



Georgia Stormwater Management Manual

Volume 1 Stormwater Policy Guidebook

First Edition
August 2001

GEORGIA STORMWATER MANAGEMENT MANUAL

Volume 1: Stormwater Policy Guidebook

First Edition – August 2001

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TABLE OF CONTENTS

FORWARD

Preface	ix
Acknowledgements	ix

INTRODUCTION

Objective of the Manual	xi
Organization of the Manual	xi
Users of this Volume	xi
How to Use this Volume	xii
Regulatory Status of the Manual	xiii
How to Get Printed Copies of the Manual	xiii
How to Find the Manual on the Internet	xiii
Contact Information	xiii

CHAPTER 1 – THE CASE FOR STORMWATER MANAGEMENT

1.1 Impacts of Development and Stormwater Runoff	1-1
1.1.1 Development Changes Land and Runoff	1-1
1.1.2 Changes to Stream Flow	1-2
1.1.3 Changes to Stream Geometry	1-4
1.1.4 Impacts to Aquatic Habitat	1-5
1.1.5 Water Quality Impacts	1-6
1.1.6 Stormwater Hotspots	1-8
1.1.7 Effects on Lakes, Reservoirs and Estuaries	1-9
1.2 Stormwater Impacts on Georgia Communities	1-9
1.3 Addressing Runoff Impacts Through Stormwater Management	1-12

CHAPTER 2 – REGULATORY REQUIREMENTS FOR GEORGIA COMMUNITIES

2.1 Overview	2-1
2.2 Stormwater Quantity and Flooding Prevention Regulations	2-1
2.2.1 National Flood Insurance Program	2-1
2.2.2 Georgia Safe Dams Act	2-1
2.3 Water Quality Regulations	2-3
2.3.1 Municipal NPDES MS4 Stormwater Permit Program	2-3
2.3.2 Industrial NPDES Stormwater Permit Program	2-4

2.3.3 NPDES Stormwater Permits for Construction Areas	2-4
2.3.4 NPDES Municipal Wastewater Discharge Permit Program	2-4
2.3.5 Erosion and Sedimentation Control Act	2-5
2.3.6 Total Maximum Daily Load Program	2-5
2.3.7 Georgia Planning Act – River Corridor Protection	2-5
2.3.8 Georgia Planning Act – Water Supply Watersheds	2-5
2.3.9 Georgia Planning Act – Groundwater Recharge Areas	2-6
2.3.10 Safe Drinking Water Act – Wellhead Protection Program.....	2-6
2.3.11 Source Water Assessment Program	2-6
2.3.12 Metropolitan River Protection Act.....	2-7
2.3.13 Wetlands–Federal 404 Permits and Georgia Planning Act.....	2-7
2.3.14 Coastal Management Program	2-7
2.3.15 Coastal Marshlands Protection Act	2-7
2.3.16 Georgia Greenspace Program	2-8

CHAPTER 3 – LOCAL STORMWATER MANAGEMENT PROGRAMS

3.1 Overview of Local Stormwater Management Programs	3-1
3.1.1 Introduction.....	3-1
3.1.2 Elements of a Comprehensive Local Stormwater Management Program	3-2
3.2 Developing an Effective Local Stormwater Management Program	3-7
3.2.1 Introduction.....	3-7
3.2.2 Defining Problems, Program Goals and Requirements	3-7
3.2.3 Determining Program Components and Priorities	3-8
3.2.4 Organizing Program Structure and Staffing.....	3-8
3.2.5 Funding the Program	3-11
3.2.6 Implementing the Program.....	3-15
3.2.7 Conclusion.....	3-15

CHAPTER 4 – IMPLEMENTING STORMWATER MANAGEMENT REQUIREMENTS FOR DEVELOPMENT

4.1 Overview	4-1
4.2 Minimum Standards for Development	4-2
4.2.1 Introduction.....	4-2
4.2.2 Applicability.....	4-3
4.2.3 Minimum Stormwater Management Standards	4-4
4.3 Stormwater Better Site Design Practices	4-5
4.3.1 Introduction.....	4-5
4.3.2 Suite of Stormwater Better Site Design Practices	4-6
4.3.3 Implementing Stormwater Better Site Design.....	4-9
4.4 Unified Stormwater Sizing Criteria	4-12
4.4.1 Introduction.....	4-12
4.4.2 Water Quality.....	4-13
4.4.3 Channel Protection	4-14
4.4.4 Overbank Flood Protection	4-15
4.4.5 Extreme Flood Protection	4-15
4.4.6 Incorporating the Unified Stormwater Sizing Criteria into Development Requirements	4-16

4.5 Stormwater Site Design Credits	4-16
4.5.1 Introduction	4-16
4.5.2 Site Design Credit #1: Natural Area Conservation	4-17
4.5.3 Site Design Credit #2: Stream Buffers	4-18
4.5.4 Site Design Credit #3: Vegetated Channels	4-18
4.5.5 Site Design Credit #4: Overland Flow Filtration / Groundwater Recharge Zones	4-19
4.5.6 Site Design Credit #5: Environmentally Sensitive Large Lot Subdivisions	4-19
4.5.7 Implementing Stormwater Site Design Credits	4-20
4.6 Downstream Assessments	4-20
4.6.1 Introduction	4-20
4.6.2 Reasons for Downstream Problems	4-20
4.6.3 Downstream Assessments: The "Ten-Percent" Rule	4-21
4.6.4 Adopting a Downstream Assessment Requirement	4-22
4.7 Guidance on Structural Stormwater Controls	4-22
4.7.1 Introduction	4-22
4.7.2 Recommended Structural Stormwater Control Practices for Georgia Communities	4-22
4.7.3 Suitability of Structural Stormwater Controls to Meet Stormwater Management Requirements	4-24
4.7.4 Implementing Application and Design Criteria for Structural Stormwater Controls	4-25
4.8 Stormwater Management Site Plans	4-26
4.8.1 Introduction	4-26
4.8.2 Contents of a Stormwater Management Site Plan	4-26
4.8.3 Procedure for Reviewing Stormwater Site Plans	4-28

CHAPTER 5 – WATERSHED-BASED STORMWATER PLANNING

5.1 Stormwater Master Planning	5-1
5.1.1 Introduction	5-1
5.1.2 Types of Stormwater Master Planning	5-1
5.2 Comprehensive Watershed Planning for Georgia Communities	5-3
5.2.1 Introduction	5-3
5.2.2 Scale of Watershed Management	5-3
5.2.3 The Watershed Planning Process	5-4
5.3 Integration of Site and Watershed-Level Stormwater Planning	5-12
5.3.1 Introduction	5-12
5.3.2 Using the Local Review Process to Comply with Watershed Plans	5-12
5.4 Inter-jurisdictional Watershed Planning	5-14
5.5 Implementation of Watershed Plans	5-15
5.5.1 Introduction	5-15
5.5.2 Tools of Watershed Management and Protection	5-15
5.5.3 Stakeholder Involvement Techniques	5-18
5.5.4 Cost (Budget)	5-18
5.5.5 Performance Monitoring and Assessment	5-19

5.6 Regional vs. On-site Stormwater Management	5-19
5.6.1 Introduction.....	5-19
5.6.2 Advantages and Disadvantages of Regional Stormwater Controls.....	5-20
5.6.3 Important Considerations for the Use of Regional Stormwater Controls.....	5-21

CHAPTER 6 – FLOODPLAIN MANAGEMENT

6.1 Local Floodplain Management and Stormwater Management.....	6-1
6.1.1 Introduction.....	6-1
6.1.2 Floodplain Management Goals	6-1
6.2 National Flood Insurance Program	6-2
6.2.1 Background	6-2
6.2.2 NFIP Program Requirements.....	6-2
6.2.3 Shortcomings of the NFIP	6-4
6.3 Strategies and Tools for Improved Floodplain Management	6-4
6.3.1 Introduction.....	6-4
6.3.2 Developing an Effective Local Floodplain Management Program.....	6-4
6.3.3 Watershed / Inter-jurisdictional Issues	6-7

CHAPTER 7 – STORMWATER SYSTEM OPERATIONS AND MAINTENANCE

7.1 Local Stormwater Operations and Maintenance Programs	7-1
7.1.1 Introduction.....	7-1
7.1.2 Key Maintenance Program Components	7-1
7.2 Implementing An Effective Operations and Maintenance Program	7-3
7.2.1 Maintenance Responsibility	7-3
7.2.2 Level of Service	7-4
7.2.3 Establishing Maintenance Responsibility and Level of Service Policies	7-5
7.2.4 Maintenance Agreements	7-6
7.2.5 Education	7-6
7.2.6 Periodic Review of Regulations and Procedures.....	7-7
7.3 Stormwater Retrofitting	7-7
7.3.1 Introduction.....	7-7
7.3.2 Stormwater Retrofitting Process	7-8
7.3.3 Types of Retrofitting Techniques	7-10

CHAPTER 8 – STORMWATER POLLUTION PREVENTION PROGRAMS

8.1 Stormwater Pollution Prevention.....	8-1
8.1.1 Introduction.....	8-1
8.1.2 Local Stormwater Pollution Prevention Activities.....	8-1

CHAPTER 9 – INFORMATION TOOLS FOR LOCAL STORMWATER MANAGEMENT

9.1 Overview	9-1
9.2 Stormwater Management System Inventories.....	9-1
9.2.1 Introduction	9-1
9.2.2 Organizing Information	9-2
9.2.3 Conducting the Inventory	9-3
9.3 Geographic Information Systems	9-4
9.3.1 Introduction	9-4
9.3.2 GIS Components.....	9-4
9.3.3 GIS Functions	9-5
9.3.4 Use of GIS in Stormwater Management	9-6
9.3.5 Other Related Technologies.....	9-8
9.4 Global Positioning Systems	9-8
9.4.1 Introduction	9-8
9.4.2 GPS Applications to Stormwater	9-9
9.5 Remote Sensing	9-9
9.5.1 Introduction	9-9
9.5.2 Digital Orthophoto Quarter Quadrangles	9-10
9.5.3 Remote Sensing Applications for Stormwater	9-11
9.6 Computer Models	9-12
9.6.1 Introduction	9-12
9.6.2 Types of Models.....	9-12
9.6.3 Model Applications	9-13
9.6.4 Basic Computer Modeling Principles	9-13
9.6.5 Selecting the Appropriate Computer Model	9-14

APPENDIX A – CONTACT AGENCIES FOR STORMWATER MANAGEMENT REGULATIONS AND PROGRAMS

APPENDIX B – STORMWATER SITE PLAN REVIEW CHECKLISTS

APPENDIX C – EXAMPLE STORMWATER FACILITY MAINTENANCE AGREEMENT

REFERENCES

List of Tables

CHAPTER 1

1.1-1	Summary of Urban Stormwater Pollutants.....	1-7
-------	---	-----

CHAPTER 2

2.1-1	Regulatory Framework for Local Stormwater Management in Georgia	2-2
2.3-1	Minimum Criteria for the Protection of Water Supply Watersheds in Georgia	2-6

CHAPTER 3

3.1-1	Types of Local Ordinances Used to Support Stormwater Management Activities	3-4
3.2-1	Stormwater Management Functions Areas and Program Components	3-9
3.2-2	Example of Stormwater Program Elements and Potentially Responsible Departments and Staff	3-10
3.2-3	Advantages and Disadvantages of Program Funding Approaches	3-13

CHAPTER 4

4.3-1	Questionnaire for Reviewing Local Development Regulations to Evaluate Compatibility with Stormwater Better Site Design Practices	4-9
4.4-1	Summary of the Statewide Stormwater Sizing Criteria for Stormwater Control and Mitigation	4-12
4.5-1	Summary of Better Site Design Practices that Provide for Site Design Stormwater Credits	4-17
4.7-1	Suitability of Structural Stormwater Controls to Meet Unified Stormwater Sizing Criteria	4-25

CHAPTER 5

5.2-1	Description of the Various Watershed Management Units	5-4
5.2-2	Example of Subwatershed Management Alternatives from a Watershed Plan	5-11
5.5-1	Land Use Planning Techniques	5-16
5.5-3	Potential Watershed Indicators	5-19

CHAPTER 6

6.3-1	Approaches to Effective Local Floodplain Management	6-5
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CHAPTER 9

9.2-1	Infrastructure Information and Uses	9-3
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List of Figures

