special site or design conditions. Generally, these practices either: (1) do not have the ability on their own to fully address one or more of the Steps in the *integrated* Focus Areas, (2) are intended to address hotspot or specific land use constraints or conditions, and/or (3) may have high or special maintenance requirements that may preclude their use. These types of structural controls are typically used for water quality treatment only. Some of these controls can be used as pretreatment measures or in series with other structural controls to meet pollutant removal goals. Such structural controls are not recommended for residential developments.

Table 3.6 summarizes the stormwater management suitability of the various stormwater controls in addressing the *integrated* Focus Areas. The *Site Development Controls Technical Manual* provides guidance on the use of stormwater controls as well as how to calculate the pollutant removal efficiency for stormwater controls in series. The *Site Development Controls Technical Manual* also provides guidance for choosing the appropriate stormwater control(s) for a site as well as the basic considerations and limitations on the use of a particular stormwater control.

Table 3.6 Suitability of Stormwater Controls to Meet *integrated* Focus Areas

Category	*integrated* Stormwater Controls	TSS/ Sediment Removal Rate	Water Quality Protection	Streambank Protection	On-Site Flood Control	Downstream Flood Control
Bioretention Areas	Bioretention Areas	80%	P	S	S	-
Channels	Enhanced Swales	80%	P	S	S	S
	Channels, Grass	50%	S	S	P	S
	Channels, Open	-	-	-	P	S
Chemical Treatment	Alum Treatment System	90%	P	-	-	-
Conveyance System Components	Culverts	-	-	-	P	P
	Energy Dissipation	-	-	P	S	S
	Inlets/Street Gutters	-	-	-	P	-
	Pipe Systems	-	-	P	P	P
Detention	Detention, Dry	65%	S	P	P	P
	Detention, Extended Dry	65%	S	P	P	P
	Detention, Multi-purpose Areas	-	-	P	P	P
	Detention, Underground	-	-	P	P	P
Filtration	Filter Strips	50%	S	-	-	-
	Organic Filters	80%	P	-	-	-
	Planter Boxes	80%	P	-	-	-
	Sand Filters, Surface/Perimeter	80%	P	S	-	-
	Sand Filters, Underground	80%	P	-	-	-
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	S	-	-	-
Infiltration	Downspout Drywell	80%	P	-	-	-
	Infiltration Trenches	80%	P	S	-	-
	Soakage Trenches	80%	P	S	-	-
Ponds	Wet Pond	80%	P	P	P	P
	Wet ED Pond	80%	P	P	P	P
	Micropool ED Pond	80%	P	P	P	P
	Multiple Ponds	80%	P	P	P	P
Porous Surfaces	Green Roof	85%	P	S	-	-
	Modular Porous Paver Systems	[2]	S	S	-	-
	Porous Concrete	[2]	S	S	-	-
Proprietary Systems	Proprietary Systems [1]	[1]	S/P	S	S	S
Re-Use	Rain Barrels	-	P	-	-	-
Wetlands	Wetlands, Stormwater	80%	P	P	P	P
	Wetlands, Submerged Gravel	80%	P	P	S	-

P = Primary Control: Able to meet design criterion if properly designed, constructed and maintained.
S = Secondary Control: May partially meet design criteria. Designated as a Secondary control due to considerations such as maintenance concerns. For Water Quality Protection, recommended for limited use in approved community-designated

areas.
- = Not typically used or able to meet design criterion.
[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data, if used as a primary control. Third-party sources could include Technology Acceptance Reciprocity Partnership, Technology Assessment Protocol – Ecology, or others.
[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

3.2.4 Option 3: Assist with Off-Site Pollution Prevention Programs and Activities

Some communities have implemented pollution prevention programs/activities in certain areas to remove pollutants from the runoff after it has been discharged from the site. This may be especially true in intensely urbanized areas facing site redevelopment where many of the BMP criteria would be difficult to apply. These programs will be identified in the local jurisdiction's approved TPDES stormwater permit and/or in a municipality's approved watershed plan. In lieu of on-site treatment, the developer can request to simply assist with the implementation of these off-site pollution prevention programs/activities.

Developers should contact the municipality to determine if there are any plans to address runoff pollutants within the region of proposed development. If no plans exist, consider proposing regional alternatives that would address pollution prevention.

Local Provisions:

3.3 Acceptable Downstream Conditions

As part of the iSWM Plan development, the downstream impacts of development must be carefully evaluated for the two focus areas of Streambank Protection and Flood Mitigation. The purpose of the downstream assessment is to protect downstream properties from increased flooding and downstream channels from increased erosion potential due to upstream development. The importance of the downstream assessment is particularly evident for larger sites or developments that have the potential to dramatically impact downstream areas. The cumulative effect of smaller sites, however, can be just as dramatic and, as such, following the *integrated* Focus Areas is just as important for the smaller sites as it is for the larger sites.

The assessment shall extend from the outfall of a proposed development to a point downstream where the discharge from a proposed development no longer has a significant impact, in terms of flooding increase or velocity above allowable, on the receiving stream or storm drainage system. The local jurisdiction shall be consulted to obtain records and maps related to the National Flood Insurance Program and the availability of Flood Insurance Studies and Flood Insurance Rate Maps (FIRMs) which will be helpful in this assessment. The assessment shall be a part of the preliminary and final iSWM plans, and must include the following properties:

- Hydrologic analysis of the pre- and post-development on-site conditions
- Drainage path that defines extent of the analysis
- Capacity analysis of all existing constraint points along the drainage path, such as existing floodplain developments, underground storm drainage systems culverts, bridges, tributary confluences, or channels
- Offsite undeveloped areas are considered as "full build-out" for both the pre- and post-development analyses
- Evaluation of peak discharges and velocities for three 24-hour storm events
  - Streambank protection storm

  - Conveyance storm
  - Flood mitigation storm
- Separate analysis for each major outfall from the proposed development

Once the analysis is complete, the designer must answer the following three questions at each determined junction downstream:

- Are the post-development discharges greater than the pre-development discharges?
- Are the post-development velocities greater than the pre-development velocities?
- Are the post-development velocities greater than the velocities allowed for the receiving system?
- Are the post-development flood heights more than 0.1 feet above the pre-development flood heights?

These questions shall be answered for each of the three storm events. The answers to these questions will determine the necessity, type, and size of non-structural and structural controls to be placed on-site or downstream of the proposed development.

Section 2.0 of the Hydrology Technical Manual gives additional guidance on calculating the discharges and velocities, as well as determining the downstream extent of the assessment.

Local Provisions:

3.4 Streambank Protection

The second focus area is in streambank protection. There are three options by which a developer can provide adequate streambank protection downstream of a proposed development. The first step is to perform the required downstream assessment as described in Section 3.3. If it is determined that the proposed project does not exceed acceptable downstream velocities or the downstream conditions are improved to adequately handle the increased velocity, then no additional streambank protection is required. If on-site or downstream improvements are required for streambank protection, easements or right-of-entry agreements will need to be obtained in accordance with Section 3.7. If the downstream assessment shows that the velocities are within acceptable limits, then no streambank protection is required. Acceptable limits for velocity control are contained in Tables 3.10 and 3.11.

Option 1: Reinforce/Stabilize Downstream Conditions

If the increased velocities are greater than the allowable velocity of the downstream receiving system, then the developer must reinforce/stabilize the downstream conveyance system. The proposed modifications must be designed so that the downstream system is protected from the post-development velocities. The developer must provide supporting calculations and/or documentation that the downstream velocities do not exceed the allowable range once the downstream modifications are installed.

Allowable bank protection methods include stone riprap, gabions, and bio-engineered methods. *Sections 3.2 and 4.0 of the Hydraulics Technical Manual* give design guidance for designing stone riprap for open channels, culvert outfall protection, riprap aprons for erosion protection at outfalls, and riprap basins for energy dissipation.

Local Provisions:

Option 2: Install Stormwater Controls to Maintain Existing Downstream Conditions

The developer must use on-site controls to keep downstream post-development discharges at or below allowable velocity limits. The developer must provide supporting calculations and/or documentation that the on-site controls will be designed such that downstream velocities for the three storm events (Streambank Protection, Conveyance, and Flood Mitigation) are within an allowable range once the controls are installed.

Local Provisions:

Option 3: Control the Release of the 1-yr, 24-hour Storm Event

Twenty-four hours of extended detention shall be provided for on-site, post-developed runoff generated by the 1-year, 24-hour rainfall event to protect downstream channels. The required volume for extended detention is referred to as the Streambank Protection Volume (denoted SP_v). The reduction in the frequency and duration of bankfull flows through the controlled release provided by extended detention of the SP_v will reduce the bank scour rate and severity.

To determine the SP_v refer to *Section 3.0 of the Hydrology Technical Manual*.

Local Provisions:

3.5 Flood Mitigation

3.5.1 Introduction

Flood analysis is based on the design storm events as defined in Section 1.3: for conveyance storm and the flood mitigation storm.

The intent of the flood mitigation criteria is to provide for public safety; minimize on-site and downstream flood impacts from the three storm events; maintain the boundaries of the mapped 100-year floodplain; and protect the physical integrity of the on-site stormwater controls and the downstream stormwater and flood mitigation facilities.

Flood mitigation must be provided for on-site conveyance system, as well as downstream outfalls as described in the following sections.

3.5.2 Flood Mitigation Design Options

There are three options by which a developer may address downstream flood mitigation. These options closely follow the three options for Streambank Protection. When on-site or downstream modifications are required for downstream flood mitigation, easements or right-of-entry agreements will need to be obtained in accordance with Section 3.7.

The developer will provide all supporting calculations and/or documentation to show that the existing downstream conveyance system has capacity (Q_f) to safely pass the full build-out flood mitigation storm discharge.

Option 1: Provide Adequate Downstream Conveyance Systems

When the downstream receiving system does not have adequate capacity, then the developer shall provide modifications to the off-site, downstream conveyance system. If this option is chosen the proposed modifications must be designed to adequately convey the full build-out stormwater peak discharges for the three storm events. The modifications must also extend to the point at which the discharge from the proposed development no longer has a significant impact on the receiving stream or storm drainage system. The developer must provide supporting calculations and/or documentation that the downstream peak discharges and water surface elevations are safely conveyed by the proposed system, without endangering downstream properties, structures, bridges, roadways, or other facilities.

Option 2: Install Stormwater Controls to Maintain Existing Downstream Conditions

When the downstream receiving system does not have adequate capacity, then the developer shall provide stormwater controls to reduce downstream flood impacts. These controls include on-site controls such as detention, regional controls, and, as a last resort, local flood protection such as levees, floodwalls, floodproofing, etc.

The developer must provide supporting calculations and/or documentation that the controls will be designed and constructed so that there is no increase in downstream peak discharges or water surface elevations due to development.

Option 3: In lieu of a Downstream Assessment, Maintain Existing On-Site Runoff Conditions

Lastly with Option 3, on-site controls shall be used to maintain the pre-development peak discharges from the site. The developer must provide supporting calculations and/or documentation that the on-site controls will be designed and constructed to maintain on-site existing conditions.

It is important to note that Option 3 does not require a downstream assessment. It is a detention-based approach to addressing downstream flood mitigation after the application of the *integrated* site design practices.

For many developments however, the results of a downstream assessment may show that significantly less flood mitigation is required than "detaining to pre-development conditions". This method may also exacerbate downstream flooding problems due to timing of flows. The developer shall confirm that detention does not exacerbate peak flows in downstream reaches.

3.6 Stormwater Conveyance Systems

3.6.1 Introduction

Stormwater system design is an integral component of both site and overall stormwater management design. Good drainage design must strive to maintain compatibility and minimize interference with existing drainage patterns; control flooding of property, structures, and roadways for design flood events; and minimize potential environmental impacts on stormwater runoff.

Stormwater collection systems must be designed to provide adequate surface drainage while at the same time meeting other stormwater management goals such as water quality, streambank protection, habitat protection, and flood mitigation.

Design

Fully developed watershed conditions shall be used for determining runoff for the conveyance storm and the flood mitigation storm.

Local Provisions:

3.6.2 Hydraulic Design Criteria for Streets and Closed Conduits

Introduction

This section is intended to provide criteria and guidance for the design of on-site flood mitigation system components including:

- Street and roadway gutters
- Stormwater inlets
- Parking lot sheet flow
- Storm drain pipe systems

Streets and Stormwater Inlets

Design Frequency

- Streets and roadway gutters: conveyance storm event
- Inlets on-grade: conveyance storm event
- Parking lots: conveyance storm event
- Storm drain pipe systems: conveyance storm event
- Low points: flood mitigation storm event
- Street ROW: flood mitigation storm event
- Drainage and Floodplain easements: flood mitigation storm event

Local Provisions:

Design Criteria

Streets and ROW

Depth in the street shall not exceed top of curb or maximum flow spread limits for the conveyance storm. The flood mitigation storm shall be contained within the right-of-ways or easements.

Parking Lots

Parking lots shall be designed for the conveyance storm not to exceed top of curb with maximum ponding at low points of one (1) foot. The flood mitigation storm shall be contained on-site or within dedicated easements.

Flow Spread Limits

Inlets shall be spaced so that the spread of flow in the street for the conveyance storm shall not exceed the guidelines listed below, as measured from the gutter or face of the curb:

Table 3.7 Flow Spread Limits

Street Classification	Allowable Encroachment
Collectors, Arterial, and Thoroughfares (greater than 2-lanes)	• 8 feet or one travel lane, both sides for a divided roadway
Residential Streets	• curb depth or maximum 6 inches at gutter

Local Provisions:

Storm Drain Pipe Design

Design Frequency

- Pipe Design: conveyance storm event within pipe with hydraulic grade line (HGL) below throat of inlets
- ROW and Easements: flood mitigation storm event must be contained within the ROW or easement

Local Provisions:

Design Criteria

- For ordinary conditions, storm drain pipes shall be sized on the assumption that they will flow full or practically full under the design discharge but will not be placed under pressure head. The Manning Formula is recommended for capacity calculations.

- The maximum hydraulic gradient shall not produce a velocity that exceeds 15 feet per second (fps). Table 3.8 shows the desirable velocities for most storm drainage design. Storm drains shall be designed to have a minimum mean velocity flowing full at 2.5 fps.

Table 3.8 Desirable Velocity in Storm Drains

Description	Maximum Desirable Velocity
Culverts (All types)	15 fps
Storm Drains (Inlet laterals)	No Limit
Storm Drains (Collectors)	15 fps
Storm Drains (Mains)	12 fps

- The minimum desirable physical slope shall be 0.5% or the slope that will produce a velocity of 2.5 feet per second when the storm sewer is flowing full, whichever is greater.

- If the potential water surface elevation exceeds 1 foot below ground elevation for the design flow, the top of the pipe, or the gutter flow line, whichever is lowest, adjustments are needed in the system to reduce the elevation of the hydraulic grade line.

- Access manholes are required at intermediate points along straight runs of closed conduits. Table 3.9 gives maximum spacing criteria.

Table 3.9 Access Manhole Spacing Criteria
(HEC 22, 2001)

Pipe Size (inches)	Maximum Spacing (feet)
12-24	300
27-36	400
42-54	500
60 and up	1000

Local Provisions:

3.6.3 Hydraulic Design Criteria for Structures

Introduction

This section is intended to provide design criteria and guidance on several on-site flood mitigation system components, including culverts, bridges, vegetated and lined open channels, storage design, outlet structures, and energy dissipation devices for outlet protection.

Open Channels

Design Frequency

- Open channels, including all natural or structural channels, swales, and ditches shall be designed for the flood mitigation storm event
- Channels shall be designed with multiple stages. A low flow channel section containing the streambank protection flows and a high flow section that contains the conveyance and flood mitigation storms will improve stability and better mimic natural channel dimensions.

Local Provisions:

Design Criteria

- Trapezoidal channels shall have a minimum channel bottom width of 6 feet.
- Channels with bottom widths greater than 6 feet shall be designed with a minimum bottom cross slope of 12 to 1 or with compound cross sections.
- Channel side slopes shall be stable throughout the entire length and the side slope shall depend on the channel material. Channel side slopes and roadside ditches with a side slope steeper than 3:1 shall require detailed geotechnical and slope stability analysis to justify slopes steeper than 3:1. However, any slope that is less than 3:1 needs a detailed analysis to prove that it can be done.
- Trapezoidal or parabolic cross sections are preferred over triangular shapes.
- For vegetative channels, design stability shall be determined using low vegetative retardance conditions (Class D). For design capacity, higher vegetative retardance conditions (Class C) shall be used.
- For vegetative channels, flow velocities within the channel shall not exceed the maximum permissible velocities given in Tables 3.10 and 3.11.
- If relocation of a stream channel is unavoidable, the cross-sectional shape, meander, pattern, roughness, sediment transport, and slope shall conform to the existing conditions insofar as practicable. Energy dissipation will be necessary when existing conditions cannot be duplicated.
- Streambank stabilization shall be provided, when appropriate, as a result of any stream disturbance such as encroachment and shall include both upstream and downstream banks as well as the local site.
- HEC-RAS, or similarly capable software approved by the entity with jurisdiction, shall be used to confirm the water surface profiles in open channels.
- The final design of artificial open channels shall be consistent with the velocity limitations for the selected channel lining. Maximum velocity values for selected lining categories are presented in

Table 3.10. Seeding and mulch shall only be used when the design value does not exceed the allowable value for bare soil. Velocity limitations for vegetative linings are reported in Table 3.11. Vegetative lining calculations and stone riprap procedures are presented in *Section 3.2 of the Hydraulics Technical Manual*.

For gabions, design velocities range from 10 fps for 6-inch mattresses up to 15 fps for 1-foot mattresses. Some manufacturers indicate that velocities of 20 fps are allowable for basket installations. The design of stable rock riprap lining depends on the intersection of the velocity (local boundary shear) and the size and gradation of the riprap material. More information on calculating acceptable riprap velocity limits is available in *Section 3.2.7 of the Hydraulics Technical Manual*.

Local Provisions:

Table 3.10 Roughness Coefficients (Manning's n) and Allowable Velocities for Natural Channels

Channel Description	Manning's n	Max. Permissible Channel Velocity (ft/s)
MINOR NATURAL STREAMS		
Fairly regular section		
1. Some grass and weeds, little or no brush	0.030	3 to 6
2. Dense growth of weeds, depth of flow materially greater than weed height	0.035	3 to 6
3. Some weeds, light brush on banks	0.035	3 to 6
4. Some weeds, heavy brush on banks	0.050	3 to 6
5. Some weeds, dense willows on banks	0.060	3 to 6
For trees within channels with branches submerged at high stage, increase above values by	0.010	
Irregular section with pools, slight channel meander, increase above values by	0.010	
Floodplain – Pasture		
1. Short grass	0.030	3 to 6
2. Tall grass	0.035	3 to 6
Floodplain – Cultivated Areas		
1. No crop	0.030	3 to 6
2. Mature row crops	0.035	3 to 6
3. Mature field crops	0.040	3 to 6
Floodplain – Uncleared		
1. Heavy weeds scattered brush	0.050	3 to 6
2. Wooded	0.120	3 to 6
MAJOR NATURAL STREAMS		
Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of "n" for larger streams of mostly regular sections, with no boulders or brush	Range from 0.028 to 0.060	3 to 6
UNLINED VEGETATED CHANNELS		
Clays (Bermuda Grass)	0.035	5 to 6
Sandy and Silty Soils (Bermuda Grass)	0.035	3 to 5
UNLINED NON-VEGETATED CHANNELS		
Sandy Soils	0.030	1.5 to 2.5
Silts	0.030	0.7 to 1.5
Sandy Silts	0.030	2.5 to 3.0
Clays	0.030	3.0 to 5.0
Coarse Gravels	0.030	5.0 to 6.0
Shale	0.030	6.0 to 10.0
Rock	0.025	15
For natural channels with specific vegetation type, refer to Table 3.11 for more detailed velocity control.		