CHAPTER 1

1.1-1	Typical Changes in Land Surface for a Commercial Site	1-1
1.1-2	Changes in Hydrology and Runoff Due to Development	1-2
1.1-3	Impervious Cover Increases Stormwater Runoff and Pollutants	1-2
1.1-4	Increased Runoff Peaks and Volumes Increase Stream Flows and Flooding	1-3
1.1-5	Hydrograph under Pre-and Post Development Conditions	1-3
1.1-6	Example of Stream Channel Bank Erosion	1-4
1.1-7	Changes to a Stream's Physical Character due to Watershed Development	1-4
1.1-8	Impacts to Aquatic Habitat Can Eliminate Sensitive Fish Species and Other Aquatic Organisms.....	1-5
1.1-9	Causes of Water Quality Impairment in Georgia	1-6
1.1-10	Trash and Debris Impact the Visual and Recreational Value of Waterbodies	1-8
1.1-11	Gas Stations are an Example of Potential Stormwater Hotspots	1-9
1.2-1	Flooding Endangers Human Life and Property.....	1-10
1.2-2	Water Quality Problems Due to Runoff Impact Drinking Water Supplies and Recreational Use of Streams, Rivers, Lakes and Beaches.....	1-10
1.2-3	Waterfronts are an Important Resource to Georgia Communities that Should be Protected from the Effects of Polluted Stormwater	1-11
1.2-4	Polluted Stormwater Runoff Impacts Sport and Commercial Fisheries and Shellfish Harvesting	1-11
1.3-1	The "Umbrella" of Comprehensive Stormwater Management	1-12

CHAPTER 4

4.1-1	Typical Stormwater Management System Design Process	4-2
4.3-1	Comparison of a Traditional Residential Subdivision Design (above) and And Innovative Site Plan Developed Using Better Site Design Practices (below)	4-7
4.3-2	Comparison of a Traditional Office Park Design (above) and an Innovative Site Plan Developed Using Better Site Design Practices and Techniques (below)	4-8
4.4-1	Representation of the Unified Stormwater Sizing Criteria	4-13
4.6-1	Detention Timing Example	4-20
4.6-2	Effect of Increased Post-Development Runoff Volume with Detention on a Downstream Hydrograph	4-21

CHAPTER 5

5.2-1	Watershed Management Units	5-4
5.2-2	Example of a Watershed Map with Subwatersheds Delineated	5-5
5.2-3	Use of Monitoring Data to Identify Problems and Issues	5-6
5.4-1	Big Haynes Creek Watershed	5-14
5.6-1	On-site Versus Regional Stormwater Management	5-20

CHAPTER 6

6.2-1	Floodplain Definitions	6-3
6.2-2	Examples of a FEMA Flood Risk Map.....	6-3

CHAPTER 9

9.3-1	Example of Overlay Analysis	9-6
9.3-2	Automated Hydrologic Modeling	9-7
9.3-3	Use of a GIS to Map Current and Potential Floodplains & Flood Prone Homes	9-7
9.5-1	Low, Medium and High Resolution Satellite Imagery	9-9
9.5-2	Example DOQQ	9-11

FORWARD

Preface

Stormwater management has entered a new phase in the state of Georgia. The requirements for NPDES municipal and industrial permits, TMDLs, watershed assessments and the desire to protect human life, property, aquatic habitats and the quality of life in our communities has brought home the pressing need to manage both stormwater quantity and quality from our developed and developing areas.

This Manual will help Georgia move forward with a comprehensive approach to stormwater management that integrates drainage design, stormwater quantity, and water quality considerations and views stormwater as important resource and opportunity for our communities. The goal of this Manual is to develop and promote a consistent and effective approach and implementation of stormwater management in the state.

Acknowledgements

This Manual is the culmination of a collaborative effort between the Atlanta Regional Commission (ARC), the Georgia Department of Natural Resources-Environmental Protection Division, and 35 cities and counties from across Georgia. These documents reflect the hard work, time and contributions of many individuals.

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DeKalb County	City of East Point
Douglas County	City of Fairburn
Fayette County	City of Griffin
Fulton County	City of Hapeville
Gwinnett County	City of Kennesaw
Henry County	City of Lithia Springs
Rockdale County	City of Marietta
Douglasville/Douglas Co. Water & Sewerage Authority	City of Palmetto
Athens-Clarke County	City of Peachtree City
Augusta-Richmond County	City of Powder Springs
Columbus-Muscogee County	City of Rome
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INTRODUCTION

Objective of the Manual

The objective of the Georgia Stormwater Management Manual is to provide guidance on addressing stormwater runoff. The goal is to provide an effective tool for local governments and the development community to reduce both stormwater quality and quantity impacts, and protect downstream areas and receiving waters.

This Manual does not cover construction site sediment and erosion control practices. Guidance on these practices can be found in the *Manual for Erosion and Sediment Control in Georgia*.

Organization of the Manual

The Georgia Stormwater Management Manual is organized as a three volume set, each volume being published as a separate document. You are currently reading Volume 1 of the Manual.

Volume One of the Manual, the *Stormwater Policy Guidebook*, is designed to provide guidance for local jurisdictions on the basic principles of effective urban stormwater management.

Volume 1 covers the problem of urban stormwater runoff and the need for local communities to address urban stormwater quantity and quality, stormwater management minimum standards, and guidance on local stormwater programs. It also provides an overview of integrated stormwater management, site and watershed level stormwater management, floodplain management, and technology and tools for implementing stormwater management programs.

Volume Two of the Manual, the *Technical Handbook*, provides guidance on the techniques and measures that can be implemented to meet a set of stormwater management minimum standards for new development and redevelopment. Volume 2 is designed to provide the site designer or engineer, as well as the local plan reviewer or inspector, with all of the information required to effectively address and control both water quality and quantity on a development site. This includes guidance on better site design practices, hydrologic techniques, criteria for the selection and design of structural stormwater controls, drainage system design, and construction and maintenance information.

Volume Three, the *Pollution Prevention Guidebook*, is a compendium of pollution prevention practices for stormwater quality for use by local jurisdictions, businesses and industry, and local citizens.

Users of This Volume

Volume 1 of the Manual is primarily intended to provide guidance for local government (city and county) officials and staff on implementing stormwater management programs. The audience for Volume 1 also includes public agencies such as Regional Development Centers and other agencies concerned with land use, development, and stormwater runoff management.

Other interested parties and the general public may find Volume 1 helpful in providing an overview of local stormwater management including the impacts of development and stormwater runoff, regulatory requirements for Georgia communities and potential management strategies that can be adopted by local jurisdictions.

How to Use This Volume

The following provides a guide to the various chapters of Volume 1 of the Manual.

- ❑ **Chapter 1 – The Case for Stormwater Management.** This chapter provides an overview of the impacts of urban stormwater runoff and the need for effective stormwater management.
- ❑ **Chapter 2 – Regulatory Requirements for Georgia Communities.** This chapter presents the regulatory framework for local stormwater management in Georgia, including the state and federal laws, regulations and programs which are required of local communities in Georgia, or which may impact local stormwater management activities.
- ❑ **Chapter 3 – Local Stormwater Management Programs.** This chapter provides an overview of local stormwater management programs. The components and activities of a comprehensive local program are discussed, as well as the steps involved in developing an effective program. The organizational and funding aspects of program development and implementation are also covered.
- ❑ **Chapter 4 – Implementing Stormwater Management Requirements for Development.** This chapter presents a set of minimum stormwater management standards for new development and redevelopment that communities can adopt as part of their local development code. In addition, Chapter 4 provides a toolbox to address development activities which includes:
 - Stormwater better site design practices to reduce both runoff and pollutants, and provide for some nonstructural on-site stormwater treatment and control
 - Unified stormwater sizing criteria for stormwater quantity and quality management
 - A methodology for requiring downstream assessments of stormwater impacts
 - Overview of structural stormwater controls
 - Guidance on implementing a stormwater management site plan requirement
- ❑ **Chapter 5 – Watershed-Based Stormwater Planning.** This chapter provides a overview of watershed-based stormwater planning, including stormwater master planning, the comprehensive watershed planning process, integration of site and watershed-level planning, inter-jurisdictional stormwater planning, and regional stormwater versus on-site stormwater management. Chapter 5 also covers implementation of watershed plans and provides a set of tools for watershed management and protection.
- ❑ **Chapter 6 – Floodplain Management.** This chapter discusses the link between local floodplain management and stormwater management, and how communities can improve their floodplain management programs to reduce flooding risks and help meet overall stormwater management goals.
- ❑ **Chapter 7 – Stormwater System Operations and Maintenance.** This chapter covers the important need for local stormwater operations and maintenance programs. Maintenance program components are discussed, as well as the concepts of maintenance responsibility and level of service. The retrofitting of existing developed areas is also covered in this chapter.
- ❑ **Chapter 8 – Stormwater Pollution Prevention Programs.** This chapter describes several of the pollution prevention activities and programs that a community can undertake to help reduce pollution to stormwater runoff.
- ❑ **Chapter 9 – Information Tools for Local Stormwater Management.** This chapter covers various information tools that can be utilized by a community to assist in their stormwater management programs including stormwater system inventories, geographic information systems (GIS), global positioning systems (GPS), remote sensing and computer models.
- ❑ **Appendix A – Contact Agencies for Stormwater Management Regulations and Programs.** This appendix includes contact information for the various regulatory and other programs covered in Chapter 2.

-
- ❑ **Appendix B – Stormwater Site Plan Review Checklists.** This appendix provides example checklists outlining the necessary steps to prepare preliminary and final stormwater management site plans.
 - ❑ **Appendix C – Example Stormwater Maintenance Agreement.** This appendix contains an example maintenance agreement for stormwater management facilities between a local government and private party.

Regulatory Status of the Manual

This Manual has been developed to provide guidance on the latest and most relevant stormwater management strategies and practices for the state of Georgia. The Manual itself has no independent regulatory authority. The minimum requirements and technical guidance included in the Manual can only become required through:

- (1) Ordinances and rules established by local communities; and
- (2) Permits and other authorizations issued by local, state and federal agencies.

Adoption of either the Georgia Stormwater Management Manual – Volume 2 or an equivalent stormwater design manual is required for all municipalities covered under the National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit.

How to Get Printed Copies of the Manual

Printed copies of the Manual or the Manual on CD can be ordered by calling 404-463-3102 or ordered online at the following Internet address:

<http://www.atlantaregional.com/bookstore/>

How to Find the Manual on the Internet

All three volumes of the Georgia Stormwater Management Manual are also available in Adobe Acrobat PDF document format for download at the following Internet address:

<http://www.georgiastormwater.com>

Contact Information

If you have any technical questions or comments on the Manual, please send an email to:

info@georgiastormwater.com

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THE CASE FOR STORMWATER MANAGEMENT

1.1 Impacts of Development and Stormwater Runoff

The growth of Georgia's towns, cities, and suburbs has profoundly altered natural drainage systems and water resources in our state. Urbanization changes not only the physical, but also the chemical and biological conditions of our waterways. This chapter describes the impacts of development and urban stormwater runoff.

1.1.1 Development Changes Land and Runoff

When land is developed, the hydrology, or the natural cycle of water is disrupted and altered. Clearing removes the vegetation that intercepts, slows and returns rainfall to the air through evaporation and transpiration. Grading flattens hilly terrain and fills in natural depressions that slow and provide temporary storage for rainfall. The topsoil and sponge-like layers of humus are scraped and removed and the remaining subsoil is compacted. Rainfall that once seeped into the ground now runs off the surface. The addition of buildings, roadways, parking lots and other surfaces that are impervious to rainfall further reduces infiltration and increases runoff. Figure 1.1-1 is an example of the changes that take place as an area is developed.



Figure 1.1-1 Typical Changes in Land Surface for a Commercial Site
(City of Alpharetta, Georgia – 1958 and 1999)

Depending on the magnitude of changes to the land surface, the total runoff volume can increase dramatically, as illustrated in Figure 1.1-2. These changes not only increase the total volume of runoff, but also accelerate the rate at which runoff flows across the land. This effect is further exacerbated by drainage systems such as gutters, storm sewers and lined channels that are designed to quickly carry runoff to rivers and streams.

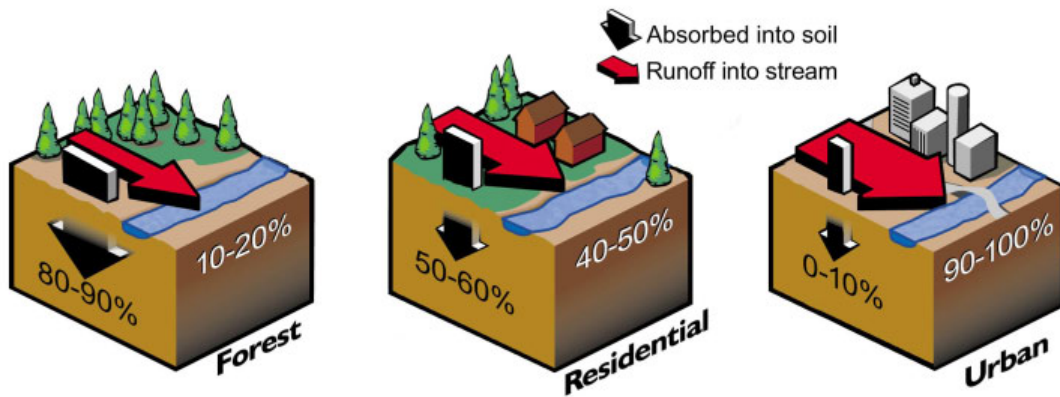


Figure 1.1-2 Changes in Hydrology and Runoff Due to Development

Based on Marsh, 1983. Graphic courtesy of Atlanta Journal-Constitution

Development and impervious surfaces also reduce the amount of water that is infiltrated into the soil and groundwater, thus reducing the amount of water that can recharge aquifers and feed streamflow during periods of dry weather.