Table 3.11 Maximum Velocities for Vegetative Channel Linings

Vegetation Type	Slope Range (%)[1]	Maximum Velocity[2] (ft/s)
Bermuda grass	0-5	6
Bahia		4
Tall fescue grass mixtures[3]	0-10	4
Kentucky bluegrass	0-5	6
Buffalo grass	5-10 >10	5 4
Grass mixture	0-5[1] 5-10	4 3
Sericea lespedeza, Weeping lovegrass, Alfalfa	0-5[4]	3
Annuals[5]	0-5	3
Sod		4
Lapped sod		5

[1] Do not use on slopes steeper than 10% except for side-slope in combination channel.
[2] Use velocities exceeding 5 ft/s only where good stands can be maintained.
[3] Mixtures of Tall Fescue, Bahia, and/or Bermuda
[4] Do not use on slopes steeper than 5% except for side-slope in combination channel.
[5] Annuals - used on mild slopes or as temporary protection until permanent covers are established.

Source: Manual for Erosion and Sediment Control in Georgia, 1996.

Vegetative Design

- A two-part procedure is required for final design of temporary and vegetative channel linings.
  - Part 1, the design stability component, involves determining channel dimensions for low vegetative retardance conditions, using Class D as defined in Table 3.12.
  - Part 2, the design capacity component, involves determining the depth increase necessary to maintain capacity for higher vegetative retardance conditions, using Class C as defined in Table 3.12.

If temporary lining is to be used during construction, vegetative retardance Class E shall be used for the design stability calculations.

- If the channel slope exceeds 10%, or a combination of channel linings will be used, additional procedures not presented below are required. References include HEC-15 (USDOT, FHWA, 1986) and HEC-14 (USDOT, FHWA, 1983).

Local Provisions:

Table 3.12 Classification of Vegetal Covers as to Degrees of Retardance

Retardance Class	Cover	Condition
A	Weeping Lovegrass	Excellent stand, tall (average 30")
	Yellow Bluestem Ischaemum	Excellent stand, tall (average 36")
B	Kudzu	Very dense growth, uncut
	Bermuda grass	Good stand, tall (average 12”)
	Native grass mixture Little bluestem, bluestem, blue gamma other short and long stem Midwest grasses	Good stand, unmowed
	Weeping lovegrass	Good stand, tall (average 24”)
	Laspedeza sericea	Good stand, not woody, tall (average 19”)
	Alfalfa	Good stand, uncut (average 11”)
	Weeping lovegrass	Good stand, unmowed (average 13”)
	Kudzu	Dense growth, uncut
	Blue gamma	Good stand, uncut (average 13”)
C	Crabgrass	Fair stand, uncut (10 – 48”)
	Bermuda grass	Good stand, mowed (average 6”)
	Common lespedeza	Good stand, uncut (average 11”)
	Grass-legume mixture: summer (orchard grass redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (6 – 8 “)
	Centipede grass	Very dense cover (average 6”)
	Kentucky bluegrass	Good stand, headed (6 – 12”)
D	Bermuda grass	Good stand, cut to 2.5”
	Common lespedeza	Excellent stand, uncut (average 4.5”)
	Buffalo grass	Good stand, uncut (3 – 6”)
	Grass-legume mixture: fall, spring (orchard grass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (4 – 5”)
	Lespedeza serices	After cutting to 2” (very good before cutting)
E	Bermuda grass	Good stand, cut to 1.5”
	Bermuda grass	Burned stubble

Note: Covers classified have been tested in experimental channels. Covers were green and generally uniform.
Source: HEC-15, 1988.

Culverts

Design Frequency

Culverts are cross drainage facilities that transport runoff under roadways or other improved areas.

- Culverts shall be designed for the flood mitigation storm or in accordance with TxDOT requirements, whichever is more stringent. Consideration when designing culverts includes: roadway type, tailwater or depth of flow, structures, and property subject to flooding, emergency access, and road replacement costs.
- The flood mitigation storm shall be routed through all culverts to be sure building structures (e.g., houses, commercial buildings) are not flooded or increased damage does not occur to the highway or adjacent property for this design event.

Local Provisions:

Design Criteria

Velocity Limitations

- The maximum velocity shall be consistent with channel stability requirements at the culvert outlet.
- The maximum allowable velocity for corrugated metal pipe is 15 feet per second. There is no specified maximum allowable velocity for reinforced concrete pipe, but outlet protection shall be provided where discharge velocities will cause erosion conditions.
- To ensure self-cleaning during partial depth flow, a minimum velocity of 2.5 feet per second is required for the streambank protection storm when the culvert is flowing partially full.

Length and Slope

- The maximum slope using concrete pipe is 10% and for CMP is 14% before pipe-restraining methods must be taken.
- Maximum vertical distance from throat of intake to flowline in a drainage structure is 10 feet.
- Drops greater than 4 feet will require additional structural design.

Headwater Limitations

- The *allowable headwater* is the depth of water that can be ponded at the upstream end of the culvert during the design flood, which will be limited by one or more of the following constraints or conditions:
    1. Headwater will be non-damaging to upstream property.
    2. Culvert headwater plus 12 inches of freeboard shall not exceed top of curb or pavement for low point of road over culvert, whichever is lower.
    3. Ponding depth will be no greater than the elevation where flow diverts around the culvert.
    4. Elevations will be established to delineate floodplain zoning.
- The headwater shall be checked for the flood mitigation storm elevation to ensure compliance with flood plain management criteria and the culvert shall be sized to maintain flood-free conditions on major thoroughfares with 12-inch freeboard at the low-point of the road.
- Either the headwater shall be set to produce acceptable velocities or stabilization/energy dissipation shall be provided where these velocities are exceeded.

- In general, the constraint that gives the lowest allowable headwater elevation establishes the criteria for the hydraulic calculations.

Tailwater Considerations

- If the culvert outlet is operating with a free outfall, the critical depth and equivalent hydraulic grade line shall be determined.
- For culverts that discharge to an open channel, the stage-discharge curve for the channel must be determined. See *Section 2.1.4 of the Hydraulics Technical Manual* on methods to determine a stage-discharge curve.
- If an upstream culvert outlet is located near a downstream culvert inlet, the headwater elevation of the downstream culvert will establish the design tailwater depth for the upstream culvert.
- If the culvert discharges to a lake, pond, or other major water body, the expected high water elevation of the particular water body will establish the culvert tailwater.

Other Criteria

- In designing debris control structures, the Hydraulic Engineering Circular No. 9 entitled *Debris Control Structures* or other approved reference is required to be used.
- If storage is being assumed or will occur upstream of the culvert, refer to *Section 2.0 of the Hydraulics Technical Manual* regarding storage routing as part of the culvert design.
- Reinforced concrete pipe (RCP), pre-cast and cast in place concrete boxes are recommended for use (1) under a roadway, (2) when pipe slopes are less than 1%, or (3) for all flowing streams. RCP and fully coated corrugated metal pipe or high-density polyethylene (HDPE) pipe may also be used in open space areas.
- Culvert skews shall not exceed 45 degrees as measured from a line perpendicular to the roadway centerline without approval.
- The minimum allowable pipe diameter shall be 18 inches.
- Erosion, sediment control, and velocity dissipation shall be designed in accordance with *Section 4.0 of the Hydraulics Technical Manual*.

Local Provisions:

Bridges

Design Frequency

Bridges are cross drainage facilities with a span of 20 feet or larger.

- Flood mitigation storm for all bridges

Local Provisions:

Design Criteria

- A freeboard of two feet shall be maintained between the computed design water surface and the low chord of all bridges.
- The contraction and expansion of water through the bridge opening creates hydraulic losses. These losses are accounted for through the use of loss coefficients. Table 3.13 gives recommended values for the Contraction (K_c) and Expansion (K_e) Coefficients.

Table 3.13 Recommended Loss Coefficients for Bridges

Transition Type	Contraction (K_c)	Expansion (K_e)
No losses computed	0.0	0.0
Gradual transition	0.1	0.3
Typical bridge	0.3	0.5
Severe transition	0.6	0.8

Additional design guidance is located in *Section 3.4 of the Hydraulics Technical Manual*.

Local Provisions:

Detention Structures

Design Frequency

Detention structures shall be designed for the three storms (streambank protection, conveyance, and flood mitigation storms) for the critical storm duration that results in the maximum (or near maximum) peak flow.

Local Provisions:

Design Criteria

- Dry detention basins are sized to temporarily store the volume of runoff required to provide flood protection up to the flood mitigation storm, if required.
- Extended detention dry basins are sized to provide extended detention of the streambank protection volume over 24 hours and can also provide additional storage volume for normal detention (peak flow reduction) of the flood mitigation storm event.
- Routing calculations must be used to demonstrate that the storage volume and outlet structure configuration are adequate. See *Section 2.0 of the Hydraulics Technical Manual* for procedures on the design of detention storage.
- Detention Basins shall be designed with an 8 foot wide maintenance access.
- No earthen (grassed) embankment slopes shall exceed 4:1.
- A freeboard of 1 foot will be required for all detention ponds.
- A calculation summary shall be provided on construction plans. For detailed calculations of unit hydrograph studies, a separate report shall be provided to the municipality for review and referenced on the construction plans. Stage-storage-discharge values shall be tabulated and flow calculations for discharge structures shall be shown on the construction plans.
- An emergency spillway shall be provided at the flood mitigation maximum storage elevation with sufficient capacity to convey the flood mitigation storm assuming blockage of the outlet works with six inches of freeboard. Spillway requirements must also meet all appropriate state and Federal criteria.
- A landscape plan shall be provided for all detention ponds.
- All detention basins shall be stabilized against significant erosion and include a maintenance plan.
- Design calculations will be provided for all spillways and outlet structures.
- Maintenance agreements shall be included for all detention structures.
- Storage may be subject to the requirements of the Texas Dam Safety Program (see iSWM Program Guidance) based on the volume, dam height, and level of hazard.
- Earthen embankments 6 feet in height or greater shall be designed per Texas Commission on Environmental Quality guidelines for dam safety (see iSWM Program Guidance).
- Vegetated slopes shall be less than 20 feet in height and shall have side slopes no steeper than 2:1 (horizontal to vertical) although 3:1 is preferred. Riprap-protected slopes shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for slopes greater than 10 feet in height. Vegetated slopes with a side slope steeper than 2:1 shall require detailed geotechnical and slope stability analysis to justify slopes steeper than 2:1.
- Areas above the normal high water elevations of the detention facility should be sloped toward the basin to allow drainage and to prevent standing water. Careful finish grading is required to avoid creation of upland surface depressions that may retain runoff. The bottom area of storage facilities should be graded toward the outlet to prevent standing water conditions. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with riprap) is recommended to convey low flows and prevent standing water conditions.

Local Provisions:

Outlet Structures

Extended detention (ED) orifice sizing is required in design applications that provide extended detention for downstream streambank protection or the ED portion of the water quality protection volume. The release rate for both the WQ_v and SP_v shall discharge the ED volume in a period of 24 hours or longer. In both cases an extended detention orifice or reverse slope pipe must be used for the outlet. For a structural control facility providing both WQ_v extended detention and SP_v control (wet ED pond, micropool ED pond, and shallow ED wetland), there will be a need to design two outlet orifices – one for the water quality control outlet and one for the streambank protection drawdown.

Design Frequency

Water quality storm
Streambank protection storm
Conveyance storm
Flood mitigation storm

Local Provisions:

Design Criteria

- Estimate the required storage volumes for water quality protection, streambank protection, conveyance storm, and flood mitigation.
- Design extended detention outlets for each storm event.
- Outlet velocities shall be within the maximum allowable range based on channel material as shown in Tables 3.10 and 3.11.
- Design necessary outlet protection and energy dissipation facilities to avoid erosion problems downstream from outlet devices and emergency spillway(s).
- Perform buoyancy calculations for the outlet structure and footing. Flotation will occur when the weight of the structure is less than or equal to the buoyant force exerted by the water.

Additional design guidance is located in *Section 2.2 of the Hydraulics Technical Manual*.

Local Provisions:

Energy Dissipation

Design Frequency

All drainage system outlets, whether for closed conduits, culverts, bridges, open channels, or storage facilities, shall provide energy dissipation to protect the receiving drainage element from erosion.

- Conveyance storm
- Flood mitigation storm

Local Provisions:

Design Criteria

- *Energy dissipaters* are engineered devices such as rip-rap aprons or concrete baffles placed at the outlet of storm water conveyance systems for the purpose of reducing the velocity, energy and turbulence of the discharged flow.
- Erosion problems at culvert, pipe and engineered channel outlets are common. Determination of the flow conditions, scour potential, and channel erosion resistance shall be standard procedure for all designs.
- Energy dissipaters shall be employed whenever the velocity of flows leaving a stormwater

management facility exceeds the erosion velocity of the downstream area channel system.

- Energy dissipater designs will vary based on discharge specifics and tailwater conditions.
- Outlet structures shall provide uniform redistribution or spreading of the flow without excessive separation and turbulence.
- Energy dissipaters are a required component of the *i*SWM Construction Plan.

Recommended Energy Dissipaters for outlet protection include the following:

- Riprap apron
- Riprap outlet basins
- Baffled outlets
- Grade Control Structures

The reader is referred to *Section 4.0 of the Hydraulics Technical Manual* and the Federal Highway Administration Hydraulic Engineering Circular No. 14 entitled, Hydraulic Design of Energy Dissipaters for Culverts and Channels, for the design procedures of other energy dissipaters.

Additional design guidance is located in *Section 4.0 of the Hydraulics Technical Manual.*

Local Provisions:

3.7 Easements, Plats, and Maintenance Agreements

Easements

Easements are required for all drainage systems that convey stormwater runoff across a development and must include sufficient area for operation and maintenance of the drainage system. Types of easements to be used include:

- Drainage easements - are required for both on-site and off-site public storm drains and for improved channels designed according to current municipality standards.
- Floodplain easements - shall be provided on-site along drainageways that are in a Special Flood Hazard Area as designated on the effective FEMA FIRM maps. No construction shall be allowed within a floodplain easement without the written approval of the municipality.
- Temporary drainage easements are required off-site for temporary channels when future off-site development is anticipated to be enclosed underground or follows an altered alignment. Temporary drainage easements will not be maintained by the municipality and will not terminate until permanent drainage improvements meeting municipality standards are installed and accepted. Temporary drainage easements will require written approval from the municipality.
- Drainage and utility easements can be combined for underground storm drains and channels, subject to adequate easement width as approved by the municipality.
- Drainage easements shall include adequate width for access and maintenance beyond the top of bank for improved channels.
- Retaining walls are not permitted within or adjacent to a drainage easement in a residential area in order to reduce the easement width. Retaining walls adjacent to the channel are allowed in non-residential areas only if the property owner provides an agreement for private maintenance.
- The minimum finished floor elevation for structures adjacent to a Special Flood Hazard Area shall be a minimum of one (1) foot above the fully-developed flood mitigation storm water surface elevation or two (2) feet above the effective FEMA base flood elevation.
- Improved channels shall have drainage easements dedicated to meet the requirements of the width of the channel, the one-foot freeboard, any perimeter fencing, and any underground tie-backs or anchors.
- Easements for detention ponds and permanent control BMPs shall be negotiated between the municipality and the property owner.
- The entire reach or each section of any drainage facility must be readily accessible to maintenance equipment. Additional easement(s) shall be required at the access point(s) and the access points shall be appropriately designed to restrict access by the public (including motorcycles).

Minimum easement width requirements for storm drain pipe are shown in Table 3.14 and shall be as follows:

- The outside face of the proposed storm drain line shall be placed five (5) feet off either edge of the storm drain easement. The proposed centerline of overflow swales shall normally coincide with the centerline of the easement.
- For pipe sizes up to 54”, a minimum of five (5) additional feet shall be dedicated when shared with utilities.
- Box culvert minimum easement width shall be determined using Table 3.14 based on an equivalent box culvert width to pipe diameter.
- For parallel storm drain systems with a combined width greater than 8 feet the minimum easement shall be equal to the width of the parallel storm drain system plus twenty (20) additional feet.

- Drainage easements will generally extend at least twenty-five (25) feet past an outfall headwall to provide an area for maintenance operations. Drainage easements along a required outfall channel or ditch shall be provided until the flowline reaches an acceptable outfall. The minimum storm drain shall not be on property line, except where a variance has been granted.

Table 3.14 Closed Conduit Easements

Pipe Size	Minimum Easement Width Required
39” and under	15 Feet
42” through 54”	20 Feet
60” through 66”	25 Feet
72” through 102”	30 Feet

Local Provisions:

Plats

All platting shall follow established development standards established by the local municipality. Plats shall include pertinent drainage information that will be filed with the plat. Elements to be included on the plat include:

- All public and private drainage easements not recorded by separate instrument
- Easements to be recorded by separate instrument shall be documented on the plat
- All floodplain easements
- Legal disclosure for drainage provisions upon sale or transfer of property
- Documentation of maintenance responsibilities and agreements including transfer of responsibility upon sale of the property

Local Provisions:

Maintenance Agreements

All drainage improvements constructed within a development and any existing or natural drainage systems to remain in use shall require a maintenance agreement that identifies responsible parties for maintenance. Both private and public maintenance responsibility shall be negotiated between the municipality and the owner and documented in the agreement. The maintenance agreement shall be written such that it remains in force upon sale of transfer of the property.

Local Provisions:

3.8 Stormwater Control Selection

3.8.1 Control Screening Process

Outlined below is a screening process for structural stormwater controls that can effectively treat the water quality volume, as well as provide water quantity control. This process is intended to assist the site designer and design engineer in the selection of the most appropriate structural controls for a development site and to provide guidance on factors to consider in their location. This information is also contained in the *Site Development Controls Technical Manual*.

The following four criteria shall be evaluated in order to select the appropriate structural control(s) or group of controls for a development:

- Stormwater treatment suitability
- Water quality performance
- Site applicability
- Implementation considerations

In addition, the following factors shall be considered for a given site and any specific design criteria or restrictions need to be evaluated:

- Physiographic factors
- Soils
- Special watershed or stream considerations

Finally, environmental regulations shall be considered as they may influence the location of a structural control on site or may require a permit.

The following steps provide a selection process for comparing and evaluating various structural stormwater controls using a screening matrix and a list of location and permitting factors. These tools are provided to assist the design engineer in selecting the subset of structural controls that will meet the stormwater management and design objectives for a development site or project.

Step 1 Overall Applicability

The following are the details of the various screening categories and individual characteristics used to evaluate the structural controls.

Table 3.15 - Stormwater Management Suitability

The first category in the matrix examines the capability of each structural control option to provide water quality treatment, downstream streambank protection, and flood control. A blank entry means that the structural control cannot or is not typically used to meet an *integrated* Focus Area. This does not necessarily mean that it should be eliminated from consideration, but rather it is a reminder that more than one structural control may be needed at a site (e.g., a bioretention area used in conjunction with dry detention storage).

Ability to treat the Water Quality Volume (WQ_v): This indicates whether a structural control provides treatment of the water quality volume (WQ_v). The presence of "P" or "S" indicates whether the control is a Primary or Secondary control, respectively, for meeting the TSS reduction goal.

Ability to provide Streambank Protection (SP_v): This indicates whether the structural control can be used to provide the extended detention of the streambank protection volume (SP_v). The presence of

a "P" indicates that the structural control can be used to meet SP_v requirements. An "S" indicates that the structural control may be sized to provide streambank protection in certain situations, for instance on small sites.

Ability to provide Flood Control (Q_f): This indicates whether a structural control can be used to meet the flood control criteria. The presence of a "P" indicates that the structural control can be used to provide peak reduction of the flood mitigation storm event.

Table 3.16 - Relative Water Quality Performance

The second category of the matrix provides an overview of the pollutant removal performance for each structural control option when designed, constructed, and maintained according to the criteria and specifications in this manual.

Ability to provide TSS and Sediment Removal: This column indicates the capability of a structural control to remove sediment in runoff. All of the Primary structural controls are presumed to remove 70% to 80% of the average annual TSS load in typical urban post-development runoff (and a proportional removal of other pollutants).

Ability to provide Nutrient Treatment: This column indicates the capability of a structural control to remove the nutrients nitrogen and phosphorus in runoff, which may be of particular concern with certain downstream receiving waters.

Ability to provide Bacteria Removal: This column indicates the capability of a structural control to remove bacteria in runoff. This capability may be of particular concern when meeting regulatory water quality criteria under the Total Maximum Daily Load (TMDL) program.

Ability to accept Hotspot Runoff: This last column indicates the capability of a structural control to treat runoff from designated hotspots. Hotspots are land uses or activities that produce higher concentrations of trace metals, hydrocarbons, or other priority pollutants. Examples of hotspots might include: gas stations, convenience stores, marinas, public works storage areas, garbage transfer facilities, material storage sites, vehicle service and maintenance areas, commercial nurseries, vehicle washing/steam cleaning, landfills, construction sites, industrial sites, industrial rooftops, and auto salvage or recycling facilities. A check mark indicates that the structural control may be used on hotspot site. However, it may have specific design restrictions. Please see the specific design criteria of the structural control for more details in the *Site Development Controls Technical Manual*. Local jurisdictions may have other site uses that they designate as hotspots. Therefore, their criteria should be checked as well.

Table 3.17 - Site Applicability

The third category of the matrix provides an overview of the specific site conditions or criteria that must be met for a particular structural control to be suitable. In some cases, these values are recommended values or limits and can be exceeded or reduced with proper design or depending on specific circumstances. Please see the specific criteria section of the structural control for more details.

Drainage Area: This column indicates the approximate minimum or maximum drainage area considered suitable for the structural control practice. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway can be permitted if more than one practice can be installed. The minimum drainage areas indicated for ponds and wetlands should not be considered inflexible limits and may be increased or decreased depending on water availability (baseflow or groundwater), the mechanisms employed to prevent outlet clogging, or design variations used to maintain a permanent pool (e.g., liners).

Space Required (Space Consumed): This comparative index expresses how much space a structural control typically consumes at a site in terms of the approximate area required as a percentage of the impervious area draining to the control.

Slope: This column evaluates the effect of slope on the structural control practice. Specifically, the

slope restrictions refer to how flat the area where the facility is installed must be and/or how steep the contributing drainage area or flow length can be.

Minimum Head: This column provides an estimate of the minimum elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the structural control.

Water Table: This column indicates the minimum depth to the seasonally high water table from the bottom or floor of a structural control.

Table 3.18 - Implementation Considerations

The fourth category in the matrix provides additional considerations for the applicability of each structural control option.

Residential Subdivision Use: This column identifies whether or not a structural control is suitable for typical residential subdivision development (not including high-density or ultra-urban areas).

Ultra-Urban: This column identifies those structural controls appropriate for use in very high-density (ultra-urban) areas, or areas where space is a premium.

Construction Cost: The structural controls are ranked according to their relative construction cost per impervious acre treated, as determined from cost surveys.

Maintenance: This column assesses the relative maintenance effort needed for a structural stormwater control, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging), and reported failure rates. It should be noted that **all structural controls** require routine inspection and maintenance.

Local Provisions:

Table 3.15 Stormwater Treatment Suitability

Category	*integrated* Stormwater Controls	Stormwater Treatment Suitability			
		Water Quality Protection	Streambank Protection	On-Site Flood Control	Downstream Flood Control
Bioretention Areas	Bioretention Areas	P	S	S	-
Channels	Enhanced Swales	P	S	S	S
	Channels, Grass	S	S	P	S
	Channels, Open	-	-	P	S
Chemical Treatment	Alum Treatment System	P	-	-	-
Conveyance System Components	Culverts	-	-	P	P
	Energy Dissipation	-	P	S	S
	Inlets/Street Gutters	-	-	P	-
	Pipe Systems	-	P	P	P
Detention	Detention, Dry	S	P	P	P
	Detention, Extended Dry	S	P	P	P
	Detention, Multi-purpose Areas	-	P	P	P
	Detention, Underground	-	P	P	P
Filtration	Filter Strips	S	-	-	-
	Organic Filters	P	-	-	-
	Planter Boxes	P	-	-	-
	Sand Filters, Surface/Perimeter	P	S	-	-
	Sand Filters, Underground	P	-	-	-
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	S	-	-	-
Infiltration	Downspout Drywell	P	-	-	-
	Infiltration Trenches	P	S	-	-
	Soakage Trenches	P	S	-	-
Ponds	Wet Pond	P	P	P	P
	Wet ED Pond	P	P	P	P
	Micropool ED Pond	P	P	P	P
	Multiple Ponds	P	P	P	P
Porous Surfaces	Green Roof	P	S	-	-
	Modular Porous Paver Systems	S	S	-	-
	Porous Concrete	S	S	-	-
Proprietary Systems	Proprietary Systems [1]	S/P	S	S	S
Re-Use	Rain Barrels	P	-	-	-
Wetlands	Wetlands, Stormwater	P	P	P	P
	Wetlands, Submerged Gravel	P	P	S	-

P = Primary Control: Able to meet design criterion if properly designed, constructed and maintained.
S = Secondary Control: May partially meet design criteria. May be a Primary Control but designated as a Secondary due to other considerations. For Water Quality Protection, recommended for limited use in approved community-designated areas.
- = Not typically used or able to meet design criterion.
[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.16 Water Quality Performance

Category	*integrated* Stormwater Controls	Water Quality Performance			
		TSS/ Sediment Removal Rate	Nutrient Removal Rate (TP/TN)	Bacteria Removal Rate	Hotspot Application
Bioretention Areas	Bioretention Areas	80%	60%/50%	-	✓
Channels	Enhanced Swales	80%	25%/40%	-	✓
	Channels, Grass	50%	25%/20%	-	
	Channels, Open	-	-	-	
Chemical Treatment	Alum Treatment System	90%	80%/60%	90%	✓
Conveyance System Components	Culverts	-	-	-	
	Energy Dissipation	-	-	-	
	Inlets/Street Gutters	-	-	-	
	Pipe Systems	-	-	-	
Detention	Detention, Dry	65%	50%/30%	70%	✓
	Detention, Extended Dry	65%	50%/30%	70%	✓
	Detention, Multi-purpose Areas	-	-	-	
	Detention, Underground	-	-	-	
Filtration	Filter Strips	50%	20%/20%	-	
	Organic Filters	80%	60%/40%	50%	✓
	Planter Boxes	80%	60%/40%	-	
	Sand Filters, Surface/Perimeter	80%	50%/25%	40%	✓
	Sand Filters, Underground	80%	50%/25%	40%	✓
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	5%/5%	-	
Infiltration	Downspout Drywell	80%	60%/60%	90%	
	Infiltration Trenches	80%	60%/60%	90%	
	Soakage Trenches	80%	60%/60%	90%	
Ponds	Wet Pond	80%	50%/30%	70%	✓
	Wet ED Pond	80%	50%/30%	70%	✓
	Micropool ED Pond	80%	50%/30%	70%	✓
	Multiple Ponds	80%	50%/30%	70%	✓
Porous Surfaces	Green Roof	85%	95%/16%	-	✓
	Modular Porous Paver Systems	[2]	80%/80%	-	
	Porous Concrete	[2]	50%/65%	-	
Proprietary Systems	Proprietary Systems [1]	[1]	[1]	[1]	
Re-Use	Rain Barrels	-	-	-	
Wetlands	Wetlands, Stormwater	80%	40%/30%	70%	✓
	Wetlands, Submerged Gravel	80%	40%/30%	70%	✓

✓ = Meets suitability criteria

\- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

Table 3.17 Site Applicability

Category	*integrated* Stormwater Controls	Site Applicability				
		Drainage Area (acres)	Space Req'd (% of Tributary imp. Area)	Site Slope	Minimum Head Required	Depth to Water Table
Bioretention Areas	Bioretention Areas	5 max[3]	5-7%	6% max	5 ft	2 ft
Channels	Enhanced Swales	5 max	10-20%	4% max	1 ft	Below WT
	Channels, Grass					
	Channels, Open					
Chemical Treatment	Alum Treatment System	25 min	None			
Conveyance System Components	Culverts					
	Energy Dissipation					
	Inlets/Street Gutters					
	Pipe Systems					
Detention	Detention, Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Extended Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Multi-purpose Areas	200 max		1% for Parking Lot; 0.25 in/ft for Rooftop		
	Detention, Underground	200 max				
Filtration	Filter Strips	2 max[3]	20-25%	2-6%		
	Organic Filters	10 max[3]	2-3%		5 to 8 ft	
	Planter Boxes		6%			
	Sand Filters, Surface/Perimeter	10 max[3] / 2 max[3]	2-3%	6% max	5 ft per 2-3 ft	2 ft
	Sand Filters, Underground	5 max	None			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	1 max[3]	None			
Infiltration	Downspout Drywell					
	Infiltration Trenches	5 max	2-3%	6% max	1 ft	4 ft
	Soakage Trenches	5 max	27 ft per 1000 ft^2 imp. area	6% max	1 ft	4 ft
Ponds	Wet Pond		2-3%	15% max	6 t 8 ft	2 ft, if hotspot or aquifer
	Wet ED Pond	25 min[3]				
	Micropool ED Pond	10 min[3]				
	Multiple Ponds	25 min[3]				
Porous Surfaces	Green Roof					
	Modular Porous Paver Systems	5 max	Varies			
	Porous Concrete	5 max	Varies			
Proprietary Systems	Proprietary Systems [1]	[1]	[1]			
Re-Use	Rain Barrels					
Wetlands	Wetlands, Stormwater	25 min	3-5%	8% max	3 to 5 ft (shallow) 6 to 8 ft (pond)	2 ft, if hotspot or aquifer
	Wetlands, Submerged Gravel	5 min			2 to 3 ft	Below WT

- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

[3] = Drainage area can be larger in some instances

Table 3.18 Implementation Considerations

Category	*integrated* Stormwater Controls	Implementation Considerations			
		Residential Subdivision Use	High Density/Ultra Urban	Capital Cost	Maintenance Burden
Bioretention Areas	Bioretention Areas	✓	✓	Moderate	Low
Channels	Enhanced Swales	✓		High	Low
	Channels, Grass	✓		Low	Moderate
	Channels, Open	✓		Low	Low
Chemical Treatment	Alum Treatment System	✓	✓	High	High
Conveyance System Components	Culverts	✓	✓	Low	Low
	Energy Dissipation	✓	✓	Low	Low
	Inlets/Street Gutters	✓	✓	Low	Low
	Pipe Systems	✓	✓	Low	Low
Detention	Detention, Dry	✓		Low	Moderate to High
	Detention, Extended Dry	✓		Low	Moderate to High
	Detention, Multi-purpose Areas	✓	✓	Low	Low
	Detention, Underground		✓	High	Moderate
Filtration	Filter Strips	✓		Low	Moderate
	Organic Filters		✓	High	High
	Planter Boxes		✓	Low	Moderate
	Sand Filters, Surface/Perimeter		✓	High	High
	Sand Filters, Underground		✓	High	High
Hydrodynamic Devices	Gravity (Oil-Grit) Separator		✓	High	High
Infiltration	Downspout Drywell	✓	✓	Low	Moderate
	Infiltration Trenches	✓	✓	High	High
	Soakage Trenches	✓	✓	High	High
Ponds	Wet Pond	✓		Low	Low
	Wet ED Pond	✓		Low	Low
	Micropool ED Pond	✓		Low	Moderate
	Multiple Ponds	✓		Low	Low
Porous Surfaces	Green Roof		✓	High	High
	Modular Porous Paver Systems		✓	Moderate	High
	Porous Concrete		✓	High	High
Proprietary Systems	Proprietary Systems [1]	[1]	✓	High	High
Re-Use	Rain Barrels	✓	✓	Low	High
Wetlands	Wetlands, Stormwater	✓		Moderate	Moderate
	Wetlands, Submerged Gravel	✓	✓	Moderate	High

✓ = Meets suitability criteria
\- = Not typically used or able to meet design criterion.
[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 2 Specific Criteria

The last three categories in the Structural Control Screening matrix provide an overview of various specific design criteria and specifications, or exclusions for a structural control that may be present due to a site's general physiographic character, soils, or location in a watershed with special water resources considerations.

Table 3.19 - Physiographic Factors

Three key factors to consider are low-relief, high-relief, and karst terrain. In the North Central Texas, low relief (very flat) areas are primarily located east of the Dallas metropolitan area. High relief (steep and hilly) areas are primarily located west of the Fort Worth metropolitan area. Karst and major carbonaceous rock areas are limited to portions of Palo Pinto, Erath, Hood, Johnson, and Somervell counties. Special geotechnical testing requirements may be needed in karst areas. The local reviewing authority should be consulted to determine if a project is subject to terrain constraints.

- Low relief areas need special consideration because many structural controls require a hydraulic head to move stormwater runoff through the facility.
- High relief may limit the use of some structural controls that need flat or gently sloping areas to settle out sediment or to reduce velocities. In other cases, high relief may impact dam heights to the point that a structural control becomes infeasible.
- Karst terrain can limit the use of some structural controls as the infiltration of polluted waters directly into underground streams found in karst areas may be prohibited. In addition, ponding areas may not reliably hold water in karst areas.

Table 3.20 - Soils

The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note that more detailed geotechnical tests are usually required for infiltration feasibility and during design to confirm permeability and other factors.

Table 3.21 - Special Watershed or Stream Considerations

The design of structural stormwater controls is fundamentally influenced by the nature of the downstream water body that will be receiving the stormwater discharge. In addition, the designer should consult with the appropriate review authority to determine if their development project is subject to additional structural control criteria as a result of an adopted local watershed plan or special provision.

In some cases, higher pollutant removal or environmental performance is needed to fully protect aquatic resources and/or human health and safety within a particular watershed or receiving water. Therefore, special design criteria for a particular structural control or the exclusion of one or more controls may need to be considered within these watersheds or areas. Examples of important watershed factors to consider include:

High Quality Streams (Streams with a watershed impervious cover less than approximately 15%). These streams may also possess high quality cool water or warm water aquatic resources or endangered species. The design objectives are to maintain habitat quality through the same techniques used for cold-water streams, with the exception that stream warming is not as severe of a design constraint. These streams may also be specially designated by local authorities.

Wellhead Protection: Areas that recharge existing public water supply wells present a unique management challenge. The key design constraint is to prevent possible groundwater contamination by preventing infiltration of hotspot runoff. At the same time, recharge of unpolluted stormwater is encouraged to maintain flow in streams and wells during dry weather.

Reservoir or Drinking Water Protection: Watersheds that deliver surface runoff to a public water supply reservoir or impoundment are a special concern. Depending on the available treatment, a

greater level of pollutant removal may be necessary for the pollutants of concern, such as bacteria pathogens, nutrients, sediment, or metals. One particular management concern for reservoirs is ensuring stormwater hotspots are adequately treated so they do not contaminate drinking water.

Local Provisions:

Table 3.19 Physiographic Factors

Category	*integrated* Stormwater Controls	Physiographic Factors		
		Low Relief	High Relief	Karst
Bioretention Areas	Bioretention Areas	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
Channels	Enhanced Swales	Generally feasible. However, slope <1% may lead to standing water in dry swales	Often infeasible if slopes are 4% or greater	
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry		Embankment heights restricted	Require poly or clay liner, Max ponding depth, Geotechnical tests
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			GENERALLY NOT ALLOWED
Filtration	Filter Strips			
	Organic Filters			
	Planter Boxes			
	Sand Filters, Surface/Perimeter	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Downspout Drywell	Minimum distance to water table of 4 ft		GENERALLY NOT ALLOWED
	Infiltration Trenches	Minimum distance to water table of 2 ft	Maximum slope of 6%; trenches must have flat bottom	GENERALLY NOT ALLOWED
	Soakage Trenches	Minimum distance to water table of 4 ft	Maximum slope of 6%; trenches must have flat bottom	GENERALLY NOT ALLOWED
Ponds	Wet Pond	Limit maximum normal pool depth to about 4 ft (dugout) Providing pond drain can be problematic	Embankment heights restricted	Require poly or clay liner Max ponding depth Geotechnical tests
	Wet ED Pond			
	Micropool ED Pond			
	Multiple Ponds			
Porous Surfaces	Green Roof			
	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Re-Use	Rain Barrels			
Wetlands	Wetlands, Stormwater		Embankment heights restricted	Require poly-liner Geotechnical tests
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.20 Soils

Category	*integrated* Stormwater Controls	Soils
Bioretention Areas	Bioretention Areas	Clay or silty soils may require pretreatment
Channels	Enhanced Swales	
	Channels, Grass	
	Channels, Open	
Chemical Treatment	Alum Treatment System	
Conveyance System Components	Culverts	
	Energy Dissipation	
	Inlets/Street Gutters	
	Pipe Systems	
Detention	Detention, Dry	Underlying soils of hydrologic group "C" or "D" should be adequate to maintain a permanent pool. Most group "A" soils and some group "B" soils will require a pond liner.
	Detention, Extended Dry	
	Detention, Multi-purpose Areas	
	Detention, Underground	
Filtration	Filter Strips	
	Organic Filters	
	Planter Boxes	Type A or B
	Sand Filters, Surface/Perimeter	Clay or silty soils may require pretreatment
	Sand Filters, Underground	
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	
Infiltration	Downspout Drywell	Infiltration rate > 0.5 inch/hr
	Infiltration Trenches	Infiltration rate > 0.5 inch/hr
	Soakage Trenches	Infiltration rate > 0.5 inch/hr
Ponds	Wet Pond	"A" soils may require pond liner "B" soils may require infiltration testing
	Wet ED Pond	
	Micropool ED Pond	
	Multiple Ponds	
Porous Surfaces	Green Roof	
	Modular Porous Paver Systems	Infiltration rate > 0.5 inch/hr
	Porous Concrete	
Proprietary Systems	Proprietary Systems [1]	
Re-Use	Rain Barrels	
Wetlands	Wetlands, Stormwater	"A" soils may require pond liner
	Wetlands, Submerged Gravel	

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.21 Special Watershed Considerations

Category	*integrated* Stormwater Controls	Special Watershed Considerations		
		High Quality Stream	Aquifer Protection	Reservoir Protection
Bioretention Areas	Bioretention Areas	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
Channels	Enhanced Swales		Hotspot runoff must be adequately treated	Hotspot runoff must be adequately treated
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry			
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			
Filtration	Filter Strips			
	Organic Filters			
	Planter Boxes			
	Sand Filters, Surface/Perimeter	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Downspout Drywell			
	Infiltration Trenches		Maintain safe distance from wells and water table. No hotspot runoff	Maintain safe distance from bedrock and water table. Pretreat runoff
	Soakage Trenches			
Ponds	Wet Pond	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wet ED Pond			
	Micropool ED Pond			
	Multiple Ponds			
Porous Surfaces	Green Roof			
	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Re-Use	Rain Barrels			
Wetlands	Wetlands, Stormwater	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 3 Location and Permitting Considerations

In the last step, a site designer assesses the physical and environmental features at the site to determine the optimal location for the selected structural control or group of controls. Table 3.22 provides a condensed summary of current restrictions as they relate to common site features that may be regulated under local, state, or federal law. These restrictions fall into one of three general categories:

- Locating a structural control within an area when expressly prohibited by law
- Locating a structural control within an area that is strongly discouraged, and is only allowed on a case by case basis. Local, state, and/or federal permits shall be obtained, and the applicant will need to supply additional documentation to justify locating the stormwater control within the regulated area.
- Structural stormwater controls must be setback a fixed distance from a site feature.