Finally, development and urbanization affect not only the quantity of stormwater runoff, but also its quality. Development increases both the concentration and types of pollutants carried by runoff. As it runs over rooftops and lawns, parking lots and industrial sites, stormwater picks up and transports a variety of contaminants and pollutants to downstream waterbodies. The loss of the original topsoil and vegetation removes a valuable filtering mechanism for stormwater runoff.



Figure 1.1-3 Impervious Cover Increases Stormwater Runoff and Pollutants

The cumulative impact of development and urban activities, and the resultant changes to both stormwater quantity and quality in the entire land area that drains to a stream, river, lake or estuary determines the conditions of the waterbody. This land area that drains to the waterbody is known as its *watershed*. Urban development within a watershed has a direct impact on downstream waters. The impacts of development on watersheds can be placed into four interrelated categories which are described over the next several pages:

- Changes to stream flow
- Changes to stream geometry
- Degradation of aquatic habitat
- Water quality impacts

1.1.2 Changes to Stream Flow

Urban development alters the hydrology of watersheds and streams by disrupting the natural water cycle. This results in:

- **Increased Runoff Volumes** – Land surface changes can dramatically increase the total volume of runoff generated in a developed watershed as seen in Figure 1.1-2.
- **Increased Peak Runoff Discharges** – Increased peak discharges for a developed watershed can be two to five times higher than those for an undisturbed watershed.
- **Greater Runoff Velocities** – Impervious surfaces and compacted soils, as well as improvements to the drainage system such as storm drains, pipes and ditches, increase the speed at which rainfall runs off land surfaces within a watershed.

- **Timing** – As runoff velocities increase, it takes less time for water to run off the land and reach a stream or other waterbody.
- **Increased Frequency of Bankfull and Near Bankfull Events** – Increased runoff volumes and peak flows increase the frequency and duration of smaller bankfull and near bankfull events (see Figure 1.1-4) which are the primary channel forming events.
- **Increased Flooding** – Increased runoff volumes and peaks also increase the frequency, duration and severity of out-of-bank flooding as shown in Figure 1.1-4.
- **Lower Dry Weather Flows (Baseflow)** – Reduced infiltration of stormwater runoff causes streams to have less baseflow during dry weather periods and reduces the amount of rainfall recharging groundwater aquifers.



Figure 1.1-4 Increased Runoff Peaks and Volumes Increase Stream Flows and Flooding
(Right Photo Source: Augusta Chronicle / Photo by Cindy Blanchard)

Streams in developed areas are often characterized as very "flashy" or "spiky" because of the increased volume of stormwater runoff, greater peak flows, and quicker hydrologic response to storms. This characterization translates into the sharp peak and increased size of the post-development hydrograph as seen in Figure 1.1-5. This diagram shows the hydrograph for a typical 30-acre residential site during a 10-year storm event.

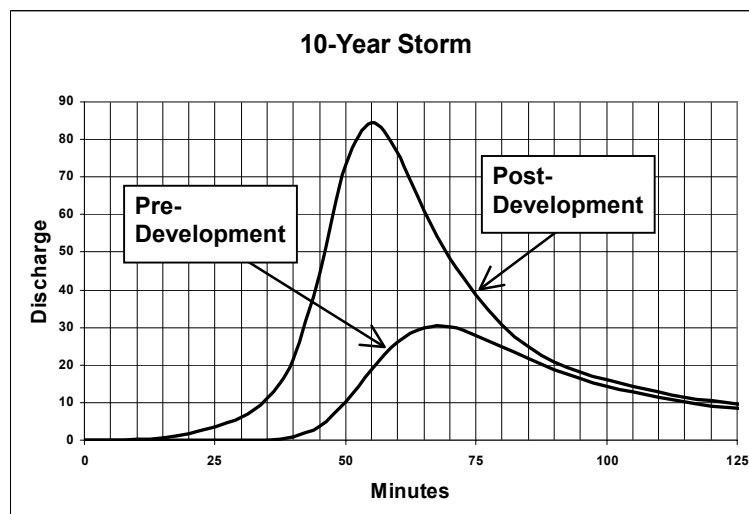


Figure 1.1-5 Hydrograph under Pre- and Post Development Conditions

1.1.3 Changes to Stream Geometry

The changes in the rates and amounts of runoff from developed watersheds directly affect the morphology, or physical shape and character, of Georgia's streams and rivers. Some of the impacts due to urban development include:

- Stream Widening and Bank Erosion – Stream channels widen to accommodate and convey the increased runoff and higher stream flows from developed areas. More frequent small and moderate runoff events undercut and scour the lower parts of the streambank, causing the steeper banks to slump and collapse during larger storms. Higher flow velocities further increase streambank erosion rates. A stream can widen many times its original size due to post-development runoff as illustrated in Figure 1.1-6.
- Stream Downcutting – Another way that streams accommodate higher flows is by downcutting their streambed. This causes instability in the stream profile, or elevation along a stream's flow path, which increases velocity and triggers further channel erosion both upstream and downstream.
- Loss of Riparian Tree Canopy – As streambanks are gradually undercut and slump into the channel, the trees that had protected the banks are exposed at the roots. This leaves them more likely to be uprooted during major storms, further weakening bank structure.
- Changes in the Channel Bed Due to Sedimentation – Due to channel erosion and other sources upstream, sediments are deposited in the stream as sandbars and other features, covering the channel bed, or substrate, with shifting deposits of mud, silt and sand.
- Increase in the Floodplain Elevation – To accommodate the higher peak flow rate, a stream's floodplain elevation typically increases following development in a watershed due to higher peak flows. This problem is compounded by building and filling in floodplain areas, which cause flood heights to rise even further. Property and structures that had not previously been subject to flooding may now be at risk.



Figure 1.1-6 Example of Stream Channel Bank Erosion

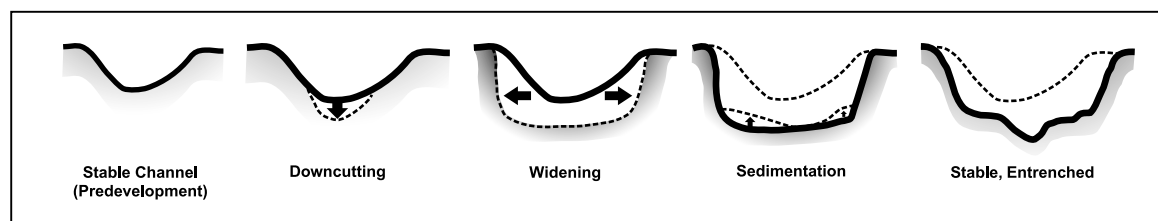


Figure 1.1-7 Changes to a Stream's Physical Character Due to Watershed Development

1.1.4 Impacts to Aquatic Habitat

Along with changes in stream hydrology and morphology, the habitat value of streams diminishes due to development in a watershed. Impacts on habitat include:

- Degradation of Habitat Structure – Higher and faster flows due to development can scour channels and wash away entire biological communities. Streambank erosion and the loss of riparian vegetation reduce habitat for many fish species and other aquatic life, while sediment deposits can smother bottom-dwelling organisms and aquatic habitat.
- Loss of Pool-Riffle Structure – Streams draining undeveloped watersheds often contain pools of deeper, more slowly flowing water that alternate with “riffles” or shoals of shallower, faster flowing water. These pools and riffles provide valuable habitat for fish and aquatic insects. As a result of the increased flows and sediment loads from urban watersheds, the pools and riffles disappear and are replaced with more uniform, and often shallower, streambeds that provide less varied aquatic habitat.
- Reduce Baseflows -- Reduced baseflows due to increased impervious cover in a watershed and the loss of rainfall infiltration into the soil and water table adversely affect in-stream habitats, especially during periods of drought.
- Increased Stream Temperature – Runoff from warm impervious areas, storage in impoundments, loss of riparian vegetation and shallow channels can all cause an increase in temperature in urban streams. Increased temperatures can reduce dissolved oxygen levels and disrupt the food chain. Certain aquatic species can only survive within a narrow temperature range. Thermal problems are especially critical for many Piedmont streams which straddle the borderline between coldwater and warmwater stream conditions.
- Decline in Abundance and Biodiversity – When there is a reduction in various habitats and habitat quality, both the number and the variety, or diversity, of organisms (wetland plants, fish, macroinvertebrates, etc.) are also reduced. Sensitive fish species and other life forms disappear and are replaced by those organisms that are better adapted to the poorer conditions. The diversity and composition of the benthic, or streambed, community have frequently been used to evaluate the quality of urban streams. Aquatic insects are a useful environmental indicator as they form the base of the stream food chain.



Figure 1.1-8 Impacts to Aquatic Habitat Can Eliminate Sensitive Fish Species and Other Aquatic Organisms

Fish and other aquatic organisms are impacted not only by the habitat changes brought on by increased stormwater runoff quantity, but are often also adversely affected by water quality changes due to development and resultant land use activities in a watershed. These impacts are discussed over the next several pages.

1.1.5 Water Quality Impacts

Nonpoint source pollution, which is the primary cause of polluted stormwater runoff and water quality impairment, comes from many diffuse or scattered sources—many of which are the result of human activities within a watershed. Development concentrates and increases the amount of these nonpoint source pollutants. As stormwater runoff moves across the land surface, it picks up and carries away both natural and human-made pollutants, depositing them into Georgia's streams, rivers, lakes, wetlands, coastal waters and marshes, and underground aquifers. Nonpoint source pollution is the leading source of water quality degradation in the Georgia as seen in Figure 1.1-9.

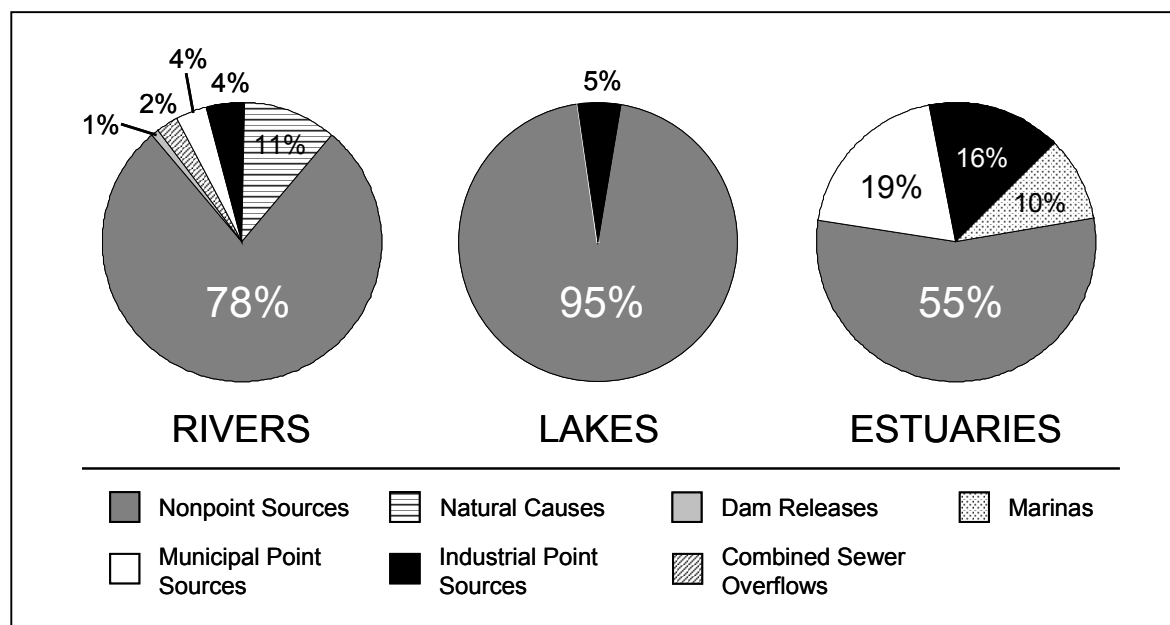


Figure 1.1-9 Causes of Water Quality Impairment in Georgia

Source: State of Georgia 303(d) List of Impaired Waters, 2001

Water quality degradation in urbanizing watersheds starts when development begins. Erosion from construction sites and other disturbed areas contribute large amounts of sediment to streams. As construction and development proceed, impervious surfaces replace the natural land cover and pollutants from human activities begin to accumulate on these surfaces. During storm events, these pollutants are then washed off into the streams. Stormwater also causes discharges from sewer overflows and leaching from septic tanks. There are a number of other causes of nonpoint source pollution in urban areas that are not specifically related to wet weather events including leaking sewer pipes, sanitary sewage spills, and illicit discharge of commercial/industrial wastewater and wash waters to storm drains.

Due to the magnitude of the problem, it is important to understand the nature and sources of urban stormwater pollution. Table 1.1-1 summarizes the major stormwater pollutants and their effects. Some of the most frequently occurring pollution impacts and their sources for urban streams are:

- **Reduced Oxygen in Streams** – The decomposition process of organic matter uses up dissolved oxygen (DO) in the water, which is essential to fish and other aquatic life. As organic matter is washed off by stormwater, dissolved oxygen levels in receiving waters can be rapidly depleted. If the DO deficit is severe enough, fish kills may occur and stream life can weaken and die. In addition, oxygen depletion can affect the release of toxic chemicals and nutrients from sediments deposited in a waterway. All forms of organic matter in urban stormwater runoff such as leaves, grass clippings and pet waste contribute to the problem. In addition, there are a number of non-stormwater discharges of organic matter to surface waters such as sanitary sewer leakage and septic tanks leaching.

Table 1.1-1 Summary of Urban Stormwater Pollutants	
Constituents	Effects
Sediments —Suspended Solids, Dissolved Solids, Turbidity	Stream turbidity Habitat changes Recreation/aesthetic loss Contaminant transport Filling of lakes and reservoirs
Nutrients —Nitrate, Nitrite, Ammonia, Organic Nitrogen, Phosphate, Total Phosphorus	Algae blooms Eutrophication Ammonia and nitrate toxicity Recreation/aesthetic loss
Microbes —Total and Fecal Coliforms, Fecal Streptococci, Viruses, E.Coli, Enterocci	Ear/Intestinal infections Shellfish bed closure Recreation/aesthetic loss
Organic Matter —Vegetation, Sewage, Other Oxygen Demanding Materials	Dissolved oxygen depletion Odors Fish kills
Toxic Pollutants —Heavy Metals (cadmium, copper, lead, zinc), Organics, Hydrocarbons, Pesticides/Herbicides	Human & aquatic toxicity Bioaccumulation in the food chain
Thermal Pollution	Dissolved oxygen depletion Habitat changes
Trash and debris	Recreation/aesthetic loss

- **Nutrient Enrichment** – Runoff from urban watersheds contains increased nutrients such as nitrogen or phosphorus compounds. Increased nutrient levels are a problem as they promote weed and algae growth in lakes, streams and estuaries. Algae blooms block sunlight from reaching underwater grasses and deplete oxygen in bottom waters. In addition, nitrification of ammonia by microorganisms can consume dissolved oxygen, while nitrates can contaminate groundwater supplies. Sources of nutrients in the urban environment include washoff of fertilizers and vegetative litter, animal wastes, sewer overflows and leaks, septic tank seepage, detergents, and the dry and wet fallout of materials in the atmosphere.
- **Microbial Contamination** – The level of bacteria, viruses and other microbes found in urban stormwater runoff often exceeds public health standards for water contact recreation such as swimming and wading. Microbes can also contaminate shellfish beds, preventing their harvesting and consumption, as well as increasing the cost of treating drinking water. The main sources of these contaminants are sewer overflows, septic tanks, pet waste, and urban wildlife such as pigeons, waterfowl, squirrels, and raccoons.
- **Hydrocarbons** – Oils, greases and gasoline contain a wide array of hydrocarbon compounds, some of which have shown to be carcinogenic, tumorigenic and mutagenic in certain species of fish. In addition, in large quantities, oil can impact drinking water supplies and affect recreational use of waters. Oils and other hydrocarbons are washed off roads and parking lots, primarily due to engine leakage from vehicles. Other sources include the improper disposal of motor oil in storm drains and streams, spills at fueling stations and restaurant grease traps.
- **Toxic Materials** – Besides oils and greases, urban stormwater runoff can contain a wide variety of other toxicants and compounds including heavy metals such as lead, zinc, copper, and cadmium, and organic pollutants such as pesticides, PCBs, and phenols. These contaminants are of concern because they are toxic to aquatic organisms and can bioaccumulate in the food chain. In addition, they also impair drinking water sources and human health. Many of these toxicants accumulate in the sediments of streams and lakes.

Sources of these contaminants include industrial and commercial sites, urban surfaces such as rooftops and painted areas, vehicles and other machinery, improperly disposed household chemicals, landfills, hazardous waste sites and atmospheric deposition.

- **Sedimentation** – Eroded soils are a common component of urban stormwater and are a pollutant in their own right. Excessive sediment can be detrimental to aquatic life by interfering with photosynthesis, respiration, growth and reproduction. Sediment particles transport other pollutants that are attached to their surfaces including nutrients, trace metals and hydrocarbons. High turbidity due to sediment increases the cost of treating drinking water and reduces the value of surface waters for industrial and recreational use. Sediment also fills ditches and small streams and clogs storm sewers and pipes, causing flooding and property damage. Sedimentation can reduce the capacity of reservoirs and lakes, block navigation channels, fill harbors and silt estuaries. Erosion from construction sites, exposed soils, street runoff, and streambank erosion are the primary sources of sediment in urban runoff.
- **Higher Water Temperatures** – As runoff flows over impervious surfaces such as asphalt and concrete, it increases in temperature before reaching a stream or pond. Water temperatures are also increased due to shallow ponds and impoundments along a watercourse as well as fewer trees along streams to shade the water. Since warm water can hold less dissolved oxygen than cold water, this “thermal pollution” further reduces oxygen levels in depleted urban streams. Temperature changes can severely disrupt certain aquatic species, such as trout and stoneflies, which can survive only within a narrow temperature range.
- **Trash and Debris** – Considerable quantities of trash and other debris are washed through storm drain systems and into streams, lakes and bays. The primary impact is the creation of an aesthetic “eyesore” in waterways and a reduction in recreational value. In smaller streams, debris can cause blockage of the channel, which can result in localized flooding and erosion.



Figure 1.1-10 Trash and Debris Impact the Visual and Recreational Value of Waterbodies

1.1.6 Stormwater Hotspots

Stormwater hotspots are areas of the urban landscape that often produce higher concentrations of certain pollutants, such as hydrocarbons or heavy metals, than are normally found in urban runoff. These areas merit special management and the use of specific pollution prevention activities and/or structural stormwater controls. Examples of stormwater hotspots include:

- Gas / fueling stations
- Vehicle maintenance areas
- Vehicle washing / steam cleaning
- Auto recycling facilities

-
- Outdoor material storage areas
 - Loading and transfer areas
 - Landfills
 - Construction sites
 - Industrial sites
 - Industrial rooftops

Volume 2 of the Manual covers the topic of stormwater hotspots in more detail.



Figure 1.1-11 Gas Stations are an Example of Potential Stormwater Hotspots

1.1.7 Effects on Lakes, Reservoirs and Estuaries

Stormwater runoff into lakes and reservoirs can have some unique negative effects. A notable impact of urban runoff is the filling in of lakes and embayments with sediment. Another significant water quality impact on lakes related to stormwater runoff is nutrient enrichment. This can result in the undesirable growth of algae and aquatic plants. Lakes do not flush contaminants as quickly as streams and act as sinks for nutrients, metals and sediments. This means that lakes can take longer to recover if contaminated.

Stormwater runoff can also impact estuaries, especially if runoff events occur in pulses, disrupting the natural salinity of an area and providing large loads of sediment, nutrients and oxygen demanding materials. These rapid pulses or influxes of fresh water into the watershed may be two to ten times greater than normal and may lead to a decrease in the number of aquatic organisms living in the unique estuarine environment. Tidal flow patterns can also effectively trap and concentrate runoff pollutants.

1.2 Stormwater Impacts on Georgia Communities

The effects of urban stormwater runoff are not only environmental, but also have very real social and economic impacts on Georgia's communities. These include:

- Endangerment of Human Life from Floodwaters – The first concern of all local governments should be that of public safety. Development changes the hydrology of a watershed such that increased runoff peak flows and volumes can potentially overwhelm underdesigned stormwater drainage facilities, structural controls and downstream conveyances, putting human life at risk. Floodwaters can cause driving hazards by overtopping roadways and washing out bridges, as well as carrying sediment and debris onto streets and highways.

- Property and Structural Damage Due to Flooding – Due to upstream development, properties that were previously outside the 100-year floodplain may now find themselves subject to flood damage. Areas that previously flooded only once every 10 years may now flood far more frequently and with more severity. Increased property and infrastructure damage can also result from stream channel widening, undersized runoff storage and conveyance facilities, and development in the floodplain.



Figure 1.2-1 Flooding Endangers Human Life and Property

(Left Photo Source: Augusta Chronicle / Photo by Jeff Janowski)

- Impairment of Drinking Water Supplies (Surface and Groundwater) – Water quality degradation from polluted stormwater runoff can contaminate both surface and groundwater drinking water supplies and potentially make them unfit for a community's use.
- Increased Cost of Treating Drinking Water – Even if a drinking water supply remains viable, heavy concentrations of contaminants such as sediment and bacteria can increase the costs of water treatment to a community and water customers.
- Loss of Recreational Opportunities on Streams, Lakes, Rivers and Ocean Beaches – Turbidity from sediment, odors, floating trash, toxic pollutants and microbial contamination from stormwater runoff all reduce the viability of waterbodies for recreational activities such as swimming, boating and fishing. In addition, the aesthetic loss along these waterways also reduces the experience for noncontact recreation such as picnicking, jogging, biking, camping and hunting.



Figure 1.2-2 Water Quality Problems Due to Runoff Impact Drinking Water Supplies and Recreational Use of Streams, Rivers, Lakes and Beaches

- Declining Property Values of Waterfront Homes and Businesses – Stormwater pollution affects the appearance or quality of downstream waterbodies, influencing the desirability of working, living, traveling or owning property near the water.



Figure 1.2-3 Waterfronts are an Important Resource to Georgia Communities that Should Be Protected from the Effects of Polluted Stormwater

(Columbus Riverwalk and Savannah Waterfront. Photos by Ed Jackson)

- Loss of Sport and Commercial Fisheries – Commercial fisheries are a significant part of Georgia's economy, generating over \$20 million annually. Only 22% of all Georgia lakes are safe for fish consumption. A significant part of the problem is attributable to polluted surface water runoff.
- Closure of Shellfish Harvesting Areas – Only 35% of Georgia's estuaries are safe for shellfish consumption. Again, a major source of impairment is stormwater runoff.



Figure 1.2-4 Polluted Stormwater Runoff Impacts Sport and Commercial Fisheries and Shellfish Harvesting

- Increased Litigation – Increased legal action can result against local governments that have not adequately addressed stormwater runoff drainage and water quality problems.
- Reduction in Quality of Life – Stormwater quantity and quality impacts can reduce the overall quality of life in a community and make it a less desirable place to live, work or play.

1.3 Addressing Runoff Impacts Through Stormwater Management

For a number of reasons—including public health and safety, environmental, economic, legal liability, regulatory responsibility and to improve quality of life—cities and counties across Georgia have a vested interest and need to effectively deal with the effects of development and stormwater runoff in their communities.

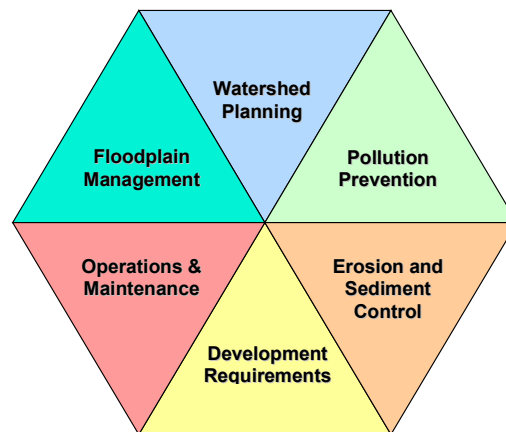
The focus of this Manual is how to effectively deal with the impacts of urban stormwater runoff through effective and comprehensive *stormwater management*. Stormwater management involves both the prevention and mitigation of stormwater runoff quantity and quality impacts as described in this chapter through a variety of methods and mechanisms.

In general, stormwater management can be broken down into the following six areas:

- **Watershed Planning** – Using the watershed as the framework for managing land use and developing large scale solutions to regional stormwater quantity and quality problems
- **Development Requirements** – Addressing the stormwater impacts of new development and redevelopment through stormwater management requirements and minimum standards
- **Erosion and Sediment Control** – Controlling erosion and soil loss from construction areas and resultant downstream sedimentation
- **Floodplain Management** – Preserving the function of floodplain areas to reduce flood hazards, minimize risks to human life and property, reduce modifications to streams and protect water quality
- **Operations and Maintenance** – Ensuring that stormwater management systems and structural controls work as designed and constructed. Includes the retrofitting of existing problem areas and streambank stabilization activities
- **Pollution Prevention** – Preventing stormwater from coming into contact with contaminants and becoming polluted through a number of management measures

Together these six categories create the “umbrella” of comprehensive stormwater management as shown in Figure 1.3-1.