This checklist is only intended as a general guide to location and permitting requirements as they relate to siting of stormwater structural controls. Consultation with the appropriate regulatory agency is the best strategy.

Local Provisions:

Table 3.22 Location and Permitting Checklist

Site Feature	Location and Permitting Guidance
Jurisdictional Wetland (Waters of the U.S) U.S. Army Corps of Engineers Regulatory Permit	• Jurisdictional wetlands must be delineated prior to siting structural control. • Use of natural wetlands for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into a natural wetland. • Structural controls may also be *restricted* in local buffer zones. Buffer zones may be utilized as a non-structural filter strip (i.e., accept sheet flow). • Should justify that no practical upland treatment alternatives exist. • Where practical, excess stormwater flows should be conveyed away from jurisdictional wetlands.
Stream Channel (Waters of the U.S) U.S. Army Corps of Engineers Section 404 Permit	• All Waters of the U.S. (streams, ponds, lakes, etc.) should be delineated prior to design. • Use of any Waters of the U.S. for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into Waters of the U.S. • In-stream ponds for stormwater quality treatment are highly discouraged. • Must justify that no practical upland treatment alternatives exist. • Temporary runoff storage preferred over permanent pools. • Implement measures that reduce downstream warming. • Section 401 certification reviews by the Texas Commission on Environmental Quality are required for projects needing a Section 404 Permit.
Water Quality Certification Texas Commission on Environmental Quality (TCEQ)	• TCEQ conducts Section 401 water quality certification reviews of projects requiring a Section 404 permit from the U.S. Army Corps of Engineers for the discharge of dredged or fill material into waters of the U.S., including wetlands. • Specific stream and reservoir buffer requirements. • May be imperviousness limitations • May be specific structural control requirements that may overlap with requirements in this manual. • Mitigation will be required for impacts to existing aquatic and terrestrial habitat.
Impaired Water Bodies Texas Commission on Environmental Quality	• Determine if the project will discharge pollutants of concern into any downstream receiving waters that have been designated as impaired water bodies on TCEQ's *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)*. • Stormwater runoff discharges containing pollutants of concern to impaired water bodies will be governed by an entity's Municipal Separate Storm Sewer System (MS4) permit, if applicable.

Table 3.22 Location and Permitting Checklist	
Site Feature	**Location and Permitting Guidance**
Groundwater Management Areas **Texas Commission on Environmental Quality**	• Conserve, preserve, protect, recharge, and prevent waste of groundwater resources through Groundwater Conservation Districts • Groundwater Conservation District pending for Middle Trinity. • Detailed mapping available from Texas Alliance of Groundwater Districts.
Floodplain Areas National Flood Insurance Program / Local Floodplain Administrator	• Grading and fill for structural control construction is generally discouraged within the 100-year floodplain, as delineated by FEMA flood insurance rate maps, FEMA flood boundary and floodway maps, or more stringent local floodplain maps. • Floodplain fill cannot raise the floodplain water surface elevation by more than limits set by the appropriate jurisdiction.
Stream Buffer Check with appropriate review authority whether stream buffers are required	• Consult local authority for stormwater policy. • Structural controls are discouraged in the streamside zone (within 25 feet or more of streambank, depending on the specific regulations).
Utilities Local Review Authority	• Call appropriate agency to locate existing utilities prior to design. • Note the location of proposed utilities to serve development. • Structural controls are discouraged within utility easements or rights of way for public or private utilities.
Roads TxDOT or DPW	• Consult TxDOT for any setback requirement from local roads. • Consult DOT for setbacks from State maintained roads. • Approval must also be obtained for any stormwater discharges to a local or state-owned conveyance channel.
Structures Local Review Authority	• Consult local review authority for structural control setbacks from structures. • Recommended setbacks for each structural control group are provided in the performance criteria in this manual.
Septic Drain fields Local Health Authority	• Consult local health authority. • Recommended setback is a minimum of 50 feet from drain field edge or spray area.
Water Wells Local Health Authority	• 100-foot setback for stormwater infiltration. • 50-foot setback for all other structural controls.

4.0 *integrated* Construction Criteria

The chapter lays out the criteria and methods to be employed during construction to limit erosion and the discharge of sediment and other pollutants from construction sites.

4.1 Applicability

Requirements for temporary controls during construction are applicable to the following projects:

- Land disturbing activity of one acre or more or
- Land disturbing activity of less than one acre, where the activity is part of a common plan of development that is one acre or larger.

A common plan of development refers to a construction activity that is completed in separate stages, separate phases, or in combination with other construction activities.

Local Provisions:

4.2 Introduction

iSWM requires the use of temporary controls during construction to prevent or reduce the discharge of sediment and other pollutants from the construction site. The temporary controls are known as Best Management Practices (BMPs). BMPs may be activities, prohibitions, maintenance procedures, structural controls, operating procedures and other measures to prevent erosion and control the discharge of sediment and other pollutants.

Construction BMPs shall be considered when developing the Preliminary iSWM Plan and shall be coordinated with the Final iSWM Plans. Construction BMPs fall into three general categories: Erosion Control, Sediment Control, and Material and Waste Control. The first category prevents erosion, and the second catches soil from erosion that does occur. It is generally more effective and less expensive to prevent erosion than to treat turbid runoff. Material and waste controls are for other sources of stormwater pollutants on a construction site.

The following priorities shall be applied to the selection of construction BMPs:

- Retain native topsoil and natural vegetation in an undisturbed state by incorporating natural drainage features and buffer areas into the site design.
- Limit the area of disturbance and vehicle access to the site.
- Limit the extent of clearing operations, and phase construction operations to minimize the area disturbed at any one time.
- Stabilize disturbed areas as soon as possible (not at the end of construction), particularly in channels and on cut/fill slopes.
- Minimize the disturbance of steep slopes during construction, and minimize slope length and steepness.

- Coordinate stream crossings, and minimize the construction of temporary stream crossings.
- Provide sediment controls, including but not limited to perimeter controls, where stormwater discharges will occur from disturbed areas.
- Prevent tracking of sediment off-site through the establishment of stabilized construction entrances and exits.
- Control sediment and other contaminants from dewatering activities.
- Control discharges of construction materials and wastes.

State Requirements

In addition to the municipality requirements outlined in this chapter, land disturbing activities must comply with the Texas Commission on Environmental Quality (TCEQ) requirements under General Permit Number TXR150000, commonly referred to as the "Construction General Permit." This permit contains requirements for a Storm Water Pollution Prevention Plan (SWP3), state and local notifications, and installation, maintenance, and inspection of best management practices on construction sites. The *Water Quality Technical Manual* contains guidance for preparing a SWP3. However, compliance with the Construction General Permit is beyond the scope of this iSWM Criteria Manual and is the sole responsibility of the construction site operator(s).

Local Provisions:

4.3 Criteria for BMPs during Construction

The iSWM Construction Plan shall include, but shall not be limited to, the following:

- Topography;
- Limits of all areas to be disturbed by construction activity, including off-site staging areas, utility lines, batch plants, and spoil/borrow areas;
- Location and types of erosion control, sediment control, and material and waste control BMPs;
- Construction details and notes for erosion control, sediment control, and material and waste control BMPs; and
- Inspections and maintenance notes.

BMPs and notes shall be provided for all the elements listed in this section, unless site conditions render an element not applicable. BMPs shall be selected and designed according to the technical criteria in the *Construction Controls Technical Manual*. Site data gathered and analyzed in Step 2 of the *integrated* Development Process shall be the basis for selecting BMPs.

The minimum design storm for temporary BMPs is the 2-year, 24-hour duration storm event.

Plans for temporary BMPs shall be prepared by a Certified Professional in Erosion and Sediment Control (CPESC) or a licensed engineer or registered landscape architect in the State of Texas who has documented experience in hydrology and hydraulics and erosion and sediment control.

Local Provisions:

4.3.1 Erosion Controls

Erosion control is first line of defense and the primary means of preventing stormwater pollution. They shall be designed to retain soil in place and to minimize the amount of sediment that has to be removed from stormwater runoff by other types of BMPs. Fact Sheets for different types of Erosion Control BMPs are in *Section 2.0 of the Construction Controls Technical Manual*.

Limits of Disturbance

On the iSWM Construction Plans, clearly show the limits of the area to be disturbed.

Design Criteria

- Minimize the disturbance of steep slopes.
- Constrain the disturbed area to the minimum necessary to construct the project.
- Include the contractor's staging area, borrow/spoil area, utilities and any other areas on or off site that will be disturbed in support of the construction activity.
- Specify construction fencing or similar protective measures to prevent disturbance of natural drainage features, trees, vegetative buffers and other existing features to be preserved.

Slope Protection

Slope protection shall be provided for disturbed or cut/fill slopes that are one vertical on three horizontal (3H:1V) or steeper, 50 feet in length or longer, or on highly erodible soils. Show the location and type of BMPs to on the plans.

Design Criteria

- Where feasible, add notes that prohibit disturbing the slope until final site grading.
- Where a stabilized discharge point is available, provide temporary berms or swales to direct stormwater away from the slope until the slope is stabilized.
- Check dams shall be used within swales that are cut down a slope.
- Temporary terraces, vegetated strips or equivalent linear controls shall be specified at regular intervals to break-up slopes longer than 50 feet until the slope is stabilized.
- Specify final stabilization measures to be initiated within 14 days of completing work on the slope.
- Hydromulch is prohibited for slope stabilization unless the slope is one vertical on five horizontal (5H:1V) or less.

Channel Protection

Show the location and type of BMPs used to prevent the erosion of channels, drainage ways, streambanks, and outfalls until permanent structures and final stabilization measures are installed.

Design Criteria

- Provide temporary energy dissipaters at discharge points.
- If final channel stabilization consists of vegetation, anchored erosion control blankets, turf reinforcement mats, or an equivalent BMP that is resistant to channel flow shall be installed until the

vegetation is established.

- If the BMPs include check dams, velocity dissipaters or other structures that extend into the channel, the BMPs shall be designed by a licensed engineer to function under the flow conditions produced by the design storm. The engineer shall verify that the BMPs will not divert flow or cause flooding of adjacent properties and structures.
- Specify final stabilization measures to be initiated within 14 days of completing work on the channel.

Temporary Stabilization

Temporary stabilization practices shall be specified for disturbed areas where work stops for 14 days or more.

Design Criteria

- Stabilization measures shall be appropriate for the time of year, site conditions, and estimated duration of use.
- Stabilization BMPs shall be provided for soil stockpiles.

Final Stabilization

Final stabilization practices shall be specified for disturbed areas that are not covered by buildings, pavement or other permanent structures upon completion of construction. Final stabilization measures shall be coordinated with the site's landscaping plan.

Design Criteria

- Final stabilization shall be specified to start within fourteen days of completing soil disturbing activities.
- If space is available, top soil shall be stockpiled during construction and distributed onto the surface of disturbed areas prior to final stabilization.
- If top soil has not been stockpiled, soil amendments (compost, fertilizer, etc.) shall be specified with the final stabilization measures.
- Final stabilization measures must provide a perennial vegetative cover with a uniform density of 70% of the native background vegetative cover or equivalent permanent measures (riprap, gabion, or geotextiles).
- Include notes requiring temporary BMPs be removed within 30 days of establishing final stabilization.

Local Provisions:

4.3.2 Sediment Controls

Sediment control BMPs shall be designed to capture sediment on the site when preventing erosion is not feasible due to on-going construction activity. Sediment control BMPs and their locations shall be designed to change with the different phases of construction as site conditions and drainage patterns change. Sediment controls for the initial phase of construction shall be installed before any site disturbing activities begin. Fact Sheets for different types of Sediment Control BMPs are in *Section 3.0 of the Construction Controls Technical Manual*.

Sediment Barriers

Sediment barriers may be linear controls (silt fence, compost socks, sediment logs, wattles, etc.), check dams, berms, sediment basins, sediment traps, active treatment systems and other structural BMPs designed to capture sediment suspended in stormwater.

Design Criteria

- Sediment barriers shall be designed to treat the volume of runoff from the design storm.
- Sediment barriers are not required for areas of the site that are undisturbed.
- If linear controls are used as the only sediment barrier for a project, the linear control shall be provided at a rate of 100 linear feet per quarter-acre of disturbed area. A series of linear controls may be needed throughout the site and are not limited to the perimeter.
- Linear controls shall not be used across areas of concentrated flow, such as drainage ditches, swales and outfalls.
- A sediment basin shall be provided where stormwater runoff from 10 acres or more of disturbed area flows to a common drainage location, unless a basin is infeasible due to site conditions or public safety. The basin shall be designed for the volume of runoff from the total area contributing (on-site and off-site) to the common drainage location, not just the volume from the disturbed portion of the contributing area. Stormwater diversion BMPs may be used to divert stormwater from upslope areas away from and around the disturbed area to minimize the design volume of the sediment basin.
- Both existing topography and graded topography shall be evaluated when determining if 10 acres or more discharges to a common location.
- If a sediment basin is infeasible on a site of 10 acres or more, a series of smaller sediment traps and/or linear controls shall be provided throughout the site to provide an equivalent level of protection.
- Permanent detention and retention basins may be used as a sediment basin during construction if all sediment is removed upon completion of construction.

Perimeter Controls

A linear BMP shall be provided at all down slope boundaries of the construction activity and side slope boundaries where stormwater runoff may leave the site. Linear sediment barriers may be used to satisfy the requirement for perimeter controls.

Storm Drain Inlet Protection

Storm drain inlet protection shall not be used as a primary sediment control BMP unless all other primary controls are infeasible due to site configuration or the type of construction activity. Inlet protection is to intended to be a last line of defense in the event of a temporary failure of other sediment controls.

Design Criteria

- Municipality approval is required before installing inlet protection on public streets.
- Inlet protection shall only be specified for low point inlets where positive overflow is provided.
- Drainage patterns shall be evaluated to ensure inlet protection will not divert flow or flood the roadway or adjacent properties and structures.

Construction Access Controls

BMPs shall be provided to prevent off-site vehicle tracking of soil and pollutants.

Design Criteria

- Limit site access to one route during construction, if possible; two routes for linear projects.
- Design the access point(s) to be at the upslope side of the construction site. Do not place the construction access at the lowest point on the construction site.
- Specify rock stabilization or an equivalent BMP for all access points.
- Include notes requiring soil tracked onto public roads be removed at a frequency that minimizes site impacts and prior to the next rain event, if feasible..
- Using water to wash sediment from streets is prohibited.

Dewatering Controls

Water pumped from foundations, vaults, trenches and other low areas shall be discharged through a BMP or treated to remove suspended soil and other pollutants before the water leaves the site. The plans shall include notes that prohibit discharging the water directly into flumes, storm drains, creeks or other drainage ways. Where state or local discharge permit requirements exist for the pollutant(s) suspected of being in the water, the plan shall include the discharge permit conditions.

Local Provisions:

4.3.3 Material and Waste Controls

Notes shall be placed on the iSWM Construction Plan for the proper handling and storage of materials and wastes that can be transported by stormwater. At a minimum, notes shall be provided for the materials and wastes in Table 4.1. Additional notes and BMPs shall be provided if other potential pollutants are expected to be on-site. Construction details shall be provided when necessary to ensure proper installation of a material or waste BMP.

All material and waste sources shall be located a minimum of 50 feet away from inlets, swales, drainage ways, channels and waters of the U.S., if the site configuration provides sufficient space to do so. In no case shall material and waste sources be closer than 20 feet from inlets, swales, drainage ways, channels and waters of the U.S.

Table 4.1 Requirements for Materials and Wastes

Material or Waste Source	Requirements
Sanitary Facilities	Sanitary facilities shall be provided on the site, and their location shall be shown on the *i*SWM Construction Plan. The facilities shall be regularly serviced at the frequency recommended by the supplier for the number of people using the facility.
Trash and Debris	Show the location of trash and debris storage on the *i*SWM Construction Plan. Store all trash and debris in covered bins or other enclosures. Trash and debris shall be removed from the site at regular intervals. Containers shall not be allowed to overflow.

Table 4.1 Requirements for Materials and Wastes

Material or Waste Source	Requirements
Chemicals and Hazardous Materials	The amount of chemicals and hazardous materials stored on-site shall be minimized and limited to the materials necessary for the current phase of construction. Chemicals and hazardous materials shall be stored in their original, manufacturer's containers inside of a shelter that prevents contact with rainfall and runoff. Hazardous material storage shall be in accordance with all Federal, state and local laws and regulations. Storage locations shall have appropriate placards and secondary containment equivalent to 110% of the largest container in storage. If an earthen pit or berm is used for secondary containment, it shall be lined with plastic. Containers shall be kept closed except when materials are added or removed. Materials shall be dispensed using drip pans or within a lined, bermed area or using other spill/overflow protection measures.
Fuel Tanks	On-site fuel tanks shall be provided with a secondary enclosure equivalent to 110% of the tank's volume. If the enclosure is an earthen pit or berm, the area shall be lined with plastic. Show the location of fuel tanks and their secondary containment on the iSWM Construction Plan.
Concrete Wash-out Water	An area shall be designated on the iSWM Construction Plan for concrete wash-out. A pit or bermed area, lined with plastic, or an equivalent containment measure shall be provided for concrete wash-out water. The containment shall be a minimum of 6 CF for every 10 CY of concrete placed plus a one foot freeboard. The discharge of wash-out water to drainage ways or storm drain infrastructure shall be prohibited.
Hyper-chlorinated Water from Water Line Disinfection	Hyper-chlorinated water shall not be discharged to the environment unless the chlorine concentration is reduced to 4 ppm or less by chemically treating to dechlorinate or by on-site retention until natural attenuation occurs. Natural attenuation may be aided by aeration. Water with measurable chlorine concentration of less than 4 ppm is prohibited from being discharged directly to surface water. It shall be discharged onto vegetation or through a conveyance system for further attenuation of the chlorine before it reaches surface water. Alternatively, permission from the sanitary sewer operator may be obtained to discharge directly to the sanitary sewer.
Vehicle/Equipment Wash Water	Vehicle and equipment washing is prohibited on the site unless a lined basin is provided to capture 100% of the wash water. The wash water may be allowed to evaporate or hauled-off for disposal.
Soil Stabilizers	Lime or other chemical stabilizers shall be limited to the amount that can be mixed and compacted by the end of each working day. Stabilizers shall be applied at rates that result in no runoff. Stabilization shall not occur immediately before and during rainfall events. Soil stabilizers stored on-site shall be considered a hazardous material and shall meet all the requirements for chemicals and hazardous materials.
Concrete Saw-cutting Water	Slurry from concrete cutting shall be vacuumed or otherwise recovered and not be allowed to discharge from the site. If the pavement to be cut is near a storm drain inlet, the inlet shall be protected by sandbags or equivalent temporary measures to prevent the slurry from entering the inlet.