Figure 1.3-1
The "Umbrella" of Comprehensive Stormwater Management



The remainder of Volume 1 of this Manual deals with ways that communities in Georgia can effectively implement comprehensive stormwater management to address the impacts of development, and both prevent and mitigate problems associated with stormwater runoff. This is accomplished by developing a local program which includes the six components described above.

The next chapter deals with the state and federal regulatory requirements for Georgia communities in the area of stormwater management.

REGULATORY REQUIREMENTS FOR GEORGIA COMMUNITIES

2.1 Overview

As a result of the impacts of development and stormwater runoff described in Chapter 1, numerous federal and state programs and regulations have been created to deal with the problems of urban runoff and nonpoint source pollution. Given the fact that local communities typically make the land use and development decisions which create runoff problems and the need for stormwater infrastructure, it is at the local level where these problems must be addressed. Therefore, federal and state legislation inevitably influence the responsibilities of local governments in managing stormwater runoff in their communities. The regulatory programs and their key provisions are summarized in Table 2.1-1.

The purpose of this section is to provide a brief overview of each of the state and federal laws, regulations and programs which are required of local communities in Georgia, or which may impact local stormwater management programs and activities. As it is not intended to be a detailed analysis of each requirement, it would be advisable that a community obtain a copy of the specific administrative rules for each program from the appropriate regulatory agency. A list of contact agencies is included in Appendix A.

2.2 Stormwater Quantity & Flooding Prevention Regulations

Because stormwater drainage and quantity management have traditionally been a local responsibility, there are few federal and state regulatory requirements for stormwater quantity control. Typically, the type of land use controls and activities necessary to prevent, control and mitigate flooding are reserved to the local governments in Georgia. However, the following two programs have been established by the federal and state authorities, respectively, to help protect public safety and prevent property damage.

2.2.1 National Flood Insurance Program

Established under the National Flood Insurance Act of 1968 and broadened with the passage of the Flood Disaster Act of 1973, the National Flood Insurance Program (NFIP) provides federally-supported flood insurance to community residents that voluntarily adopt and enforce regulations to reduce future flood damage. As part of the program, the federal government defines minimum standards for floodplain development that the local communities must adopt to be eligible for program benefits. More information on the NFIP and floodplain management in general is provided in Chapter 6.

2.2.2 Georgia Safe Dams Act

The Georgia Safe Dams Act regulates the construction of dams that are capable of storing at least 100 acre-feet of water or are at least 25 feet tall. A permit from EPD is required for construction of a dam if dam failure would likely result in a death downstream. Local communities must insure that all dams remain within compliance with the provisions of the Act, which might entail retrofitting older dams and lakes.

Table 2.1-1 Regulatory Framework for Local Stormwater Management in Georgia										
Basis of Regulation	Quantity Based Regulations		Quality Based Regulations							
Area of Regulation	Flood Control	Dam Safety	Municipal Stormwater	Construction Stormwater	Water Quality Standards	Water Supply Protection	Groundwater Protection	Erosion & Sediment Control	Stream and River Protection	Wetland Protection
Objective	Flood prevention and property protection	Protect the safety of Georgia residents	Management of municipal stormwater	Control of stormwater from construction sites	Control of point and nonpoint loads so that quality standards are met	Protection of municipal drinking water supplies	Protection of municipal groundwater aquifers	Control of erosion and sedimentation and stream protection	Protect water quality, control of erosion, reduction of flood hazards	Protection of wetlands and waters
Federal Legislation	Flood Insurance & Floodplain Management Program (1)	National Dam Inspection Act of 1972	Clean Water Act			Safe Drinking Water Act		NA	NA	Clean Water Act; Rivers and Harbors Act
State Legislation	NA	Georgia Safe Dams Act	Georgia Rules and Regulations			Georgia Planning Act; Safe Drinking Water Act		Georgia Erosion & Sediment Control Act	Metropolitan River Protection Act (2)	Georgia Rules and Regulations; Georgia Planning Act; Coastal Marshlands Protection Act
Enforcement Agency (s)	Local agencies that issue building permits	Georgia EPD	Georgia EPD (3)			Georgia EPD; DCA (3)		Local agencies; Soil and Water Conservation Districts; EPD	Atlanta Regional Commission and local agencies	US COE US EPA
Enforcement Mechanism	Local floodplain ordinances	Permits for dam construction	NPDES Phase I and II Municipal Stormwater Permits	NPDES Permits for construction sites	Watershed assessment req'ts; TMDLs (4)	Water supply watershed regulations; SWAP program (5)	Groundwater recharge area criteria; wellhead protection provisions	Land Disturbing Permits	Chattahoochee Corridor Plan (6)	Section 401/404 Permits; Section 10 Permits

Notes:

- 1) Broadened and modified with passage of the Flood Disaster Act of 1973 and National Flood Insurance Act of 1994
- 2) Atlanta metro area only
- 3) Final enforcement authority for federal laws under the Clean Water Act and Safe Drinking Water Act rests with the U.S. EPA
- 4) Refers to the federal and state Total Maximum Daily Load (TMDL) initiative
- 5) Refers to the federal and state Source Water Assessment Program (SWAP)
- 6) The ARC Chattahoochee Corridor Plan requires prior approval for all development, clearing, and other land disturbing activity from Buford Dam to the downstream border of Fulton and Douglas Counties

2.3 Water Quality Regulations

The increasing focus on nonpoint source pollution and stormwater quality with the amendment of the Clean Water Act in 1987 and subsequent legislation requires Georgia communities to address urban runoff water quality. Numerous federal and state requirements define what is required of local governments in terms of their local stormwater management programs and related community planning and development efforts. Below is an overview of the key programs which impact local communities.

2.3.1 Municipal NPDES MS4 Stormwater Permit Program (Phase I and II)

The National Pollutant Discharge Elimination System (NPDES) permit system was originally established by the Clean Water Act of 1972 to control wastewater discharges from various industries and wastewater treatment plants known as “point” sources. Congress amended the Clean Water Act with the Water Quality Act of 1987 to expand the NPDES permit program to address “nonpoint” source pollution through schedules for permitting municipal stormwater discharges. The Municipal Separate Storm Sewer System (MS4) stormwater discharge permit establishes guidelines for municipalities to minimize pollutants in stormwater runoff to the “maximum extent practicable.”

Under Georgia EPD’s Municipal Separate Storm Sewer System (MS4) permit program, local governments in regulated areas are required to establish a comprehensive stormwater management program (SWMP) and to develop a plan and program to control stormwater pollution discharges to waters of the State to the maximum extent practical and to eliminate non-stormwater discharges from entering the stormwater system.

This is accomplished through the implementation of a municipal program which includes such measures as structural and non-structural stormwater controls, best management practices (BMPs), regular inspections, enforcement activities, stormwater monitoring and public education efforts. Stormwater management ordinances, erosion and sediment control ordinances, development regulations and other local regulations provide the necessary legal authority to implement the stormwater management programs.

Since 1993, the Phase I permit requirements have applied in Georgia to large and medium municipal separate storm sewer systems (defined by a population greater than 250,000 and population between 100,000 and 250,000, respectively, or those areas contributing to water quality violations). The Phase I program includes all the following jurisdictions:

- All local governments in the five-county Atlanta metro area of Clayton, Cobb, DeKalb, Fulton and Gwinnett counties, including the City of Atlanta
- All local governments in Chatham County, including the City of Savannah
- Augusta-Richmond County
- Bibb County
- Columbus-Muscogee County
- City of Macon

Federal regulations were adopted in 1999 to extend the NPDES MS4 permit program to smaller (Phase II) communities. The Phase II rules take a slightly different approach to how the local stormwater management programs are implemented by requiring the SWMP to consist of the following six elements, termed “minimum control measures”:

1. Public Education and Outreach
2. Public Participation / Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Control
5. Post-Construction Runoff Control
6. Pollution Prevention / Good Housekeeping

A Phase II MS4 community will be required to identify its selection of management practices and measurable goals for each minimum measures in the permit application. Georgia EPD is currently working on its Phase II stormwater permitting strategy. The Phase II MS4 program is expected to be implemented by 2003.

2.3.2 Industrial NPDES Stormwater Permit Program

The NPDES program also requires that the discharge of stormwater from certain types of industrial facilities be regulated under a permit program. Industrial stormwater is defined as that discharged from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing or materials storage areas. Discharge of stormwater from regulated industrial facilities is managed under a single general permit that was re-issued by Georgia EPD in 1998.

Currently, ten categories of industrial facilities are required to have an NPDES permit for their stormwater discharge. These include:

- Manufacturing facilities
- Mining, oil and gas operations
- Hazardous waste treatment, storage or disposal facilities
- Recycling facilities
- Steam electric power generating facilities
- Transportation facilities
- Facilities treating domestic sewage or sewage sludge.
- Landfills, land application sites and open dumps
- Facilities subject to effluent guidelines and new performance standards under 40 CFR Subchapter N (for example, feedlots, cement and phosphate manufacturing; petroleum refining; coal, ore and mineral mining; asphalt, etc.)
- Construction activities

New industrial facilities are required to submit a Notice of Intent (NOI) 48 hours prior to conducting any new activity. Provisions of the permit require preparation of a Stormwater Pollution Prevention Plan and annual certification of plan implementation. Industrial facilities must comply with the requirements of the general industrial stormwater permit, including preparation and submittal of Stormwater Pollution Prevention Plans.

2.3.3 NPDES Stormwater Permits for Construction Areas

The NPDES stormwater permit for construction activities is directed toward controlling the quality of stormwater runoff from construction activities. The permit emphasizes the application of best management practices to control erosion and sedimentation processes during the construction phase of development (similar to the Erosion and Sedimentation Act below). Construction managers need to obtain stormwater permits from Georgia EPD by filing a Notice of Intent (NOI) prior to initiating construction activities that disturb an area greater than five acres or tracts of less than five acres that are part of a larger overall development with an area of greater than five acres. Phase II of the NPDES stormwater permit for construction activities, expected to be implemented in 2003, will extend the program to land disturbing activities of one to five acres.

2.3.4 NPDES Municipal Wastewater Discharge Permit Program and Watershed Assessments

For communities applying for new or expanded NPDES point source permits for municipal wastewater treatment facilities, the Georgia EPD requires comprehensive watershed assessments which look at both point and nonpoint sources. The watershed assessments relate to the federal Total Maximum Daily Load (TMDL) initiative (see 2.3.6).

2.3.5 Erosion and Sedimentation Control Act

The Erosion and Sedimentation Control Act was established for controlling erosion and sedimentation from land-disturbing activities. Georgia law directs local governments to enact erosion and sedimentation ordinances. These ordinances are to require that permits be obtained for land-disturbing activities within the jurisdiction. Permit applicants must submit an erosion and sedimentation control plan which incorporates specific conservation and engineering practices known as best management practices (BMPs). The Act includes special requirements for land-disturbing activities in stream buffer zones. Land disturbing activities are not allowed within 25 horizontal feet of any State waters (warm water streams) unless a variance is granted by EPD for drainage structures. The Act also includes special requirements for trout streams.

This program relates directly to requirements under the NPDES program in that that program also requires sediment and erosion controls for all disturbed areas greater than one acre. One erosion and sediment control plan for a site will typically suffice for the NPDES and State erosion and sedimentation control permit requirements.

2.3.6 Total Maximum Daily Load (TMDL) Program

Under Section 303(d) of the Clean Water Act, the State of Georgia is required to develop a list of impaired waters that do not meet water quality standards. The Georgia EPD must then establish priority rankings for waters on the list and develop Total Maximum Daily Loads (TMDLs) for listed waters. The TMDL specifies the maximum amount of a specific pollutant of concern that a designated segment of a water body can receive and still meet water quality standards. The TMDL also allocates pollutant loadings among point and nonpoint pollutant sources, including stormwater runoff. A number of TMDLs have been issued for water bodies across the state.

For each pollutant identified, a TMDL implementation plan must be developed. The implementation plans must identify the sources of the pollutant and provide a list of actions or management measures needed to reduce the pollutant, a schedule for implementing controls or measures, milestones for implementation, and a monitoring program to measure progress. Controls and management measures need to be in place five years after the plan is developed. The TMDL program has a broad impact on local stormwater management programs because nonpoint sources of pollutants must be addressed at the local level.

2.3.7 Georgia Planning Act – River Corridor Protection

The Georgia Planning Act establishes corridors along some large rivers as critical natural resource areas. The river corridors and other critical natural resources are to be protected through comprehensive planning at the local level. Each local government with a protected river in its jurisdiction is directed to adopt a river corridor protection plan that meets minimum planning standards established by the Georgia EPD. Minimum standards are designed to protect large rivers from the impacts of human activities on land immediately adjacent to the river (100 feet on each side). Communities must comply with the requirements of the state's River Corridor Protection criteria if stormwater activities are within the protected areas of this plan.

2.3.8 Georgia Planning Act – Water Supply Watersheds

The Georgia Planning Act identifies water supply watersheds as key natural resources and sets regulatory activities to protect the quality and quantity of water available from watersheds that are used for public water supply. Water supply watersheds are defined as land contained within a drainage basin that has a governmentally-owned public drinking water intake downstream. Georgia EPD requires that development and associated stormwater runoff within the watershed not contaminate the water source to a point where the water cannot be treated to meet drinking water standards. Reservoir management plans must be submitted to EPD for all reservoirs in water supply watersheds. Requirements are specified based on the type of water supply watershed (small or large) and on the location as shown in Table 2.3-1 below.

Table 2.3-1 Minimum Criteria for the Protection of Water Supply Watersheds in Georgia

Watershed Size (mi ²)	Reservoir Present?	Vegetative Buffer around Reservoir (ft)	Vegetative Buffer along Perennial Streams (ft)		Setback for Impervious Surfaces along Perennial Streams (ft)		Overall Impervious Surface Density
			within 7 mile radius*	outside radius*	within 7 mile radius*	outside radius*	
> 100	No	none	none	none	none	none	no criteria
> 100	Yes	150	100	none	150	none	no criteria
< 100	No	none	100	50	150	75	25% or less
< 100	Yes	150	100	50	150	75	25% or less

* "7 mile radius" means within 7 miles upstream of a reservoir boundary if present or of the surface water intake if no reservoir is present

The water supply watershed requirements provide for the development of alternative criteria to these standards. Alternative criteria must provide equal or better protection of the water supply watershed and all local governments within the watershed must approve of and adopt the criteria.

2.3.9 Georgia Planning Act – Groundwater Recharge Areas

The Georgia Planning Act identifies groundwater recharge areas as key natural resources. The Georgia EPD has established minimum criteria for groundwater recharge areas in order to prevent groundwater contamination from development. These criteria are to be incorporated within local comprehensive plans. Within Georgia, minimum criteria have been established only for the most significant recharge areas, which cover approximately 23 percent of the state. For new residences served by septic systems, the criteria specify minimum lot sizes greater than those required for those not in a significant recharge area. Permanent stormwater infiltration basins are prohibited in areas having high pollution susceptibility.

2.3.10 Safe Drinking Water Act – Wellhead Protection Program

Under the Federal Safe Drinking Water Act, Georgia EPD administers a wellhead protection program to protect public water supplies that use groundwater. Wellhead protection is the practice of managing an area around a water well or a spring to prevent any contaminants released at the ground's surface from reaching the subsurface drinking water. Within the wellhead protection area, some stormwater management activities involving the infiltration of runoff, particularly from hotspot areas, may be limited or prohibited.

2.3.11 Source Water Assessment Program (SWAP)

The 1996 amendments to the Federal Safe Drinking Water Act brought about a new approach for ensuring clean and safe drinking water served by public water supplies known as the Source Water Assessment Program. The U.S. EPA is advocating prevention as an important tool in the protection of public drinking water sources from contamination. In order to implement source protection, an assessment of potential pollutant sources in water supply watersheds must be conducted. The goals of this assessment project will be reached through implementation of a four-step method which includes watershed delineation, inventory of potential pollutant sources within the watershed, analysis of susceptibility of a water intake to the pollutant sources, and communication of this information to the public.

As many pollutants can enter waterways and reservoirs through stormwater drainage systems, the SWAP efforts will provide a informational resource to local stormwater pollution prevention and mitigation programs. Future water supply protection efforts to control the identified potential pollution sources should be coordinated with and included as part of a local stormwater program.

2.3.12 Metropolitan River Protection Act (Atlanta metro area only)

The Metropolitan River Protection Act (MRPA) was passed by the Georgia General Assembly in 1973 in recognition of the Chattahoochee River's value as a resource and its vulnerability to the effects of urban development. The stated purposes of the Act include protection of water quality, erosion control, reduction of flood hazards, protection of recreational values, and protection of property rights. The Act created a corridor extending 2000 feet from each bank of the Chattahoochee and its impoundments, which originally covered the 48 miles of river between Buford Dam and Peachtree Creek. In 1984, the Act was amended to require local governments in the river basin to adopt buffer zone ordinances for tributaries outside of the 2000 foot Corridor. In 1998, the Act was amended again to extend the Corridor to the downstream limits of Fulton and Douglas Counties.

The Act authorizes the Atlanta Regional Commission to adopt a plan for the Corridor that established criteria for all land-disturbing activity to protect the Corridor's land and water resources. All land-disturbing projects and proposed activities in the Corridor are subject to review for consistency with the standards of the adopted Corridor Plan. These standards include: natural vegetative buffers and impervious surface setbacks along the River and tributary streams, limits on land disturbance and impervious surface, and requirements in the river floodplain. Outside of the Corridor, projects need to adhere to the local tributary buffer requirements.

2.3.13 Wetlands – Federal 404 Permits and Georgia Planning Act

The U.S. Army Corps of Engineers administers a permit program for activities in, on or around the waters of the U.S. Regulated activities include excavating, dredging or depositing fill materials into water of the U.S. The permit program protects wetlands and all "waters of the United States" across Georgia. Waters of the U.S. include all surface waters, such as coastal and navigable inland waters, lakes, rivers, streams and their tributaries; interstate waters and their tributaries; wetlands adjacent to the above (e.g. swamps, marshes, bogs, or other land areas); and isolated wetlands and lakes, intermittent streams, and other waters where degradation could affect interstate commerce. Section 404 permits (and possibly Section 10 permits) are required for stormwater activities that may impact natural wetlands.

Protection of wetlands in Georgia is also accomplished through comprehensive planning and ordinances at the local level through the Georgia Planning Act. The Act establishes provisions for planning by local governments and authorizes the DNR to develop minimum planning standards for the protection of critical natural resources, including wetlands.

2.3.14 Coastal Management Program

The state Coastal Management Program was recently developed to establish Georgia as a participant in the federal Coastal Zone Management Act of 1972. The goal of the program is to balance economic development in Georgia's coastal zone with preservation of natural, environmental, historic, archeological, and recreational resources. The program establishes a network of federal, state, and local agencies to address coastal issues. Activities under the program include permitting, planning, resource protection, and economic development activities. Certain requirements of this Act are designed to protect marshlands, and include the use of stormwater controls in critical areas near the coast to reduce the discharge of urban stormwater pollutants. The requirements are similar in nature to those anticipated under the NPDES Phase II regulations.

2.3.15 Coastal Marshlands Protection Act

The Coastal Marshlands Protection Act manages certain activities and structures in marsh areas and requires permits for other activities and structures. The jurisdiction of the Act includes marshlands, intertidal areas, mudflats, tidal water bottoms, and salt marsh areas within estuarine

areas of the state. The estuarine area is defined as all tidally influenced waters, marshes and marshlands lying within a tide-elevation range from 5.6 feet above mean high-tide level and below.

A Marshlands Protection Permit administered through the DNR's Coastal Resources Division is required for any project which involves removing, filling, dredging, draining or otherwise altering any marshlands. In cases where the proposed activity involves construction on State-owned tidal water bottoms, a Revocable License issued by the Coastal Resources Division may also be required.

2.3.16 Georgia Greenspace Program

The Georgia Greenspace Program was established in 2000 to provide a framework within which developed and rapidly developing counties and their municipalities can preserve community greenspace. It promotes the adoption, by such counties and cities, of policies and rules which will enable them to preserve at least 20 percent of their land areas as connected and open greenspace which can be used for informal recreation and natural resource protection.

"Greenspace" means permanently protected land and water, including agricultural and forestry land, that is in its undeveloped, natural state or that has been developed only to the extent consistent with, or is restored to be consistent with, one or more listed goals for natural resource protection which include water quality protection, flood protection and stream channel protection.

Much of this land can be preserved as floodplains and wetlands along stream corridors, and linked to create riparian greenways. These community greenspace areas and greenways can be used to serve stormwater management functions as indicated above. State grants from the Georgia Greenspace Commission are available to assist counties with their green space programs.

LOCAL STORMWATER MANAGEMENT PROGRAMS

3.1 Overview of Local Stormwater Management Programs

3.1.1 Introduction

To effectively deal with the problems of urban stormwater runoff and meet stormwater regulatory requirements as covered in Chapters 1 and 2, respectively, Georgia communities need to adopt a comprehensive approach to stormwater management that ties together stormwater quantity control with water quality protection, protection of stream channels and riparian corridors, floodplain management, habitat preservation and restoration, and the use of stormwater facilities for multiple purposes.

Given this broad charge, the development of a comprehensive stormwater management program often involves a “rethinking” of stormwater by local communities. Those responsible for stormwater management can no longer limit their mission to drainage and flood control. Rather, local government agencies need to broaden their mission to encompass these broader goals.

Urban stormwater runoff needs to be viewed as a valuable water resource that can and should be managed within the context of the community and watershed as a whole. Further, as all of the actions within a watershed ultimately impact Georgia’s downstream waters, a holistic approach to stormwater management must be developed.

Local governments have a large responsibility for stormwater management in Georgia since it is at the city and county level where land use, development and infrastructure decisions are typically made. The overall purposes of a local stormwater management program are to:

- Minimize the adverse impacts of stormwater runoff on the community;
- Meet the state and federal regulatory requirements for stormwater runoff quantity and quality management; and
- Ensure that the community’s priorities, needs and desires are taken into account in meeting stormwater management goals.

In addition, an effective local stormwater program requires an institutional structure that includes:

- ✓ Adequate legal authority
- ✓ Performance standards for development
- ✓ Design assistance and guidance
- ✓ Program funding and staffing
- ✓ Commitment to enforcement
- ✓ Public education
- ✓ Citizen involvement

The purpose of this chapter is to provide an overview of the development of a comprehensive local stormwater management program. The section below discusses the respective components and activities of a comprehensive local program. The remainder of the chapter looks at the steps in developing an effective local program.

3.1.2 Elements of a Comprehensive Local Stormwater Management Program

The various program activities that will be included in a local program will vary according to the goals, requirements and resources of the community in question. The following is a description of elements that should be considered developing a comprehensive local program:

- **Information / System Inventory** – Information needs are critical to a successful program. The development of an inventory of the stormwater system is one of the first steps in developing a comprehensive stormwater management program. Relevant information includes location and classification of storm drains; drainage networks; structural stormwater control facilities; streams, ponds and wetlands; industrial discharges and combined sewer outfalls; watershed boundaries; floodplains; existing and proposed land use and zoning; and known water quality problem areas. This information can be collected and stored on paper maps or, ideally, in an integrated municipal GIS system. Stormwater system inventories and geographic information tools are covered in more depth in Chapter 9.
- **Watershed-Based Planning** – Stormwater master planning and watershed planning help to establish the priorities for stormwater management decision-making and should be incorporated early into an effective local program. Watershed-based planning is a tool which allows a community to assess current and future stormwater problems as well as potential solutions within a drainage basin. It can be used to assess the health of existing water resources and make informed land use, transportation, greenspace and other community-level decisions based upon current and projected land use and development within a watershed and its associated subwatersheds. Watershed plans assist communities in developing and evaluating stormwater management scenarios and alternatives.

Watershed and stormwater master plans can be used to identify drainage system and stream segments in need of channel improvement or restoration, and potential locations for regional stormwater control facilities. Watershed planning can also provide a community with the necessary information for conserving natural areas and open space as well as the development of riparian buffers and greenways. In addition, they may also promote a wide range of additional goals including water supply protection, wetland protection and preservation, streambank and stream corridor restoration, habitat protection, protection of historical and cultural resources, enhancement of recreational opportunities, and aesthetic and quality of life issues.

In addition to providing better opportunities for managing stormwater problems and watershed resources, the watershed planning approach also involves stakeholders and provides community consensus in the land use and stormwater management decision-making process. Further, watershed plans promise a reduction in the overall capital and operation and maintenance costs for stormwater management from reduced downstream flooding and optimal siting and sizing of stormwater control measures. Other benefits include contributions to community land use plans, and increased equity and opportunities for developers. The process of watershed plan development and implementation of watershed plans are discussed in detail in Chapter 5.

- **Development Requirements** – Adoption of a comprehensive and integrated set of stormwater management requirements for all new development and redevelopment is critical to addressing the problems of post-construction urban stormwater runoff and is required for NPDES municipal stormwater programs. These requirements are ideally built into a community's development ordinances and supported by a plan review process. This Manual provides a recommended set of minimum standards for new development and redevelopment from which local requirements can be developed.

Chapter 4 provides an in-depth discussion of the minimum stormwater management standards for new development and redevelopment along with an overview of a stormwater management design approach for meeting the goals. This approach includes a suite of stormwater better site design practices, a set of unified stormwater design criteria, stormwater site design credits, a provision for downstream assessments, and guidance and design criteria on structural stormwater controls. Chapter 4 also provides a step-by-step procedure for local review of stormwater management site plans.