Local Provisions:

4.3.4 Installation, Inspection and Maintenance

The iSWM Construction Plan shall include details and notes that specify the proper installation, inspection and maintenance procedures for BMPs. The BMPs for the initial phase of construction must be implemented before starting any activities that result in soil disturbance, including land clearing. Notes shall indicate the sequence of BMP installation for subsequent phases of construction.

Notes on the iSWM Construction Plan shall indicate the frequency of inspections and the areas to be inspected. Inspections shall include:

- Inspecting erosion and sediment controls to ensure that they are operating correctly;
- Inspecting locations where vehicles enter or exit the site for evidence of off-site tracking;
- Inspecting material and waste controls to ensure they are effective; and
- Inspecting the perimeter of disturbed areas and discharge points for evidence of sediment or other pollutants that may have been discharged.

Erosion, sediment, and material and waste controls shall be repaired, replaced, modified and/or added if inspections reveal the controls were not installed correctly, are damaged, or are inadequate or ineffective in controlling their targeted pollutant.

Notes for maintenance of BMPs shall require the removal of sediment from BMPs when the sediment reaches half of the BMP's capacity or more frequently. Sediment discharged from the site shall be removed prior to the next rain event, where feasible, and in no case later than seven days after it is discovered. Upon completion of construction, sediment shall be removed from all storm drain infrastructure and permanent BMPs before the temporary BMPs are removed from the site.

Local Provisions:

5.0 Additional Local Requirements

- Municipality can update detailed checklists for iSWM Plans based on their requirements

Checklist for Conceptual iSWM Plan Preparation and Review

	Included?		
	Yes	No	Comments
Mapping and plans which illustrate at a minimum:			
(recommended scale of 1" = 50' or greater)			
1. Project Description			
A. Name, legal address and telephone number of applicant	____	____	_____
B. Name, legal address and telephone number of preparer	____	____	_____
C. Common address and legal description of site	____	____	_____
D. Vicinity map	____	____	_____
E. Proposed land use with Standard Industrial Code No.	____	____	_____

	Yes	No	Comments
2. Planning Concerns			
A. Have any previous drainage or watershed plans been completed in the watershed? (If yes, describe)	____	____	_____
B. Is there any known history of flooding downstream? (If yes, describe conditions and locations)	____	____	_____
C. Is there any known history of excessive erosion downstream? (If yes, describe conditions and locations)	____	____	_____
D. Are there any known downstream drainage constrictions such as undersized culverts or channels? Size?	____	____	_____
E. Are there any known or suspected wetland areas, mitigation areas, 404 permit areas, or other natural habitat features which require special consideration?	____	____	_____
F. Are there any existing dams over six feet in height which are or will be subject to TCEQ regulations?	____	____	_____
G. Are there any existing impoundments subject to TCEQ water rights permitting? (Livestock ponds are not exempt when converted to other uses.)	____	____	_____
H. Are there any existing environmental concerns on the site requiring special treatment or design consideration (i.e. fuel stations, vehicle maintenance, auto recycling, illegal dump sites, landfills, etc.)?	____	____	_____

Checklist for Conceptual iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
3. Existing Conditions			
A. Copy of applicable digital orthophoto showing proposed project boundaries			
B. Best available existing topography (no greater than 2-foot contours recommended)			
C. Total Site Area and Total Impervious Area (acres)			
D. Benchmarks used for site control if available			
E. Perennial and intermittent streams			
F. Predominant soils from USDA soil surveys and/or on site soil borings			
G. Boundaries of existing predominant vegetation			
H. Location and boundaries of natural feature protection and conservation areas such as wetlands, lakes, ponds, and other setbacks (e.g., stream buffers, drinking water well setbacks, septic setbacks, etc.)			
I. Location of existing roads, buildings, parking lots and other impervious areas			
J. Location of existing utilities (e.g., water, sewer, gas, electric) and easements			
K. Location of existing conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow			
L. Flow paths			
M. Location of floodplain/floodway limits and relationship of site to upstream/downstream properties and drainages			
N. Location and dimensions of existing channels, bridges or culvert crossings			
4. Conceptual Site Layout			
A. Complete the iSWM Conceptual Plan Worksheet			
B. Hydrologic analysis to determine conceptual runoff rates, volumes and velocities to support selection of Stormwater Controls			
C. Conceptual site design identifying *integrated* site design practices used			
D. Identification and calculation of stormwater site design credits			

Checklist for Conceptual iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
E. Approximate downstream assessment limits for all outfalls			
F. Conceptual estimates of *integrated* Design Focus Area requirements			
G. Conceptual selection, location and size of proposed structural stormwater controls			
H. Conceptual limits of proposed clearing and grading			

Checklist for Preliminary iSWM Plan Preparation and Review

	Included?		
	Yes	No	Comments
Mapping and plans which illustrate at a minimum:			
(recommended scale of 1" = 50' or greater)			
1. Existing Conditions Hydrologic Analysis			
A. Existing and proposed topography (no greater than 2-foot contours recommended)			
B. Total Site Area and Total Impervious Area (acres)			
C. Perennial and intermittent streams			
D. Predominant soils from USDA soil surveys or soil borings			
E. Boundaries of existing predominant vegetation and proposed limits of clearing and grading			
F. Location and boundaries of natural feature protection and conservation areas such as wetlands, lakes, ponds, and other setbacks (e.g., stream buffers, drinking water well setbacks, septic setbacks, etc.)			
G. Location of existing and proposed roads, buildings, parking lots and other impervious areas			
H. Location of existing and proposed utilities (e.g., water, sewer, gas, electric) and easements			
I. Preliminary selection and location of stormwater controls			
J. Location of existing and proposed conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow			
K. Flow paths			
L. Location of floodplain/floodway limits and relationship of site to upstream/downstream properties and drainages			
M. Preliminary location and dimensions of proposed channel modifications, such as bridge or culvert crossings			
N. Existing conditions hydrologic analysis for runoff rates, volumes and velocities showing methodologies used and supporting calculations			

Checklist for Preliminary iSWM Plan Preparation and Review (continued)

	Included?		
	Yes	No	Comments
2. Project Description and Design Considerations (updated information from Conceptual Plan)			
A. Name, legal address and telephone number of applicant			
B. Name, legal address and telephone number of preparer			
C. Common address and legal description of site			
D. Vicinity Map			
E. Discussion of *integrated* Site Design Practices			
F. Discussion of Credits for *integrated* Site Design			
G. Discussion of stormwater controls			
H. Discussion of groundwater recharge considerations			
I. Discussion of hotspot land uses and runoff treatment			

	Yes	No	Comments
3. Post-Development Hydrologic Analysis			
A. Proposed (post-development) conditions hydrologic analysis for runoff rates, volumes, and velocities showing the methodologies used and supporting calculations			
B. Preliminary estimates of *integrated* Design Focus Area requirements			
C. Preliminary identification and calculation of credits for *integrated* site designs			
D. Location and boundary of proposed natural feature protection areas			
4. Downstream Assessments			
A. Preliminary analysis of potential downstream impact/effects of project, where necessary			

Checklist for Preliminary iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
5. Stormwater Management System Design			
A. Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms.....	____	____	_____
B. Preliminary sizing calculations for stormwater controls including contributing drainage area, storage, and outlet configuration.....	____	____	_____
C. Narrative describing the selected stormwater controls.....	____	____	_____

Checklist for Final iSWM Plan Preparation and Review

	Included?		
	Yes	No	Comments
1. Existing Conditions Hydrologic Analysis			
A. Updated checklist from **Preliminary iSWM Site Plan**.....	____	____	_____
2. Project Description and Design Considerations			
A. Updated checklist from **Preliminary iSWM Site Plan**.....	____	____	_____
3. Post-Development Hydrologic Analysis			
A. Updated checklist from **Preliminary iSWM Site Plan**.....	____	____	_____
B. Final sizing calculations for stormwater controls including contributing drainage area, storage, and outlet configuration.....	____	____	_____
C. Stage-discharge or outlet rating curves and inflow and outflow hydrographs for storage facilities.....	____	____	_____
D. Final analysis of potential downstream impact/effects of project, where necessary	____	____	_____
E. Dam safety and breach analysis, where necessary	____	____	_____
4. Downstream Assessments			
A. Update checklist from **Preliminary iSWM Site Plan**.....	____	____	_____
5. Stormwater Management System Design			
A. Update checklist from **Preliminary iSWM Site Plan**.....	____	____	_____
B. Existing and proposed structural elevations (e.g., invert of pipes, manholes, etc.).....	____	____	_____
C. Design water surface elevations	____	____	_____

Checklist for Final iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
D. Structural details and specifications of structural control designs, outlet structures, embankments, spillways, grade control structures, conveyance channels, etc.			
E. Professional Engineer seal, signature and date			

6. iSWM Construction Plan

A. Existing topography and natural drainage features and post-development topography and drainage features			
B. Limits of disturbance, including off-site areas that will be disturbed and natural features to be protected within the disturbed areas			
C. Location, details, BMP design calculations (if applicable), and notes for erosion controls			
D. Locations, details, BMP design calculations (if applicable), and notes for sediment controls			
E. Location, details, BMP design calculations (if applicable), and notes for material and waste controls			
F. Inspection and maintenance notes			
G. Sequence of BMP installation based on sequence of construction phases			
H. Schedule and phasing of temporary and permanent stabilization on different area of the site			
I. Temporary structures that will be converted into permanent storm water controls			
J. Prepared by CPESC, PE or RLA			

Checklist for Final iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
7. Landscaping Plan			
A. Arrangement of planted areas, natural areas, and other landscaped features			
B. Information required to construct landscaping elements			
C. Descriptions and standards for the methods, materials and vegetation that are to be used			

	Yes	No	Comments
8. Operations and Maintenance Plan			
A. Name, legal address and phone number of responsible parties for maintenance activities			
B. Description and schedule of maintenance tasks			
C. Description of applicable easements			
D. Description of funding source			
E. Access and safety issues			
F. Procedures for testing and disposal of sediments, if required			
G. Expected service life of structures and estimated cost to replace			
H. Executed Maintenance Agreement(s), as required			
9. Evidence of Acquisition of Applicable Federal, State, and Local Permits			
A. USACE Regulatory Program permits			
B. 401 water quality certification			
C. TPDES Construction permit			
D. Other_____			
E. Other_____			

Checklist for Final iSWM Plan Preparation and Review (continued)

	Yes	No	Comments
10. Waiver requests			
A. Evidence of acquisition of all necessary legal agreements (e.g., easements, covenants, land trusts, etc.)			

Transportation *integrated* Stormwater Management (TriSWM) Appendix

Table of Contents

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1.0 Overview of TriSWM Appendix

1.1 Introduction

The TriSWM Appendix has been developed as an appendix to the iSWM Criteria Manual for Site Development and Construction for use by cities, counties, and transportation agencies in the planning and design of stormwater management systems for public streets, roads, and highways. The purpose of this Appendix is to provide design guidance and a framework for incorporating effective and environmentally sustainable stormwater management into the project development and construction processes and to encourage a greater regional uniformity in developing plans for stormwater management systems that meet the following goals:

- Control runoff within and from the site to minimize flood risk to people and properties;
- Assess discharges from the site to minimize downstream bank and channel erosion; and
- Reduce pollutants in stormwater runoff to protect water quality and assist communities in meeting regulatory requirements.

The table below indicates the chapters or sections of the iSWM Criteria Manual for Site Development and Construction that have been replaced by information in the TriSWM Appendix for use in the planning and design of stormwater management facilities for public transportation projects. Chapters or sections of the iSWM Criteria Manual for Site Development and Construction not referenced in the table are to be used "as is."

Affected Chapter/Section of the iSWM Criteria Manual	Replacement Chapter/Section in TriSWM Appendix	Comments
Chapter 1, Overview of iSWM Criteria Manual	Chapter 1, Overview of TriSWM Appendix	General content modifications as needed to reflect TriSWM requirements.
Chapter 2, *integrated* Development Process	Chapter 2, TriSWM Planning and Development Process	Complete section replaced; the project planning and development process for public facilities is significantly different than for private development projects.
Chapter 3, Section 3.2, Water Quality Protection	Chapter 3, Section 3.2, TriSWM Water Quality Protection	The Water Quality Protection Criteria has been modified due to the nature of linear facilities.
Chapter 3, Section 3.8, Stormwater Control Selection	Chapter 3, Section 3.8, TriSWM Stormwater Control Selection	The "*Ability to treat the Water Quality Volume"* section has been modified to reflect TriSWM water quality treatment designations. The tables have been changed as indicated below.
Table 3.6, Suitability of Stormwater Controls to Meet *integrated* Focus Areas, and Table 3.15, Stormwater Treatment Suitability[1]	Table 3.2, Stormwater Treatment Suitability[2]	Designations in the "Water Quality Protection" column have been changed to reflect TriSWM designations (Primary or Secondary changed to Levels I, II, or III). Also, *integrated* Stormwater Controls not typically associated with streets or roadways (Green Roofs, Rain Barrels, etc.) have been removed.

Affected Chapter/Section of the iSWM Criteria Manual	Replacement Chapter/Section in TriSWM Appendix	Comments
Table 3.16 Water Quality Performance	Table 3.3 Water Quality Performance	*integrated* Stormwater Controls not typically associated with streets or roadways have been removed.
Table 3.17 Site Applicability	Table 3.4 Site Applicability	
Table 3.18 Implementation Considerations	Table 3.5 Implementation Considerations	
Table 3.19 Physiographic Factors	Table 3.6 Physiographic Factors	
Table 3.20 Soils	Table 3.7 Soils	
Table 3.21 Special Watershed Considerations	Table 3.8 Special Watershed Considerations	
Table 3.22 Location and Permitting Checklist	Table 3.9 Location and Permitting Checklist	Minor updates for clarification.

1. Tables 3.6 and 3.15 in the iSWM Criteria Manual contain the same information and are both replaced by Table 3.2 in the TriSWM Appendix.
2. The Water Quality Protection designations for stormwater controls in Table 3.2 of the TriSWM Appendix shall also be used in place of the Water Quality Protection designations in Table 1.3 of the Stormwater Controls Technical Manual.

Note: Stormwater runoff from residential streets should be managed as part of the overall stormwater management system for the entire site. The iSWM Criteria Manual for Site Development and Construction should be used for the planning and design of stormwater management facilities for residential subdivisions and internal residential streets. The TriSWM Appendix does not apply to local or residential classified streets within residential subdivisions, unless required by the local jurisdiction. However, when a city or county cooperates with a developer in the construction of a collector or arterial street for access, the local government may require the use of the TriSWM Appendix for that portion of the project.

Local Provision Boxes

Throughout this manual there are “Local Provision” boxes. These boxes are used by a local government/agency to add, delete, or modify sections of the criteria and specify the options allowed and/or required by the local government/agency. Additional local information can be added at the back of this document.

Local Provisions:

Applicability

TriSWM is applicable under the following conditions for projects that will ultimately disturb one or more acres as indicated in Table 1.1.

Table 1.1 Applicability

Applicable for TriSWM Criteria :	Applicable for iSWM Construction Criteria:
Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger.	Land disturbing activity of 1 acre or more **OR** land disturbing activity of less than 1 acre where the activity is part of a common plan of development that is one acre or larger. (Requirements located in Chapter 4, *integrated* Construction Criteria of the iSWM Criteria Manual for Site Development and Construction)

The criteria within the TriSWM Appendix is applicable to projects that disturb 1 acre or more, including projects less than one acre that are part of a larger common project plan or scope that will disturb 1 acre or more. A common plan of development consists of construction activity that is completed in separate stages, separate phases, or in combination with other construction activities.

Projects located in or near critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria. Furthermore, these sites may need to utilize certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area or watershed.

For some projects, particularly expansion projects, practical limitations may present obstacles to fully meeting stormwater management requirements within the project right-of-way (ROW). Limitations could include lack of land availability, engineering constraints, health and safety issues associated with operations and maintenance activities, or low benefit/cost ratio. If the project planning, assessment, and design process reveals that stormwater requirements for a project cannot be met because it is not feasible to do so, an explanation must be provided in the planning documents for the project. The explanation must include the reasons why the requirements cannot be met for the site and the provisions for stormwater management that can be provided.

Projects below Applicability Threshold

Projects that are below the size threshold for applicability requirements (above) are not subject to the water quality or streambank protection requirements of the TriSWM Appendix. However, it is recommended that these criteria still be used and that temporary controls be provided during construction. Flood mitigation and conveyance criteria still apply. The planning process is also simplified for sites below the applicable criteria to an optional pre-development review before the final submittal of the engineering plans.

Local Provisions:

1.2 TriSWM Development Process

Chapter 2 presents information on the process of collecting and considering appropriate information needed to effectively and efficiently manage stormwater on roadway, street, and highway projects. Descriptions of the city/county and Texas Department of Transportation (TxDOT) project development processes are provided along with information on site analysis and inventory, conditions for accepting off-site flows, and special planning and design considerations.

Local Provisions:

1.3 TriSWM Design Criteria

Chapter 3 presents an approach for meeting stormwater runoff quality and quantity management goals by addressing the key adverse impacts of development on stormwater runoff. Its framework consists of three focus areas, each with options in terms of how the focus area is applied.

Design Focus Areas

The stormwater management focus areas and goals are:

- **Water Quality Protection:** Remove or reduce pollutants in stormwater runoff to protect water quality
- **Streambank Protection:** Regulate discharge from the site to minimize downstream bank and channel erosion
- **Flood Mitigation and Conveyance:** Control runoff within and from the site to minimize flood risk to people and properties for the conveyance storm as well as the 100-year storm.

Each of the Design Focus Areas must be used in conjunction with the others to address the overall stormwater impacts from a development site. When used as a set, the Design Focus Areas control the entire range of hydrologic events, from the smallest runoff-producing rainfalls up to the 100-year, 24-hour storm.

Local Provisions:

Design Storms

TriSWM design is based on the following four (4) storm events.

Table 1.2 Storm Events

Storm Event Name	Storm Event Description
"Water Quality"	Criteria based on a volume of 1.5 inches of rainfall, not a storm frequency
"Streambank Protection"	1-year, 24-hour storm event
"Conveyance"	25-year, 24-hour storm event
"Flood Mitigation"	100-year, 24-hour storm event

Throughout the manual the storms will be referred to by their storm event names.

Local Provisions:

Design Focus Area Application Options

There are multiple options provided to meet the required criteria for water quality protection, streambank protection, and flood mitigation. Design requirements and options are summarized in Table 1.3.

Design criteria for streambank protection and flood mitigation are based on a **downstream assessment**. The purpose of the downstream assessment is to protect downstream properties and channels from increased flooding and erosion potential due to the proposed project. A downstream assessment is required to determine the extent of improvements necessary for streambank protection and flood mitigation. Downstream assessments shall be performed for streambank protection, conveyance, and flood mitigation storm events. More information on downstream assessments is provided in Section 3.3. of the iSWM Criteria Manual for Site Development and Construction

If a project causes no adverse impacts to existing conditions, then it is possible that little or no mitigation would be required.

Table 1.3 Summary of Options for Design Focus Areas			
Design Focus Area	**Reference Section**	**Required Downstream Assessment**	**Design Requirements/Options**
Water Quality Protection	**3.2** TriSWM Appendix	no	Water Quality Protection requirements are determined based on the quality of receiving waters, proximity of project discharge to any wetlands and/or drinking water supply intakes, and projected traffic volume. Refer to Section 3.2 to determine the Water Quality Treatment Level required (Treatment Level I, II, or III).
Streambank Protection	**3.4** iSWM Criteria Manual	yes	**Option 1:** Reinforce/stabilize downstream conditions
			Option 2: Install stormwater controls to maintain or improve existing downstream conditions
			Option 3: Provide on-site controlled release of the 1-year, 24-hour storm event over a period of 24 hours (Streambank Protection Volume, SP_V)
Flood Mitigation and Conveyance	**3.5 and 3.6** iSWM Criteria Manual	yes	**Flood Mitigation** **Option 1:** Provide adequate downstream conveyance systems
			Option 2: Install stormwater controls on-site to maintain or improve existing downstream conditions
			Option 3: In lieu of a downstream assessment, maintain existing on-site runoff conditions
			Conveyance Minimize localized site flooding of streets, sidewalks, and properties by a combination of on-site stormwater controls and conveyance systems

Local Provisions:

2.0 TriSWM Development Process

2.1 Project Development Goals

In order to most effectively and efficiently manage stormwater on new public roadway, street, and highway projects, as well as significant expansion projects, consideration of stormwater runoff needs to be fully integrated into the project planning and design process. This involves a comprehensive planning approach and a thorough understanding of the physical characteristics and natural resources in proximity to the proposed route. In addition, the management of the quantity and the quality of stormwater should be addressed in an integrated approach. The purpose of the TriSWM Appendix is to provide design guidance and a framework for incorporating effective and environmentally sensitive stormwater management into the street and highway project development process and to encourage a greater uniformity in developing plans for stormwater management systems that meet the following goals:

- Provide safe driving conditions
- Minimize the downstream flood risk to people and properties
- Minimize downstream bank and channel erosion
- Reduce pollutants in stormwater runoff to protect water quality.

2.2 Stormwater Management Planning

2.2.1 Introduction

The planning phase offers the greatest opportunity to avoid adverse water quality impacts as alignments and right-of-way requirements are developed and refined. Conducting natural and cultural resource studies concurrently with early project planning provides timely information to assist in identifying and avoiding potential impacts. Sections 2.2.6, Site Analysis and Inventory, and 2.3, Special Planning and Design Considerations, describe the features that should be considered and avoided if possible. Avoiding impacts may reduce or eliminate the need for higher level water quality treatment controls.

Once the alignment has been determined, planning and design of stormwater management controls should be performed early in the preliminary design phase of the project so that adequate right-of-way may be acquired. This would generally be at the site assessment and preliminary design phases of a city/county street project or the preliminary design phase of a TxDOT project. The proposed alignment should include sufficient reserved land to construct and maintain all required BMPs at appropriate locations.

Local Provisions:

2.2.2 City / County Project Development Process

Local governments plan for the preservation and creation of transportation corridors through master thoroughfare plans and/or comprehensive plans. The function of these planning tools is to establish the future roadway network and design guidelines to provide an adequate level of service. Thoroughfare

planning is used by local government to proactively prepare for future traffic conditions, accommodate growth and development and identify projects for the capital improvements program (CIP), determine roadway right-of-way requirements, and improve community aesthetics and safety. Conventional thoroughfare planning should be expanded to include avoidance of sensitive natural features where possible and to accommodate stormwater management best management practices (BMPs).

Planning for individual projects typically starts with identification in the capital improvement program, which is a long-range financial planning tool to address community needs in the long-term future for improving streets, drainage, parks, public facilities, utilities and other city functions. Projects selected for funding in the CIP would proceed through various stages of development including Site Assessment, Preliminary Design, Right-of-Way Acquisition, Final Design, and Drawings & Specifications.

The Site Assessment phase consists of identifying physical and environmental constraints on the potential alignment of the project. The Preliminary Design phase incorporates information from the site assessment and identifies the vertical alignment for the street or roadway. Typically, preliminary design drawings are reviewed by the local government at a point where the engineering design is approximately 30 to 50 percent complete. Once the preliminary plans and vertical alignment are approved, activities to acquire the right-of-way are initiated. While right-of-way acquisition efforts are in progress, the final design drawings and specifications for the project are completed and reviewed by the local government.

Since many stormwater management best management practices require additional space beyond the typical right-of-way (50' two-lane streets, 120 – 130' for 6-lane divided with median), stormwater management practices must be identified during the Preliminary Design phase. Once stormwater management controls are identified, the right-of-way acquisition process and development of the final design may proceed accordingly.

Local Provisions:

2.2.3 TxDOT Project Development Process

The TxDOT project development process is laid out in detail in the Project Development Process Manual, which may be accessed at http://onlinemanuals.txdot.gov/txdotmanuals/pdp/index.htm. A general characterization of the process is outlined below:

- Planning and Programming
  Consists of needs identification, site visit, project authorization, compliance with planning requirements, determination of study requirements, and construction funding identification.
- Preliminary Design
  Consists of data collection and preliminary design preparation, public meetings, preliminary schematic preparation, geometric schematic preparation (including determination of right-of-way needs), and value engineering. Development of the preliminary and geometric schematics is a particularly important phase since alternative alignments are evaluated, ROW and access control requirements are defined, and initial siting and sizing of permanent stormwater BMPs must be determined.
- Environmental
  Consists of environmental issues determination and data collection, interagency coordination and permitting, environmental documentation, public hearing, and environmental clearance. This process is further described below.
- Right-of-Way and Utilities

Consists of right-of-way and utility data collection, mapping, appraisals and acquisition, and utility adjustments.

- Plans, Specifications, and Engineering Development
  Consists of the design conference, design of bridges, final vertical and horizontal alignment design, roadway design, drainage design, and final review.
- Letting
  Consists of final funding approval and bidding and award of construction contract.

The project development process is overseen by the District's Area Engineer and Project Manager. The District Environmental Quality Coordinator (DEQC) reviews project plans prior to letting to ensure that the Stormwater Pollution Prevention Plan and Environmental Permits, Issues, and Commitments (EPIC) plan sheets are complete. The EPIC sheet is used to summarize the special requirements and restrictions related to the construction activity that has been permitted and the conditions of any permits. For example, it may depict areas to be avoided during construction due to the presence of endangered species, wetlands, etc. The DEQC and divisional and central management are aided by the Environmental Compliance Oversight System (ECOS). It's a database system that tracks the environmental process for projects generated by TxDOT's 25 Districts. The ECOS tracks and facilitates coordination throughout the TxDOT system concerning:

- Project environmental clearance
- Environmental Permits, Issues and Commitments (EPIC)
- Public involvement
- Cultural resources protection
- Hazardous material avoidance or removal
- Corps of Engineers permits
- Biological resource protection
- Water quality protection
- Coordination with other regulatory agencies as necessary

Local Provisions:

2.2.4 Determine/Confirm Local Requirements

The consultant or project designer must determine the stormwater management requirements of the jurisdiction(s) that the project will be located in. For local governments that have adopted the iSWM™ Criteria Manual for Site Development and Construction, much of this information is available in the jurisdiction's adopted version of the iSWM Criteria Manual. These requirements may include:

- Design storm frequencies
- Conveyance design criteria
- Floodplain criteria

- Buffer/setback criteria
- Watershed-based criteria
- Need for physical site evaluations such as infiltration tests, geotechnical evaluations, etc.

Local Provisions:

2.2.5 Conditions for Accepting Off-Site Flows

Local governments and the Texas Department of Transportation (TxDOT) must provide for the passage of off-site flows through street and highway right-of-way to maintain natural drainage paths. If a private developer's project discharges off-site flow to public right-of-way, local governments designated as Municipal Separate Storm Sewer Systems (MS4s) must require the private development project to comply with the requirements of the *integrated* Stormwater Management (iSWM™) Criteria Manual for Site Development and Construction (if adopted) or other local government post construction stormwater quality management requirements. Once the local government MS4 accepts discharge of water onto its right-of-way, the jurisdiction becomes liable for the quality of that discharge under Texas Pollutant Discharge Elimination System (TPDES) regulations.

TxDOT lacks statutory authority to prohibit or control post-construction discharges of stormwater from development projects outside the right-of-way. TxDOT should coordinate with local governments to the extent possible to ensure that private development projects meet the jurisdiction's post construction stormwater management requirements.

Local Provisions:

2.2.6 Site Analysis and Inventory

Using approved field and mapping techniques, the project designer shall collect and review information on the existing site conditions and map the following site features:

- Topography
- Drainage patterns and basins
- Intermittent and perennial streams / receiving waters
- Stream flow data
- Soils
- Ground cover and vegetation
- Wetlands
- Critical habitat areas
- Boundaries of wooded areas
- Floodplain boundaries

- Steep slopes
- Required buffers
- Other required protection areas (e.g., well setbacks)
- Clean Water Act Section 303(d) listed impaired stream segments
- Proposed stream crossing locations
- Existing stormwater facilities (open channels & enclosed)
- Existing development
- Utilities
- Adjacent areas
- Property lines and easements

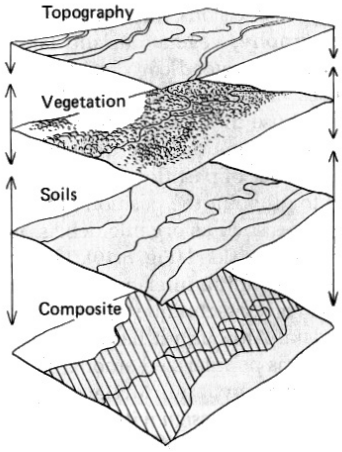

Figure 1.1
Composite Analysis
(Source: Marsh, 1983)

Some of this information may be available from previously performed studies or from a feasibility study. For example, some of the resource protection features may have been mapped as part of erosion and sediment control activities. Other recommended site information to map or obtain includes utilities information, seasonal groundwater levels, and geologic data.

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 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 once (see Figure 1.1).

Local Provisions:

2.3 Special Planning and Design Considerations

This section discusses several environmental features that need to be identified and assessed during the earliest stages of planning for a project, as well as design considerations for bridges and right-of-way. Proposed alignments for a project should avoid sensitive natural resources to the greatest extent practicable. In cases where avoidance is not possible, providing an undisturbed buffer and additional practices or structural controls to minimize impact must be considered.

Preserving natural conservation areas such as undisturbed forested and vegetated areas, floodplains, stream corridors and wetlands helps to preserve the original hydrology and avoids the impact of stormwater runoff and pollutants. Undisturbed vegetated areas also stabilize soils, provide for filtering and infiltration, decreases evaporation, and increases transpiration.

Buffer areas and sensitive features in proximity to project alignments should be clearly marked on all construction and grading plans to ensure equipment is kept out of these areas and native vegetation is kept in an undisturbed state. The boundaries of each conservation area should be mapped by carefully determining the limit that should not be crossed by construction activity.

Projects located in or near critical or sensitive areas, or as identified through a watershed study or plan, may be subject to additional performance and/or regulatory criteria. Furthermore, these sites may need to utilize certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area or watershed.

For some projects, particularly expansion projects, practical limitations may present obstacles to fully meeting stormwater management requirements within the project right-of-way (ROW). Limitations could include lack of land availability, engineering constraints, health and safety issues associated with operations and maintenance activities, or low benefit/cost ratio. If the project planning, assessment, and design process reveals that stormwater requirements for a project cannot be met because it is not feasible to do so, an explanation must be provided in the planning documents for the project. The explanation must include the reasons why the requirements cannot be met for the site and the provisions for stormwater management that can be provided.

Local Provisions:

2.3.1 Sensitive Areas

Stream segments classified by the Texas Commission on Environmental Quality (TCEQ) as Exceptionally-High quality should be avoided if possible when considering potential alignments. These are waters that have been designated "Exceptional Quality Aquatic Habitat" by the TCEQ or "Endangered/Protected Species Habitat" by the Texas Parks and Wildlife Department.

- Exceptional Quality Aquatic Habitat – segments that are significant due to unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality
- Endangered/Protected Species Habitat – sites along segments where water development projects would have significant detrimental effects on state or federally listed threatened and endangered species, and sites along segments that are significant due to the presence of unique, exemplary, or unusually extensive natural communities

Local Provisions:

2.3.2 Wetlands

Because the alteration of ground cover and drainage patterns will almost always affect the hydrology of wetlands, and because hydrologic changes strongly impact vegetation and amphibian communities, it is always preferable to avoid wetland areas when determining road or street alignments if possible.

An important measure to maintain the health of a natural wetland is the protection and control of the wetland's hydroperiod. The hydroperiod is the pattern of fluctuation of water depth and the frequency and duration of drying in the summer. A hydrological assessment is performed to determine pre-project hydroperiod characteristics and to model the post-project conditions. Coordination with the TCEQ is necessary to properly assess the impact of hydroperiod changes.

The design of facilities adjacent to wetlands should maximize natural water storage and infiltration opportunities within the project area. Natural wetlands may not be used in lieu of runoff treatment BMPs. Any construction of stormwater treatment or flow control facilities is discouraged within natural wetland areas, with the exception of the following situations, which involve additional permitting:

- Necessary conveyance systems with applicable permits

- Lower quality wetland approved for hydrologic modification

Local Provisions:

2.3.3 Floodplains

Development in floodplain areas can reduce the ability of the floodplain to convey stormwater, potentially causing safety problems or significant damage to the site in question, as well as to both upstream and downstream properties. Ideally, the entire 100-year full-buildout floodplain should be avoided for clearing or building activities, and should be preserved in a natural undisturbed state where possible. Floodplain protection is complementary to riparian buffer preservation.

Roadway construction can displace hydrologic storage, resulting in increased stream flows, erosion, and decreased infiltration. Loss of hydrologic storage may require creation of additional hydrologic storage elsewhere in the watershed. Design for management of stormwater runoff from transportation facilities in floodplains differs from parcel based BMPs primarily in the increased influence of off-site stormwater entering the facility, space limitations of a linear facility, and the likelihood that roadways will cross jurisdictional boundaries.

Local Provisions:

2.3.4 Aquifers and Wellhead Protection Areas

Pollutants can enter aquifers through stormwater runoff treatment and storage systems. Local ordinances may specify minimum setbacks or buffers between wellheads and roadway construction. In Texas, the TCEQ's Source Water Assessment Program (SWAP), Source Water Protection Program (SWP) and Wellhead Protection Program (WHP) may also impact BMP selection and implementation for transportation projects. Aquifer recharge zones may also have state or local restrictions.

Local Provisions:

2.3.5 Streams and Riparian Areas

Roadway alignments should cross streams and riparian areas as few times as possible and should be located a sufficient distance from the stream when the alignment is parallel. Maintaining riparian buffers is important for the protection of stream banks and stream ecosystems.

Forested riparian buffers should be maintained and reforestation should be encouraged where no wooded buffer exists. Proper restoration should include all layers of the forest plant community, including understory, shrubs and groundcover, not just trees. A riparian buffer can be of fixed or variable width, but should be continuous and not interrupted by impervious areas that would allow stormwater to concentrate and flow into the stream without first flowing through the buffer.

Ideally, riparian buffers should be sized to include the 100-year floodplain as well as steep banks and wetlands. The buffer depth needed to perform properly will depend on the size of the stream and the surrounding conditions, but a minimum 25-foot undisturbed vegetative buffer is needed for even the smallest perennial streams and a 50-foot or larger undisturbed buffer is ideal. Any structural controls for management of stormwater should be located outside the riparian buffer if possible.

Generally, the riparian buffer should remain in its natural state. However, some maintenance is periodically necessary, such as planting to minimize concentrated flow, the removal of exotic plant species when these species are detrimental to the vegetated buffer and the removal of diseased or damaged trees.

Local Provisions:

2.3.6 Impaired Water Bodies

Impaired water bodies are those surface waters identified in the *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* as not meeting water quality standards. In compliance with the federal Clean Water Act, the Texas Commission on Environmental Quality (TCEQ) researches, updates, and then publishes the list every two years. Impaired water bodies are eventually assigned a Total Maximum Daily Load (TMDL), which is the maximum amount of the impairing pollutant that the water body can receive and still comply with water quality standards. There are several impaired water bodies in the Dallas-Fort Worth metropolitan area, including those with and without TMDLs. Impairments may be for a variety of pollutants including bacteria and legacy pollutants such as PCBs and dioxin. Discharges of stormwater runoff containing pollutants of concern (any pollutant identified as a cause of impairment) to impaired water bodies will be governed by an entity's Texas Pollutant Discharge Elimination System (TPDES) Municipal Separate Storm Sewer System (MS4) permit, if applicable.

Local Provisions:

2.3.7 Facilities Designated as Hazardous Materials Routes

Shipments of hazardous materials along roadways that are listed on the National Hazardous Material Route Registry have the potential for accidental release of hazardous materials. Hazardous material traps should be considered for placement depending on the level of sensitivity of receiving waters, the probability of spills, and the nature of the stormwater collection system (particularly if the road surface drains directly to inlet and pipe system that discharge to surface waters). Gravity or other proprietary oil-water separators provide some level of protection, but the capacity may be exceeded and these devices are also generally not effective at containing corrosives. For maximum protection of sensitive areas, detention basins lined with clay, concrete, or other impermeable liner with a capture volume of at least 10,000 gallons should be considered.

Local Provisions:

2.3.8 Bridges

The portion of bridge stormwater runoff associated with the part of the bridge over water is the same volume as would have fallen in the water body without the presence of the bridge. The water quality, however, is impacted by material deposited on the road surface. Furthermore, the bridge itself doesn't offer an opportunity for treatment or infiltration. Although bridges have traditionally been built with gutters routing stormwater directly into the receiving waters, this is no longer the preferred alternative. It is recommended that runoff be collected and conveyed to the ends of the bridge and directed to the selected treatment facility as necessary. Collection and conveyance systems must be designed to prevent backup of stormwater onto the bridge surface in the event of clogging by trash and debris.

Local Provisions:

2.3.9 Right-of-Way

After the stormwater treatment requirements of the project are determined, and the hydrology of the site is known, the area required for stormwater treatment facilities can be estimated. Availability and cost of right-of-way may influence treatment selection. Placement of the roadway and stormwater treatment facilities within the right-of-way can be adjusted and additional right-of-way requirements may be identified.

Local Provisions:

2.3.10 Protection of Permanent Stormwater Controls during Construction

Permanent stormwater controls must be protected from damage due to excess sedimentation during construction of the project. All disturbed areas upstream of permanent stormwater controls should ideally achieve final stabilization prior to stormwater runoff being permitted to flow into the permanent control. At a minimum, permanent stormwater controls receiving runoff from disturbed areas must be protected by sediment controls such as silt fence or filter tubes. Permanent stormwater controls must be fully operational (no sediment buildup, no clogged filter media, plant material in place, proper infiltration rates achieved, etc.) as a condition of project acceptance from the contractor.