- **Design Criteria and Guidance** – In support of local development standards and requirements, a community must provide supporting guidance and technical criteria for the design, construction and maintenance of stormwater management facilities. For most communities in Georgia, the inclusion of water quality provisions and stream channel and habitat protection into stormwater management activities represents a new approach to the “traditional” drainage responsibilities. Practitioners in the development community (i.e. site designers and engineers) also must face a host of new concepts and ideas that alter their “traditional” approach of managing stormwater on development sites. Many have had little experience in designing or constructing effective structural stormwater controls, or inspecting and maintaining stormwater runoff systems to maximize pollutant prevention and removal. Therefore it is imperative that adequate design assistance and guidance be provided to those being regulated by the local stormwater management program.

A formal set of design criteria and specifications for structural control and drainage system design is critical to ensuring that local requirements and goals are met. Volume 2 of this Manual is a comprehensive technical document for stormwater management which can be adopted by a community as its primary design aid for developers. Volume 2 is designed to support the recommended minimum stormwater management standards and includes information and criteria on stormwater site plan preparation, better site design, recommended hydrologic methods, structural stormwater control selection and design, drainage system design, and inspection and maintenance provisions. A community may wish to prepare an addendum to Volume 2 which includes any specific local criteria and/or additional material. Additional design aids may be necessary depending on a local community’s requirements.

Training on the design, construction, and inspection and maintenance of stormwater management facilities and structural control practices is an essential part of providing technical guidance to developers, engineers and contractors. Regular education programs are important to assure that individuals remain current in the latest requirements and design criteria. It also provides opportunities for training the large influx of new personnel each year in the design, engineering and construction industries. Education programs help all parties to understand their roles and responsibilities, which is essential to an effective program.

- **Floodplain Management** – Floodplain management involves the designation of flood-prone areas and the limiting of their uses to those compatible with a given degree of risk. It is also aimed at minimizing modifications to streams, reducing flood hazards and protecting the water quality of streams. As such, floodplain management can be seen as a subset of the larger consideration of surface water and stormwater management within a local community.

Though it is often considered separately in most communities, there are many areas in which floodplain management directly overlaps with other areas of stormwater management. The development of riparian buffers and greenway corridors along streams and rivers can also preserve floodplain areas and protect their function in safely conveying floodwaters. Floodplain regulations and development restrictions, particularly when based upon the full build-out 100-year floodplain, can greatly reduce future flooding impacts and may allow communities to waive stormwater quantity control (detention) requirements for larger storm events in some areas.

Ideally, flooding and floodplains should be managed at the watershed level, and floodplain management should be an important goal of comprehensive watershed plans. Consequently, floodplain management activities should be fully integrated into

comprehensive stormwater management programs and handled in a complementary and coordinated approach. More information on strategies and tools for improved local floodplain management are provided in Chapter 6.

- **Erosion and Sediment Control** – Sediment loadings to receiving waters are highest during the construction phase of development. Consequently, erosion and sediment control on construction sites is an important element of a comprehensive stormwater management program for water quality and habitat protection. A combination of clearing restrictions, erosion prevention, and sediment controls, coupled with a diligent plan review and strict construction enforcement are needed to help mitigate these impacts.

Guidance on best management practices for construction site sediment and erosion control can be found in the *Manual for Erosion and Sediment Control in Georgia*. In addition, a number of the better site design practices and techniques described in Chapter 5 can reduce the total amount of area that is cleared and graded. It is essential that erosion and sediment control be considered in stormwater concept plans and implemented throughout the construction phase to prevent damage to natural stormwater drainage systems and post-construction structural stormwater controls and conveyance facilities.

- **Ordinances** – Local ordinances are typically the implementation vehicle for many stormwater program objectives. They can include provisions for stormwater management requirements (both water quantity and quality) for development, protection of natural areas, erosion and sediment control, the prohibition of non-stormwater discharges to municipal storm sewers, and nonpoint source pollution control. Table 3.1-1 below outlines some types of local ordinances used to support stormwater management activities.

Table 3.1-1 Types of Local Ordinances Used to Support Stormwater Management Activities	
Stormwater Ordinance	Typically contains comprehensive performance criteria for all components of the stormwater management system along with procedures for obtaining approval for construction.
Zoning Ordinance	Specifies land uses and site plan minimums which support stormwater management through the use of buffers, setbacks, densities, open spaces, dedications, etc. May also contain the FEMA regulations implementing the National Flood Insurance Program.
Sub-division / Development Ordinance	Specifies the proper design, permitting and inspection procedures for the sub-division of land for the purpose of development. May contain performance standards similar to a Stormwater Ordinance.

In some communities all stormwater related requirements are aggregated into one comprehensive stormwater ordinance. This has the advantage of insuring a comprehensive and consistent approach to land development and other stormwater related activities. It may have a disadvantage in that it may become disconnected from other provisions for land development and from the staff elements that enforce those other provisions. In some communities the stormwater requirements are scattered among several documents. In these cases it is often helpful to pull the pieces together into a special informational publication which can be conveniently used by a developer, and which will insure all stormwater requirements are met, regardless of source of the authority.

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- **Plan Review** – Having an effective local review process for stormwater management plans (including erosion control plans) for development is a key element in the successful implementation of stormwater management objectives. The review should be comprehensive, considering all of the potential impacts of a development.

The project review and approval process should be explicitly outlined and readily understandable to the development community, including all submittal and permit requirements. Chapters 4 and 5 provide more discussion on implementing a local plan review process.

- **Inspection and Enforcement** – A community needs to provide the means for the enforcement of established ordinances and permit requirements. Trained personnel are required to inspect and ensure compliance for erosion and sediment control, stormwater management plans, removal of illicit connections, and private maintenance of structural stormwater controls. Chapter 7 provides more information on the types of inspections required and on enforcement methods to ensure compliance.
- **Stormwater System Improvements** – There are several ways that a local government can make physical improvements to the stormwater management system. These can include capital improvements such as the design and construction of conveyance structures or regional controls, streambank stabilization and improvement programs, and the acquisition of floodplain areas and natural areas such as buffers and wetlands.
- **Operations and Maintenance** – An essential component of a comprehensive stormwater management program is the ongoing operation and maintenance of the various components of the stormwater drainage, control, and conveyance systems. Failure to provide effective maintenance can reduce the hydraulic capacity and the pollutant removal efficiency of stormwater controls and conveyance systems.

Operations and maintenance activities can include cleaning and maintenance of catch basins, drainage swales, open channels, storm sewer pipes, stormwater ponds and other structural controls. Street sweeping and other pollution reduction activities also fall under operations and maintenance. Ideally, the best program addresses operations and maintenance concerns proactively instead of reacting to problems that occur such as flooding or water quality degradation.

A clear assignment of stormwater inspection and maintenance responsibilities, whether they be accomplished by the local government, land owners, private concerns, or a combination of these, is essential to ensuring that stormwater management systems function as they were intended. Maintenance requirements are an important consideration in the selection and design of structural stormwater controls and therefore site designs should strive to make their systems as simple and maintenance free as possible.

Stormwater system operations and maintenance can also include the retrofitting of existing development to meet water quality and/or water quality goals and streambank restoration. More guidance on inspection and maintenance of stormwater controls and systems is found in Chapter 7.

- **Monitoring** – Monitoring data can assist in management decisions and/or provide support for enforcement actions. Typical monitoring data include water quality and streamflow measurements, as well as streambank and habitat assessments. The monitoring program should be designed to address specific issues or problems within individual watersheds. Short-term monitoring can be used to evaluate the performance of implemented solutions. Long-term collection of data can be used to identify trends.
- **Pollution Prevention** – Also known as “source controls,” pollution prevention management practices are an important way to prevent water quality problems in stormwater runoff from a variety of sources. The intent of source control practices is to prevent stormwater from

coming in contact with pollutants in the first place rather than providing structural controls for treatment and pollutant removal. Pollution prevention include categories of measures such as:

- Materials management (use, exposure, and disposal/recycling controls)
- Spill prevention and cleanup
- Removal of illicit connections
- Prevention of illegal dumping
- Street and storm drain maintenance
- Public information and education

Examples of source control practices include covering piles of soil to prevent erosion, safe hazardous waste storage, dry weather screening of stormwater outfalls to detect illicit connections, storm drain stenciling, street sweeping, fertilizer use restrictions, leaf collection programs, and efforts to educate and influence citizen's actions (such as proper motor oil disposal and household hazardous waste management) that impact stormwater runoff quality.

Many of these practices are easily implemented and are cost-effective means of reducing stormwater contaminants. As such, they should be considered, where appropriate, for all residential, commercial, industrial, institutional, and municipal projects and activities. In addition, many are required activities for NPDES municipal stormwater management programs. Implementation of pollution prevention practices is discussed further in Chapter 8.

- **Public Education and Involvement** – In order to gain public support for local stormwater management programs, both citizens and the business community alike need to be educated and involved in the process. General education efforts can provide information about stormwater issues and pollution prevention practices. Educational efforts can include:
 - Meetings and presentations
 - Newsletters, fact sheets and brochures
 - Homeowner education materials
 - Media campaigns
 - Coordination with activist groups for program support

In addition, programs like Georgia Adopt-A-Stream can involve local citizens in the cleanup and monitoring of local streams. The public can also be involved in the development of watershed plans and overall stormwater management policy. More information on stormwater public information and education programs is provided in Chapter 8, as well as in Volume 3 of the Manual.

- **Funding** – Adequate funding of local stormwater management program activities is perhaps one of the most critical, and yet difficult aspects of establishing a comprehensive program. The best-designed stormwater management program will founder without sufficient community support and a stable and sufficient funding source. An effective and ongoing program that includes planning, engineering, plan review, capital improvements, maintenance, and enforcement activities will typically require more resources than is typically available from general appropriations—the traditional way that most local governments in Georgia have funded drainage and stormwater infrastructure activities.

The next section provides an overview of various approaches that a community can take to establish a dedicated funding source, including the creation of a stormwater utility.

3.2 Developing an Effective Local Stormwater Management Program

3.2.1 Introduction

Developing a comprehensive local stormwater management program requires extensive planning and forethought on a community's needs and resources in the area of stormwater management. Below are four key areas discussed in this section that need to be considered in establishing an effective program:

- Program Goals and Requirements
- Program Components and Priorities
- Organizational Structure and Staffing
- Program Funding

In addition, a community must determine the best approach for implementing and building public support for the program. The goal of this section is to provide an overview of the necessary steps that must be undertaken in putting together an effective local stormwater management program.

3.2.2 Defining Problems, Program Goals and Requirements

The first step in building an effective and comprehensive local stormwater management program is to evaluate and document the current problems, needs, and regulatory requirements for stormwater management facing the local government. This includes:

- Identifying the location and magnitude of existing and/or potential stormwater-related problems including flooding, property damage, water quality impairment, streambank erosion and habitat degradation; and
- Determining the state or federal regulatory requirements that must be met by the community.

The existence of stormwater-related problems or mandated requirements leads to formal recognition by the elected officials and in turn establishes the basis for developing the program. This step should ideally be performed with a team from several departments to insure coordination and include the public in the process through the use of a stakeholder or citizens' group.

All stormwater program goals should be based on problems which are clearly recognized as being important by the general public and that can be addressed by the basic powers and responsibilities of the local government. Often a consensus building approach is used to develop general program goals with citizen input. These goals often include the following general foundational responsibilities:

- | | |
|---------------------------------------|---------------------------------------|
| • Protect life and health | • Guide development |
| • Minimize property damage | • Protect floodplain function |
| • Ensure a functional drainage system | • Encourage economic development |
| • Protect water quality | • Protect and enhance the environment |
| • Protect drinking water supplies | • Improve quality of life |

In addition, a community may have a number of local priorities, such as fisheries or wetland protection, that are additional goals for the local stormwater program to address.

Objectives are then formed for each key program functional area keeping basic goals in mind. For example, a goal might be to protect streams such that they maintain their designated beneficial use standard. Objectives might involve floodplain acquisition, establishing buffer requirements, implementing a monitoring program, establishing a greenway master plan, etc. Written policies, regulations, etc. then grow out of these objectives.

3.2.3 Determining Program Components and Priorities

Once stormwater needs and requirements have been identified, and goals and objectives developed, a community can begin to formulate the activities that need to be undertaken. It is best to do this in two steps:

1. Develop overall stormwater program priorities in each of the key functional areas.
2. Then translate these priorities into actual program components with an implementation schedule.

Questions to ask include:

- 1) What should the major stormwater program priorities be in the next three to five years?
 - Priorities are developed to address program requirements and goals/objectives.
 - A special effort is made to identify specific opportunities to move in a more proactive direction rather than simply being reactive.
 - Efforts are made at anticipating future concerns not currently identified and plan for them.
- 2) How should these program priorities be translated into specific program changes or new program activities in terms of resources, manpower, and policy?
 - Specific program elements and/or changes are proposed.
 - A three to five year cost-of-service estimate is made to assess the ability of the local government to accomplish the program priorities under the program.
 - The needs of each program priority in terms of policy changes and tools required to implement the policy are also defined.