Local Provisions:

3.0 TriSWM Design Criteria

3.1 Hydrologic Methods

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.1, Hydrologic Methods.

3.2 TriSWM Water Quality Protection

3.2.1 Water Quality Treatment Level Criteria

In assessing the need to incorporate post-construction water quality control measures into street and highway construction projects, the quality of receiving waters is to be considered along with projected traffic volume for the facility. Of many variables that affect the quality of runoff from a roadway (rainfall characteristics, traffic type, surrounding land use, etc.), average daily traffic volume (ADT) is a determining factor for which data is readily available.

Various studies and reports published by the Federal Highway Administration have concluded that greater pollutant levels in stormwater runoff could be anticipated where traffic volume exceeds 30,000 ADT. Therefore, 30,000 vehicles per day (VPD) is used as the threshold between low volume and high volume roadways and the corresponding level of post-construction stormwater quality treatment required.

The water quality of streams or reservoirs and existence of downstream critical areas are used to classify receiving waters and riparian environments. The classification is based on the susceptibility of the receiving waters and riparian areas to negative impact from pollutants in stormwater runoff from the proposed project. The classification of receiving waters is as follows:

1. **High**: These are receiving waters that meet one or more of the following criteria:
   - Designated as "Exceptional Quality Aquatic Habitat" by the TCEQ
   - Identified as Endangered/Protected Species Habitat by the Texas Parks and Wildlife Department
   - Proximity and potential impact to drinking water supply reservoir (as determined by water treatment provider)

2. **Moderate**: These are receiving waters that meet one or more of the following criteria:
   - Three or more designated uses on the Texas Surface Water Quality Standards, or any perennial stream* not classified on the Texas Surface Water Quality Standards
   - Wetlands located on the project site or downstream of the project where flow from the project would constitute more than 10% of total flow to the wetland

3. **Minimal**: All receiving waters not categorized above, including receiving waters listed with two or less designated uses on the Texas Surface Water Quality Standards and intermittent streams*

* Intermittent stream: A stream that has a period of zero flow for at least one week during most years. Perennial stream: A stream that has flow nearly continually (does not reach zero flow for one week or more) during most years.

Table 3.1 shows the level of post-construction stormwater management measures required for street and highway projects based on the previously discussed factors of traffic volume and quality of receiving waters. The levels should be considered during project planning and design for construction of new streets and highways and major reconstruction projects. The ADT will be based on a 20-year design

projection.

Table 3.1 Post-Construction Water Quality Treatment Levels			
Traffic Volume	**Receiving Water / Riparian Area Susceptibility**		
	Minimal	**Moderate**	**High**
Low (<30,000 VPD)	Level I	Level I	Level II
High (>30,000 VPD)	Level I	Level II	Level III

Once the treatment level requirements have been established for the project, select practices or structural stormwater controls in accordance with the appropriate category. Section 3.8 and the *Site Development Controls Technical Manual* contain selection, pollutant removal effectiveness, and design information for the structural controls listed.

Treatment Level I

Select one or more of the following practices and/or structural controls:

- Program of Scheduled Pollution Prevention Practices
  Municipal pollution prevention/good housekeeping practices such as street sweeping, storm drain inlet cleaning, and proper application of landscape chemicals
- Off-site Pollution Prevention Activities/Programs
  Route stormwater runoff to new or existing watershed-level BMPs (i.e. regional detention, Dallas CBD sumps, etc.) identified in the entity's MS4 Permit / Stormwater Management Program
- Grass Channels
- Filter Strips
- Gravity (Oil-Grit) Separator
- Proprietary Structural Controls
- Porous Concrete / Modular Porous Paver Systems

Treatment Level II

Select one or more of the following practices and/or structural controls:

- Enhanced Swales
- Bioretention Areas
- Dry Detention / Extended Detention Dry Basins
- Supplement with any BMPs identified in Level I

Treatment Level III

Select one or more of the following practices and/or structural controls:

- Organic Filter
- Sand Filter
- Underground Sand Filter
- Infiltration Trenches
- Stormwater (Wet) Ponds
- Stormwater Wetlands

- Alum Treatment Systems (used as pretreatment in conjunction with wet pond)
- Supplement with any BMPs identified in Levels I and II

Once the treatment level is established and potential practices and structural controls are identified, the volume of runoff to be treated must be calculated in accordance with the following section for some controls. Refer to the *Site Development Controls Technical Manual* for each of the proposed controls to determine whether the water quality protection volume is applicable. Structural controls or practices from a higher Treatment Level category may be used to meet lower Treatment Level requirements if desired. Combinations of practices and controls may also be implemented. A detailed discussion of each of the controls, as well as design criteria and procedures, can be found in the *Site Development Controls Technical Manual*.

Local Provisions:

3.2.2 Water Quality Protection Volume

Treat the Water Quality Protection Volume by reducing total suspended solids from the development site for runoff resulting from rainfall of 1.5 inches (85th percentile storm). Stormwater runoff equal to the Water Quality Protection Volume generated from sites must be treated using a variety of on-site structural and nonstructural techniques with the goal of removing a target percentage of the average annual total suspended solids.

The Water Quality Protection Volume (WQ_v) is the runoff from the first 1.5 inches of rainfall. Thus, a stormwater management system designed for the WQ_v will treat the runoff from all storm events of 1.5 inches or less, as well as a portion of the runoff for all larger storm events. For methods to determine the WQ_v, see *Section 1.2 of the Water Quality Technical Manual*.

Local Provisions:

3.2.3 Stormwater Controls Overview

This section provides an overview of stormwater controls used to address stormwater quality, as well as streambank protection and flood mitigation, which are covered in Sections 3.4 and 3.5 of the iSWM Criteria Manual for Site Development and Construction. Table 3.2, Stormwater Treatment Suitability (located in Section 3.8.1 of the TriSWM Appendix) summarizes the stormwater management suitability of the various stormwater controls in addressing the stormwater Focus Areas. The *Site Development Controls Technical Manual* provides guidance on the use of stormwater controls as well as how to calculate the pollutant removal efficiency for stormwater controls in series. The *Site Development Controls Technical Manual* also provides guidance for choosing the appropriate stormwater control(s) for a site as well as the basic considerations and limitations on the use of a particular stormwater control.

The stormwater control practices recommended in this manual vary in their applicability and ability to meet stormwater management goals:

Water Quality Protection
Stormwater Controls are classified as Level I, Level II, or Level III depending on the ability of the control to achieve the desired reduction in pollutants. When designed to treat the required Water Quality Volume (WQ_v) and constructed and maintained in accordance with recommended specifications, the desired level of protection is presumed to be provided to the receiving waters.

Streambank Protection and Flood Control
Stormwater Controls designated as "Primary" controls have the ability to fully address one or more of the Steps in the TriSWM Planning and Design Approach if designed appropriately. Several of these structural controls can be designed to provide primary control for downstream streambank protection (SPv) and flood control (Qf). These structural controls are recommended stormwater management facilities for a site wherever feasible and practical.

Stormwater Controls designated as "Secondary" controls are recommended only for limited use or for special site or design conditions. Generally, these practices either: (1) do not have the ability on their own to fully address a specifc stormwater Focus Area, (2) are intended to address hotspot or specific land use constraints or conditions, and/or (3) may have high or special maintenance requirements that may preclude their use.

Using Other or New Structural Stormwater Controls
Local governments and agencies can utilize controls not included in this guide at their discretion. Such controls may be utilized if independent performance data shows that the structural control conforms to requirements for treatment, conveyance, maintenance, and environmental impact.

Local Provisions:

3.3 Acceptable Downstream Conditions

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.3, Acceptable Downstream Conditions.

3.4 Streambank Protection

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.4, Streambank Protection.

3.5 Flood Mitigation

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.5, Flood Mitigation.

3.6 Stormwater Conveyance Systems

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.6, Stormwater Conveyance Systems.

3.7 Easements, Plats, and Maintenance Agreements

Refer to the iSWM Criteria Manual for Site Development and Construction, Section 3.7, Easements, Plats, and Maintenance Agreements.

3.8 TriSWM Stormwater Control Selection

3.8.1 Control Screening Process

Outlined below is a screening process for structural stormwater controls that can effectively treat the water quality volume, as well as provide water quantity control. This process is intended to assist the site designer and design engineer in the selection of the most appropriate structural controls for a development site and to provide guidance on factors to consider in their location. This information is also contained in the *Site Development Controls Technical Manual*.

The following four criteria shall be evaluated in order to select the appropriate structural control(s) or group of controls for a development:

- Stormwater treatment suitability
- Water quality performance
- Site applicability
- Implementation considerations

In addition, the following factors shall be considered for a given site and any specific design criteria or restrictions need to be evaluated:

- Physiographic factors
- Soils
- Special watershed or stream considerations

Finally, environmental regulations shall be considered as they may influence the location of a structural control on site or may require a permit.

The following steps provide a selection process for comparing and evaluating various structural stormwater controls using a screening matrix and a list of location and permitting factors. These tools are provided to assist the design engineer in selecting the subset of structural controls that will meet the stormwater management and design objectives for a development site or project.

Step 1 Overall Applicability

The following are the details of the various screening categories and individual characteristics used to evaluate the structural controls.

Table 3.2 – Stormwater Treatment Suitability

The first category in the matrix examines the capability of each structural control option to provide water quality treatment, downstream streambank protection, and flood control. A blank entry means that the structural control cannot or is not typically used to meet an *integrated* Focus Area. This does not necessarily mean that it should be eliminated from consideration, but rather it is a reminder that more than one structural control may be needed at a site (e.g., a bioretention area used in conjunction with dry detention storage).

Ability to provide water quality protection: Stormwater Controls are classified as Level I, Level II, or Level III depending on the ability of the control to achieve the desired reduction in pollutants. When designed to treat the required Water Quality Volume (WQ_v) and constructed and maintained in accordance with recommended specifications, the desired level of protection is presumed to be provided to the receiving waters.

Ability to provide Streambank Protection (SP_v): This indicates whether the structural control can be used to provide the extended detention of the streambank protection volume (SP_v). The presence of a "P" indicates that the structural control can be used to meet SP_v requirements. An "S" indicates that the structural control may be sized to provide streambank protection in certain situations, for instance on small sites.

Ability to provide Flood Control (Q_f): This indicates whether a structural control can be used to meet the flood control criteria. The presence of a "P" indicates that the structural control can be used to provide peak reduction of the flood mitigation storm event.

Table 3.3 - Relative Water Quality Performance

The second category of the matrix provides an overview of the pollutant removal performance for each structural control option when designed, constructed, and maintained according to the criteria and specifications in this manual.

Ability to provide TSS and Sediment Removal: This column indicates the capability of a structural control to remove sediment in runoff. All of the Primary structural controls are presumed to remove 70% to 80% of the average annual TSS load in typical urban post-development runoff (and a proportional removal of other pollutants).

Ability to provide Nutrient Treatment: This column indicates the capability of a structural control to remove the nutrients nitrogen and phosphorus in runoff, which may be of particular concern with certain downstream receiving waters.

Ability to provide Bacteria Removal: This column indicates the capability of a structural control to remove bacteria in runoff. This capability may be of particular concern when meeting regulatory water quality criteria under the Total Maximum Daily Load (TMDL) program.

Ability to accept Hotspot Runoff: This last column indicates the capability of a structural control to treat runoff from designated hotspots. Hotspots are land uses or activities that produce higher concentrations of trace metals, hydrocarbons, or other priority pollutants. Examples of hotspots might include: gas stations, convenience stores, marinas, public works storage areas, garbage transfer facilities, material storage sites, vehicle service and maintenance areas, commercial nurseries, vehicle washing/steam cleaning, landfills, construction sites, industrial sites, industrial rooftops, and auto salvage or recycling facilities. A check mark indicates that the structural control may be used on hotspot site. However, it may have specific design restrictions. Please see the specific design criteria of the structural control for more details in the *Site Development Controls Technical Manual*. Local jurisdictions may have other site uses that they designate as hotspots. Therefore, their criteria should be checked as well.

Table 3.4 - Site Applicability

The third category of the matrix provides an overview of the specific site conditions or criteria that must be met for a particular structural control to be suitable. In some cases, these values are recommended values or limits and can be exceeded or reduced with proper design or depending on specific circumstances. Please see the specific criteria section of the structural control for more details.

Drainage Area: This column indicates the approximate minimum or maximum drainage area considered suitable for the structural control practice. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway can be permitted if more than one practice can be installed. The minimum drainage areas indicated for ponds and

wetlands should not be considered inflexible limits and may be increased or decreased depending on water availability (baseflow or groundwater), the mechanisms employed to prevent outlet clogging, or design variations used to maintain a permanent pool (e.g., liners).

Space Required (Space Consumed): This comparative index expresses how much space a structural control typically consumes at a site in terms of the approximate area required as a percentage of the impervious area draining to the control.

Slope: This column evaluates the effect of slope on the structural control practice. Specifically, the slope restrictions refer to how flat the area where the facility is installed must be and/or how steep the contributing drainage area or flow length can be.

Minimum Head: This column provides an estimate of the minimum elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the structural control.

Water Table: This column indicates the minimum depth to the seasonally high water table from the bottom or floor of a structural control.

Table 3.5 - Implementation Considerations

The fourth category in the matrix provides additional considerations for the applicability of each structural control option.

Residential Subdivision Use: This column identifies whether or not a structural control is suitable for typical residential subdivision development (not including high-density or ultra-urban areas).

Ultra-Urban: This column identifies those structural controls appropriate for use in very high-density (ultra-urban) areas, or areas where space is a premium.

Construction Cost: The structural controls are ranked according to their relative construction cost per impervious acre treated, as determined from cost surveys.

Maintenance: This column assesses the relative maintenance effort needed for a structural stormwater control, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging), and reported failure rates. It should be noted that **all structural controls** require routine inspection and maintenance.

Local Provisions:

Table 3.2 Stormwater Treatment Suitability

Category	Stormwater Controls	TSS/ Sediment Removal Rate	Water Quality Protection#	Streambank Protection	On-Site Flood Control	Downstream Flood Control
Bioretention Areas	Bioretention Areas	80%	Level II	S	S	-
Channels	Enhanced Swales	80%	Level II	S	S	S
	Channels, Grass	50%	Level I	S	P	S
	Channels, Open	-	-	-	P	S
Chemical Treatment	Alum Treatment System	90%	Level III	-	-	-
Conveyance System Components	Culverts	-	-	-	P	P
	Energy Dissipation	-	-	P	S	S
	Inlets/Street Gutters	-	-	-	P	-
	Pipe Systems	-	-	P	P	P
Detention	Detention, Dry	65%	Level II	P	P	P
	Detention, Extended Dry	65%	Level II	P	P	P
	Detention, Multi-purpose Areas	-	-	P	P	P
	Detention, Underground	-	-	P	P	P
Filtration	Filter Strips	50%	Level I	-	-	-
	Organic Filters	80%	Level III	-	-	-
	Sand Filters, Surface/Perimeter	80%	Level III	S	-	-
	Sand Filters, Underground	80%	Level III	-	-	-
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	Level I	-	-	-
Infiltration	Infiltration Trenches	80%	Level III	S	-	-
Ponds	Wet Pond	80%	Level III	P	P	P
	Wet ED Pond	80%	Level III	P	P	P
	Micropool ED Pond	80%	Level III	P	P	P
Porous Surfaces	Modular Porous Paver Systems	[2]	Level I	S	-	-
	Porous Concrete	[2]	Level I	S	-	-
Proprietary Systems	Proprietary Systems [1]	[1]	Level I	S	S	S
Wetlands	Wetlands, Stormwater	80%	Level III	P	P	P
	Wetlands, Submerged Gravel	80%	Level III	P	S	-

P = Primary Control: Able to meet design criterion if properly designed, constructed and maintained.

S = Secondary Control: May partially meet design criteria. Designated as a Secondary control due to considerations such as maintenance concerns. For Water Quality Protection, recommended for limited use in approved community-designated areas.

= Applicability of controls to meet Water Quality Treatment Level Criteria.

- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data, if used as a primary control. Third-party sources could include Technology Acceptance Reciprocity Partnership, Technology Assessment Protocol – Ecology, or others.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

Table 3.3 Water Quality Performance

Category	Stormwater Controls	Water Quality Performance			
		TSS/ Sediment Removal Rate	Nutrient Removal Rate (TP/TN)	Bacteria Removal Rate	Hotspot Application
Bioretention Areas	Bioretention Areas	80%	60%/50%	-	✓
Channels	Enhanced Swales	80%	25%/40%	-	✓
	Channels, Grass	50%	25%/20%	-	
	Channels, Open	-	-	-	
Chemical Treatment	Alum Treatment System	90%	80%/60%	90%	✓
Conveyance System Components	Culverts	-	-	-	
	Energy Dissipation	-	-	-	
	Inlets/Street Gutters	-	-	-	
	Pipe Systems	-	-	-	
Detention	Detention, Dry	65%	50%/30%	70%	✓
	Detention, Extended Dry	65%	50%/30%	70%	✓
	Detention, Multi-purpose Areas	-	-	-	
	Detention, Underground	-	-	-	
Filtration	Filter Strips	50%	20%/20%	-	
	Organic Filters	80%	60%/40%	50%	✓
	Sand Filters, Surface/Perimeter	80%	50%/25%	40%	✓
	Sand Filters, Underground	80%	50%/25%	40%	✓
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	40%	5%/5%	-	
Infiltration	Infiltration Trenches	80%	60%/60%	90%	
Ponds	Wet Pond	80%	50%/30%	70%	✓
	Wet ED Pond	80%	50%/30%	70%	✓
	Micropool ED Pond	80%	50%/30%	70%	✓
Porous Surfaces	Modular Porous Paver Systems	[2]	80%/80%	-	
	Porous Concrete	[2]	50%/65%	-	
Proprietary Systems	Proprietary Systems [1]	[1]	[1]	[1]	
Wetlands	Wetlands, Stormwater	80%	40%/30%	70%	✓
	Wetlands, Submerged Gravel	80%	40%/30%	70%	✓

✓ = Meets suitability criteria

\- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

Table 3.4 Site Applicability

Category	Stormwater Controls	Site Applicability				
		Drainage Area (acres)	Space Req'd (% of Tributary imp. Area)	Site Slope	Minimum Head Required	Depth to Water Table
Bioretention Areas	Bioretention Areas	5 max[3]	5-7%	6% max	5 ft	2 ft
Channels	Enhanced Swales	5 max	10-20%	4% max	1 ft	Below WT
	Channels, Grass					
	Channels, Open					
Chemical Treatment	Alum Treatment System	25 min	None			
Conveyance System Components	Culverts					
	Energy Dissipation					
	Inlets/Street Gutters					
	Pipe Systems					
Detention	Detention, Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Extended Dry		2-3%	15% across pond	6 to 8 ft	2 ft
	Detention, Multi-purpose Areas	200 max		1% for Parking Lot; 0.25 in/ft for Rooftop		
	Detention, Underground	200 max				
Filtration	Filter Strips	2 max[3]	20-25%	2-6%		
	Organic Filters	10 max[3]	2-3%		5 to 8 ft	
	Sand Filters, Surface/Perimeter	10 max[3] / 2 max[3]	2-3%	6% max	5 ft per 2-3 ft	2 ft
	Sand Filters, Underground	5 max	None			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	1 max[3]	None			
Infiltration	Infiltration Trenches	5 max	2-3%	6% max	1 ft	4 ft
Ponds	Wet Pond		2-3%	15% max	6 t 8 ft	2 ft, if hotspot or aquifer
	Wet ED Pond	25 min[3]				
	Micropool ED Pond	10 min[3]				
Porous Surfaces	Modular Porous Paver Systems	5 max	Varies			
	Porous Concrete	5 max	Varies			
Proprietary Systems	Proprietary Systems [1]	[1]	[1]			
Wetlands	Wetlands, Stormwater	25 min	3-5%	8% max	3 to 5 ft (shallow) 6 to 8 ft (pond)	2 ft, if hotspot or aquifer
	Wetlands, Submerged Gravel	5 min			2 to 3 ft	Below WT

- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

[2] = Porous surfaces provide water quality benefits by reducing the effective impervious area.

[3] = Drainage area can be larger in some instances

Table 3.5 Implementation Considerations

Category	Stormwater Controls	Implementation Considerations			
		Residential Subdivision Use	High Density/Ultra Urban	Capital Cost	Maintenance Burden
Bioretention Areas	Bioretention Areas	✓	✓	Moderate	Low
Channels	Enhanced Swales	✓		High	Low
	Channels, Grass	✓		Low	Moderate
	Channels, Open	✓		Low	Low
Chemical Treatment	Alum Treatment System	✓	✓	High	High
Conveyance System Components	Culverts	✓	✓	Low	Low
	Energy Dissipation	✓	✓	Low	Low
	Inlets/Street Gutters	✓	✓	Low	Low
	Pipe Systems	✓	✓	Low	Low
Detention	Detention, Dry	✓		Low	Moderate to High
	Detention, Extended Dry	✓		Low	Moderate to High
	Detention, Multi-purpose Areas	✓	✓	Low	Low
	Detention, Underground		✓	High	Moderate
Filtration	Filter Strips	✓		Low	Moderate
	Organic Filters		✓	High	High
	Sand Filters, Surface/Perimeter		✓	High	High
	Sand Filters, Underground		✓	High	High
Hydrodynamic Devices	Gravity (Oil-Grit) Separator		✓	High	High
Infiltration	Downspout Drywell	✓	✓	Low	Moderate
	Infiltration Trenches	✓	✓	High	High
	Soakage Trenches	✓	✓	High	High
Ponds	Wet Pond	✓		Low	Low
	Wet ED Pond	✓		Low	Low
	Micropool ED Pond	✓		Low	Moderate
	Multiple Ponds	✓		Low	Low
Porous Surfaces	Green Roof		✓	High	High
	Modular Porous Paver Systems		✓	Moderate	High
	Porous Concrete		✓	High	High
Proprietary Systems	Proprietary Systems [1]	[1]	✓	High	High
Re-Use	Rain Barrels	✓	✓	Low	High
Wetlands	Wetlands, Stormwater	✓		Moderate	Moderate
	Wetlands, Submerged Gravel	✓	✓	Moderate	High

✓ = Meets suitability criteria

\- = Not typically used or able to meet design criterion.

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 2 Specific Criteria

The last three categories in the Stormwater Control Screening matrix provide an overview of various specific design criteria and specifications, or exclusions for a structural control that may be present due to a site's general physiographic character, soils, or location in a watershed with special water resources considerations.

Table 3.6 - Physiographic Factors

Three key factors to consider are low-relief, high-relief, and karst terrain. In the North Central Texas, low relief (very flat) areas are primarily located east of the Dallas metropolitan area. High relief (steep and hilly) areas are primarily located west of the Fort Worth metropolitan area. Karst and major carbonaceous rock areas are limited to portions of Palo Pinto, Erath, Hood, Johnson, and Somervell counties. Special geotechnical testing requirements may be needed in karst areas. The local reviewing authority should be consulted to determine if a project is subject to terrain constraints.

- Low relief areas need special consideration because many structural controls require a hydraulic head to move stormwater runoff through the facility.
- High relief may limit the use of some structural controls that need flat or gently sloping areas to settle out sediment or to reduce velocities. In other cases, high relief may impact dam heights to the point that a structural control becomes infeasible.
- Karst terrain can limit the use of some structural controls as the infiltration of polluted waters directly into underground streams found in karst areas may be prohibited. In addition, ponding areas may not reliably hold water in karst areas.

Table 3.7 - Soils

The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note that more detailed geotechnical tests are usually required for infiltration feasibility and during design to confirm permeability and other factors.

Table 3.8 - Special Watershed or Stream Considerations

The design of stormwater controls is fundamentally influenced by the nature of the downstream water body that will be receiving the stormwater discharge. In addition, the designer should consult with the appropriate review authority to determine if their development project is subject to additional structural control criteria as a result of an adopted local watershed plan or special provision.

In some cases, higher pollutant removal or environmental performance is needed to fully protect aquatic resources and/or human health and safety within a particular watershed or receiving water. Therefore, special design criteria for a particular structural control or the exclusion of one or more controls may need to be considered within these watersheds or areas. Examples of important watershed factors to consider include:

High Quality Streams (Streams with a watershed impervious cover less than approximately 15%). These streams may also possess high quality cool water or warm water aquatic resources or endangered species. The design objectives are to maintain habitat quality through the same techniques used for cold-water streams, with the exception that stream warming is not as severe of a design constraint. These streams may also be specially designated by local authorities.

Wellhead Protection: Areas that recharge existing public water supply wells present a unique management challenge. The key design constraint is to prevent possible groundwater contamination by preventing infiltration of hotspot runoff. At the same time, recharge of unpolluted stormwater is encouraged to maintain flow in streams and wells during dry weather.

Reservoir or Drinking Water Protection: Watersheds that deliver surface runoff to a public water

supply reservoir or impoundment are a special concern. Depending on the available treatment, a greater level of pollutant removal may be necessary for the pollutants of concern, such as bacteria pathogens, nutrients, sediment, or metals. One particular management concern for reservoirs is ensuring stormwater hotspots are adequately treated so they do not contaminate drinking water.

Local Provisions:

Table 3.6 Physiographic Factors

Category	Stormwater Controls	Physiographic Factors		
		Low Relief	High Relief	Karst
Bioretention Areas	Bioretention Areas	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
Channels	Enhanced Swales	Generally feasible. However, slope <1% may lead to standing water in dry swales	Often infeasible if slopes are 4% or greater	
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry		Embankment heights restricted	Require poly or clay liner, Max ponding depth, Geotechnical tests
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			GENERALLY NOT ALLOWED
Filtration	Filter Strips			
	Organic Filters			
	Sand Filters, Surface/Perimeter	Several design variations will likely be limited by low head		Use poly-linear or impermeable membrane to seal bottom
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Infiltration Trenches	Minimum distance to water table of 2 ft	Maximum slope of 6%; trenches must have flat bottom	GENERALLY NOT ALLOWED
Ponds	Wet Pond	Limit maximum normal pool depth to about 4 ft (dugout) Providing pond drain can be problematic	Embankment heights restricted	Require poly or clay liner Max ponding depth Geotechnical tests
	Wet ED Pond			
	Micropool ED Pond			
Porous Surfaces	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Wetlands	Wetlands, Stormwater		Embankment heights restricted	Require poly-liner Geotechnical tests
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.7 Soils

Category	Stormwater Controls	Soils
Bioretention Areas	Bioretention Areas	Clay or silty soils may require pretreatment
Channels	Enhanced Swales	
	Channels, Grass	
	Channels, Open	
Chemical Treatment	Alum Treatment System	
Conveyance System Components	Culverts	
	Energy Dissipation	
	Inlets/Street Gutters	
	Pipe Systems	
Detention	Detention, Dry	Underlying soils of hydrologic group "C" or "D" should be adequate to maintain a permanent pool. Most group "A" soils and some group "B" soils will require a pond liner.
	Detention, Extended Dry	
	Detention, Multi-purpose Areas	
	Detention, Underground	
Filtration	Filter Strips	
	Organic Filters	
	Sand Filters, Surface/Perimeter	Clay or silty soils may require pretreatment
	Sand Filters, Underground	
Hydrodynamic Devices	Gravity (Oil-Grit) Separator	
Infiltration	Infiltration Trenches	Infiltration rate > 0.5 inch/hr
Ponds	Wet Pond	"A" soils may require pond liner "B" soils may require infiltration testing
	Wet ED Pond	
	Micropool ED Pond	
Porous Surfaces	Modular Porous Paver Systems	Infiltration rate > 0.5 inch/hr
	Porous Concrete	
Proprietary Systems	Proprietary Systems [1]	
Wetlands	Wetlands, Stormwater	"A" soils may require pond liner
	Wetlands, Submerged Gravel	

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Table 3.8 Special Watershed Considerations

Category	Stormwater Controls	Special Watershed Considerations		
		High Quality Stream	Aquifer Protection	Reservoir Protection
Bioretention Areas	Bioretention Areas	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
Channels	Enhanced Swales		Hotspot runoff must be adequately treated	Hotspot runoff must be adequately treated
	Channels, Grass			
	Channels, Open			
Chemical Treatment	Alum Treatment System			
Conveyance System Components	Culverts			
	Energy Dissipation			
	Inlets/Street Gutters			
	Pipe Systems			
Detention	Detention, Dry			
	Detention, Extended Dry			
	Detention, Multi-purpose Areas			
	Detention, Underground			
Filtration	Filter Strips			
	Organic Filters			
	Sand Filters, Surface/Perimeter	Evaluate for stream warming	Needs to be designed with no exfiltration (ie. outflow to groundwater)	
	Sand Filters, Underground			
Hydrodynamic Devices	Gravity (Oil-Grit) Separator			
Infiltration	Infiltration Trenches		Maintain safe distance from wells and water table. No hotspot runoff	Maintain safe distance from bedrock and water table. Pretreat runoff
Ponds	Wet Pond	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wet ED Pond			
	Micropool ED Pond			
Porous Surfaces	Modular Porous Paver Systems			
	Porous Concrete			
Proprietary Systems	Proprietary Systems [1]			
Re-Use	Rain Barrels			
Wetlands	Wetlands, Stormwater	Evaluate for stream warming	May require liner if "A" soils are present Pretreat hotspots 2 to 4 ft separation distance from water table	
	Wetlands, Submerged Gravel			

[1] = The application and performance of proprietary commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data if used as a primary control.

Step 3 Location and Permitting Considerations

In the last step, a site designer assesses the physical and environmental features at the site to determine the optimal location for the selected structural control or group of controls. Table 3.9 provides a condensed summary of current restrictions as they relate to common site features that may be regulated under local, state, or federal law. These restrictions fall into one of three general categories:

- Locating a structural control within an area when expressly prohibited by law
- Locating a structural control within an area that is strongly discouraged, and is only allowed on a case by case basis. Local, state, and/or federal permits shall be obtained, and the applicant will need to supply additional documentation to justify locating the stormwater control within the regulated area.
- Structural stormwater controls must be setback a fixed distance from a site feature.

This checklist is only intended as a general guide to location and permitting requirements as they relate to siting of stormwater structural controls. Consultation with the appropriate regulatory agency is the best strategy.

Local Provisions:

Table 3.9 Location and Permitting Checklist	
Site Feature	**Location and Permitting Guidance**
Jurisdictional Wetland (Waters of the U.S) U.S. Army Corps of Engineers Regulatory Permit	• Jurisdictional wetlands must be delineated prior to siting structural control. • Use of natural wetlands for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into a natural wetland. • Structural controls may also be *restricted* in local buffer zones. Buffer zones may be utilized as a non-structural filter strip (i.e., accept sheet flow). • Should justify that no practical upland treatment alternatives exist. • Where practical, excess stormwater flows should be conveyed away from jurisdictional wetlands.
Stream Channel (Waters of the U.S) U.S. Army Corps of Engineers Section 404 Permit	• All Waters of the U.S. (streams, ponds, lakes, etc.) should be delineated prior to design. • Use of any Waters of the U.S. for stormwater quality treatment is contrary to the goals of the Clean Water Act and should be avoided. • Stormwater should be treated prior to discharge into Waters of the U.S. • In-stream ponds for stormwater quality treatment are highly discouraged. • Must justify that no practical upland treatment alternatives exist. • Temporary runoff storage preferred over permanent pools. • Implement measures that reduce downstream warming. • Section 401 certification reviews by the Texas Commission on Environmental Quality are required for projects needing a Section 404 Permit.
Water Quality Certification Texas Commission on Environmental Quality (TCEQ)	• TCEQ conducts Section 401 water quality certification reviews of projects requiring a Section 404 permit from the U.S. Army Corps of Engineers for the discharge of dredged or fill material into waters of the U.S., including wetlands. • Specific stream and reservoir buffer requirements. • May be imperviousness limitations • May be specific structural control requirements that may overlap with requirements in this manual. • Mitigation will be required for impacts to existing aquatic and terrestrial habitat.
Impaired Water Bodies Texas Commission on Environmental Quality	• Determine if the project will discharge pollutants of concern into any downstream receiving waters that have been designated as impaired water bodies on TCEQ's *Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)*. • Stormwater runoff discharges containing pollutants of concern to impaired water bodies will be governed by an entity's Municipal Separate Storm Sewer System (MS4) permit, if applicable.

Table 3.9 Location and Permitting Checklist

Site Feature	Location and Permitting Guidance
Groundwater Management Areas Texas Commission on Environmental Quality	• Conserve, preserve, protect, recharge, and prevent waste of groundwater resources through Groundwater Conservation Districts • Groundwater Conservation District pending for Middle Trinity. • Detailed mapping available from Texas Alliance of Groundwater Districts.
Floodplain Areas National Flood Insurance Program / Local Floodplain Administrator	• Grading and fill for structural control construction is generally discouraged within the 100-year floodplain, as delineated by FEMA flood insurance rate maps, FEMA flood boundary and floodway maps, or more stringent local floodplain maps. • Floodplain fill cannot raise the floodplain water surface elevation by more than limits set by the appropriate jurisdiction.
Stream Buffer Check with appropriate review authority whether stream buffers are required	• Consult local authority for stormwater policy. • Structural controls are discouraged in the streamside zone (within 25 feet or more of streambank, depending on the specific regulations).
Utilities Local Review Authority	• Call appropriate agency to locate existing utilities prior to design. • Note the location of proposed utilities to serve development. • Structural controls are discouraged within utility easements or rights of way for public or private utilities.
Roads TxDOT or DPW	• Consult TxDOT for any setback requirement from local roads. • Consult DOT for setbacks from State maintained roads. • Approval must also be obtained for any stormwater discharges to a local or state-owned conveyance channel.
Structures Local Review Authority	• Consult local review authority for structural control setbacks from structures. • Recommended setbacks for each structural control group are provided in the performance criteria in this manual.
Septic Drain fields Local Health Authority	• Consult local health authority. • Recommended setback is a minimum of 50 feet from drain field edge or spray area.
Water Wells Local Health Authority	• 100-foot setback for stormwater infiltration. • 50-foot setback for all other structural controls.

3.8.2 Example Application

A 2-mile existing 2 lane roadway is being expanded to a 4 lane divided roadway with a 15 foot median in an urban area within the Dallas/Fort Worth metropolitan area. The roadway will exceed a traffic count of 30,000 vehicles per day. The impervious coverage of the approximate 20 acre site will be 80%. The site drains to two receiving waters, 75% to an urban river with two designated uses on the Texas Surface Water Quality Standards and 25% to an unclassified urban stream. There is a small city park adjacent to the roadway. Low permeability soils limit the use of infiltration practices.

Table 3.10 lists the results of the selection analysis using the screening process described previously. The shaded rows indicate the controls that used alone or in combination may be considered for managing stormwater quality and/or quantity for portions of the site. The **X**'s indicate inadequacies in the control and ✓'s indicate adequate control capabilities for the particular category when considered for this site.

The receiving waters must be evaluated to determine the level of treatment required. The 15 acre area that drains to the urban river will require Level I treatment, while the 5 acre area that drains to the urban stream will require Level II treatment. The level designations are based on the definitions of "Minimal" and "Moderate" receiving water classifications located in Section 3.2.1, Water Quality Treatment Level Criteria, and on Table 3.1, Post-Construction Water Quality Treatment Levels.

There are no special watershed factors or physiographic factors to preclude the use of any of the practices from the structural control list. Other limiting factors of the site might include limited space within the right of way to include non-pipe storm water conveyance necessary for many Level I treatment options; limited space for detention facilities; downstream condition of the urban river and stream; offsite drainage; and large stormwater volumes.

A traditional roadway cross section for the 15 acre roadway section will only require good housekeeping practices such as street sweeping, storm drain inlet cleaning, and proper application of landscape chemicals for Level I treatment as long as the downstream assessment does not show need for additional flood and streambank protection. In order to provide secondary flood control and/or streambank protection for the 15 acres draining to the urban river, a series of grass channels can be placed in the median with the roadway draining towards the median rather than the edges of the right of way. This series of grass channels can be connected to the overall storm drainage system flowing to the urban river. The downstream conveyance system may need to be improved if downstream assessment shows need for additional flood control and/or streambank protection.

Level II treatment for the 5 acre roadway section will require the use of bioretention facilities, an enhanced swale or a detention facility which would all connect to the storm drainage system draining to the urban stream. The additional width of the right of way beyond the roadway limits determines the placement of the bioretention facilities or enhanced swale. These can either be placed in the median or on the edges of the roadway in lieu of curb and gutter with the runoff draining to the location of the stormwater control(s). The dry/extended dry detention pond could be placed in the public park adjacent to the roadway and would be better suited to provide flood control and streambank protection if a downstream assessment shows that they are necessary.

Table 3.10 Sample Structural Control Selection Matrix

Structural Control Alternative	Water Quality Treatment Level	Streambank Protection and Flood Control	Site Applicability	Implementation Considerations	Other Issues
Bioretention	Level II	✓[1]	✓[2]	✓	
Enhanced Swale	Level II	✓[1]	✓[2]	✓[3]	
Channels, Grass	Level I	✓[1]	✓[2]	✓[3]	
Dry Detention Pond	Level II	✓	✓	✓[3]	
Extended Dry Detention Pond	Level II	✓	✓	✓[3]	
Filter Strips	Level I	**X**	✓[2]	✓[3]	
Gravity (Oil-Grit) Separator	Level I	**X**	✓[2]	✓	Typically only for drainage areas less than 1 acre
Modular Porous Paver Systems	Level I	**X**	**X**	✓	Not used for travelled lane applications
Porous Concrete	Level I	**X**	**X**	✓	Typically used for low traffic applications
Proprietary Systems[4]	Level I	✓[1]	**UNK**	✓	High cost and maintenance requirements
Scheduled Pollution Prevention Practices	Level I	**X**	**NA**	✓	
Off-Site Pollution Prevention Activities	Level I	**UNK[5]**	**UNK[5]**	**UNK[5]**	

Notes:
1. Only when used with another structural control that provides onsite and downstream flood control
2. Can treat a portion of the site
3. Typically not used in high density / ultra urban settings; however conditions on this site are favorable for this control
4. The application and performance of specific commercial devices and systems must be provided by the manufacturer and should be verified by independent third-party sources and data
5. Must be determined by the jurisdiction or agency on a case-by-case basis depending on the type of proposed off-site activity

Additional Local Requirements