The various elements and activities that will be included in a local stormwater management program will vary depending on the needs, priorities and resources of the community in question. Section 3.1.2 at the beginning of this chapter and Table 3.2-1 below outline program elements that should be considered in a comprehensive program.

3.2.4 Organizing Program Structure and Staffing

The next step is to evaluate the current stormwater management activities within the community and determine how the planned program will be handled organizationally. This includes assessing current local programs and activities that may be applicable to the stormwater management program and determining which governmental department or agency will be assigned to a program element or task. The functions that need to be addressed for a stormwater management program can be divided into the following areas:

- General Administration
- Financial Management
- Stormwater Planning and Engineering
- Capital Improvements
- Operations and Maintenance
- Regulation and Enforcement

Table 3.2-1 can be used as an initial tool to help identify the operational or program functions needed. This table has divided a generic stormwater program into the six major functional areas reflecting the elements that may be included in the local stormwater management program and require financial and other resources. This chart can be used both as a starting point in a local community's assessment of its stormwater program, and as a tool to seek ways to improve the program and allocate resources and staff.

Table 3.2-1 Stormwater Management Functional Areas and Program Components

1. Administration

General Administration
Program Planning and Development
Personnel

Intra-local Coordination
Public Awareness and Involvement
State and Federal Regulation Compliance

2. Billing and Finance

Financial Management/Budgeting
Capital Outlay

Customer Service
Billing Operations (Stormwater Utility)

3. Stormwater Planning and Engineering

Stormwater and Watershed Master Planning
Development Requirements
Design Criteria & Standards
Development Plan Review / Approval
Field Data Collection
Stormwater Modeling

Design, Field and Ops Engineering
Hazard Mitigation
Retrofitting Program
Zoning Support
Multi-objective Planning Support
GIS and Database Management

4. Capital Improvements

Construction
Land Acquisition

Easements and Rights-of-Way
Structural Control Retrofits

5. Operations and Maintenance

General Routine and Remedial Maintenance
Emergency Response Maintenance
Street Maintenance Program

Spill Response and Clean Up
Infrastructure Management
Public Assistance

6. Regulation and Enforcement

Code Development & Enforcement
General Permit Administration
Drainage System Inspection
Drainage System Regulation
Development Site Inspections
Stormwater Monitoring Program

Specialized Inspection Programs
Zoning and Land Use Regulation
Flood Insurance Program
Floodplain Management
Sediment and Erosion Control Program
Illicit Connection & Illegal Dumping Program

Traditionally stormwater has been the concern of drainage engineers. However, comprehensive stormwater management is a multi-disciplinary management undertaking that also requires the expertise of urban planners, development specialists, transportation planners and engineers, water quality specialists, code inspectors, and many others. As such, stormwater responsibilities are often dispersed among several departments and/or organizations. These departments often work independently, and sometimes at cross purposes.

Some of the local government departments or agencies that may need to be part of the development and/or implementation of the stormwater management program and related policy include:

- Planning and Community Development
- Engineering
- Public Works

- Transportation / Streets
- Building / Code Enforcement
- Parks and Recreation
- Facilities and Fleet Management
- Water and Sewer Utilities
- Sanitation
- Police / Fire
- Legal
- Finance and Accounting

Table 3.2-2 shows an example of several stormwater program elements and the departments or agencies and staff members which might be responsible.

Table 3.2-2 Example of Stormwater Program Elements and Potentially Responsible Departments and Staff	
Review of Stormwater Management Plans	Development Department (engineers, planners) Engineering Department (engineers, technicians)
Stormwater Quality Monitoring	Water & Sewer Department (engineers, technicians, lab analysts) Health Department (scientists, lab analysts)
Site inspections	Development Department (inspectors, planners) Engineering Department (inspectors, engineers) Building Department (inspectors, engineers) Transportation Department (inspectors, engineers)
Maintenance of structural controls	Public Works Department (maintenance personnel) Transportation Department (engineers, maintenance personnel)

A community's options for organizing a stormwater management program can fall into one of three basic configurations:

- Organization within Another Department – This is a very common organizational structure for a local government. Typically, stormwater activities would be organized under an already existing agency or department such as public works, transportation or utilities department that has traditionally handled drainage issues.
- Stand-alone Organization – Some local government have established a fully functioning stormwater management department or agency that operates independently from other departments. Funding may come from an independent source such as a stormwater utility. These types of organizations typically have more latitude to issue revenue bonds and respond directly to many stormwater-related issues.
- Array or Multi-matrix Organization – Sometimes no formal stormwater entity exists within a local government. Instead, stormwater responsibilities are shared internally among several departments or agencies. This type of organization is typical of smaller cities and counties. Some communities may also choose to hire outside contractors to perform some services such as stormwater planning, plan review, engineering design or maintenance activities. These types of programs are typically funded by general revenues or impact/permit fees.

Whether a new stormwater management department is created or existing departments handle this program, a variety of staff expertise and interdepartmental coordination will be required. Development of a consensus between the various departments that provide stormwater management services in a community is an important consideration. Any process that shifts staff, budget and prestige between managers and departments, especially those that require reorganization, require careful attention to educating all levels of staff; directing and focusing managers who are increasing their department's size, budget and responsibilities; and placing managers who are losing staff and resources.

Since the need to organize stormwater programs rarely brings about a total governmental reorganization, communities can remedy the situation of an ineffective stormwater organization by the following methods:

- Forming an ad hoc staff committee to seek ways to work jointly and in coordination for all the various aspects and functions of the stormwater program;
- Reorganizing to the extent necessary to align programs which have primary stormwater duties;
- Assigning overall stormwater coordination duties at a level at which all authority comes together, often in the form of a stormwater manager; and
- Developing a stormwater policy and procedures manual in which all significant stormwater duties and actions are outlined (often with flowcharts) with defined authority, responsibility and procedures.

3.2.5 Funding the Program

The best designed stormwater management program will founder without sufficient community support and funding. Funding is required for both the formation and ongoing operation of a local stormwater program. In terms of the long-term operation of the program, the key funding issues are: (1) how much money is required to fund the program annually, and (2) how to support the program with a consistent and dedicated funding base.

In Georgia, general revenues from property taxes are typically the main funding source for local stormwater management activities. However, there are a number of alternative funding methods for stormwater management programs including the sale of bonds, development impact fees, the formation of local improvement districts, and the creation of stormwater user fee systems (also know as stormwater utilities). Each funding approach has its own advantages and limitations. These methods are discussed below and should be explored and assessed as to potential revenue, suitability and public acceptance.

General Fund

General appropriations are a traditional way of funding most government programs and services. The strongest advantage of general funding is that it represents a stable funding source from local taxes. The disadvantage is that stormwater activities must compete with other local programs and activities for limited funds. A government which elects to use its general fund may subject its stormwater operations to budget deliberations each fiscal year.

General Obligation Bonds

Debt financing of capital and operation and maintenance (O&M) costs can be accomplished through issuing general obligation bonds, revenue bonds, or a combination of the two. A bond issue requires voter approval on a referendum ballot and is subject to local administrative policy in the form of debt ceilings. Most stormwater project debt has been financed through issuance of 15-year term bonds. These bonds are repayable from service charge proceeds, general revenues and other sources (e.g. development fees), depending on the type of debt issued.

Development Impact Fees

The funding source involves the assessment of a development impact fee on developers of new projects with a proposed watershed system area. The project's total share of costs are determined not by the benefits received but by the impacts it creates in requiring new facilities and/or increased service levels. Development impact fees may be assessed as a permit or plan review fee. These are generally one-time fees, the revenues of which are used specifically to finance new stormwater facilities or other system components. While paid by the developer, these type of costs are typically passed onto the property owner.

A variation of the development impact or permit fee approach commonly used by small jurisdictions is the use of a private consultant to conduct plan reviews, construction inspections, and maintenance inspections. Using this scenario, the consultant would directly bill the developer for all services rendered. Ongoing maintenance inspections could be billed to the local jurisdiction. This type of arrangement typically results in a very low cost to the community for implementation.

Special Assessments / Tax Districts

A community may create special tax (or local improvement) districts to develop stormwater control systems. This approach is good in cases where capital improvements (or land acquisition), special studies and/or extraordinary maintenance benefits a specific area or number of properties within a jurisdiction. The result is that only those who benefit from the systems pay for them. Special districts function as quasi-municipal corporations created by law. As such, these districts have several funding options available: special taxes on property with the district area, development fees, user fees and, in some instances, debt financing. Creation of these districts requires voter approval. An alternative to creating these districts is to develop basin-specific user fees through a stormwater utility.

User Fees / Stormwater Utilities

A stormwater user fee system is a financing option that provides a stable and dedicated revenue source for stormwater management. User fees for stormwater management present an alternative to increased taxes or impact fees for the support of local program operations and maintenance, as well as the funding of other stormwater program activities. In a stormwater user fee system, stormwater infrastructure and programs are considered a public service or utility similar to wastewater and water programs that are funded on a similar basis.

Similar to water and wastewater rates, stormwater fees are assessed on users of the system based on average conditions for groups of customers with similar service requirements. Typically, fees are based on some measure of a property's impervious area. Rates may be assessed in charges per either equivalent dwelling unit (e.g. "x" dollars per EDU per month) or unit area (e.g. "x" dollars per 100 square feet per month). Alternative methodologies include the use of a runoff factor or coefficient based on the type or category of land use, a flat fee per customer, or a combination of any of these methods.

A stormwater utility operates similarly to water, sewer, or fire districts, which are funded through service fees and administered separately from the general tax fund, ensuring stable and adequate funding for these public services. Stormwater utilities have existed for a number of years in several states, but have only recently been used in Georgia.

A stormwater utility can provide a vehicle for:

- Consolidating or coordinating activities and responsibilities that were previously dispersed among several departments and divisions;
- Generating funding that is adequate, stable and equitable (as it is borne by the user on the basis of the user's demand placed on the stormwater system), and dedicated solely to stormwater management
- Developing programs that are comprehensive, cohesive and consistent year-to-year

Generally a community enacts two ordinances to create a stormwater utility, one to establish the various components of the utility and the other to determine the rate structure. Forming the utility through two separate ordinances allows the flexibility to alter the rate structure without having to revise the ordinance governing the basic structure of the utility. The first ordinance may also include a statement of the goals of the utility. The second ordinance tries to structure the service charges to create a logical and equitable relationship between the quantity of stormwater leaving a property, the benefits received by the stormwater system and the amount assessed.

The stormwater utility rate should be designed to defray the costs of the service provided by the municipality. It is important that there is an equitable relationship between the amount of stormwater generated by a given property, the benefit received by the ratepayer, and the corresponding fee assessed. Generally, case law suggests that a rate will be deemed valid where (1) the revenue generated benefits for the payers, primarily even if not exclusively, (2) the revenue is only used for the projects for which it was generated, (3) the revenue generated does not exceed the costs of the projects, and (4) the rate is uniformly applied among similarly situated properties.

Below are several features which should enhance its chances of surviving any legal challenge:

- Operation as a separate public utility (similar to a water or power utility)
- Detailed findings explaining why the project is needed to protect the public health, safety and welfare
- Revenues from fees are segregated and managed as a separate fund
- Fees are proportionate to the burden placed on the system by class of property
- Credits can be implemented
- Findings and resultant fees are based upon a professional analysis
- An appeal process is provided

Though they are not without significant administrative, political and potential legal hurdles, stormwater utilities are worth considering as a potential funding source for local stormwater management activities.

Table 3.2-3 provides a summary of the advantages and disadvantages of the various stormwater program funding approaches.

Table 3.2-3 Advantages and Disadvantages of Program Funding Approaches		
	<u>Advantages</u>	<u>Disadvantages</u>
General Fund	Short lead-time; ease of implementation. Capitalizes on existing resources; may be attached to public works, planning, other appropriate department. Existing funding base is known. If community-wide benefits realized, is a very equitable approach. May have more options available for funding capital projects; therefore, the cost of capital may be lower.	Initial capital outlays likely to require significant general fund withdrawal or tax increase. If funding levels increased through contributions from other programs/ departments, subject to budget deliberations each year. This may impede research and maintenance activities. If funding levels increased through taxes, subject to political sensitivity of raising raising taxes of those who may not benefit from improvements. Success dependent on general financial health of local government. Inflexible structure for setting funding priorities – funding may not be consistent with actual program needs.

Table 3.2-3 (continued)**General Obligation Bonds****Advantages**

Covers funding needs for significant time period.

Results in dedicated, known source of funds which may include funding for operating requirements.

May be linked to other projects (e.g., road improvements) to improve acceptability.

Disadvantages

Likely to require tax increase on all constituents, some of whom may not benefit from improvements.

Interest, dividend and issuance costs added to total costs for the life of payoff.

Not stable enough to support all O&M indefinitely. Unlikely to attract investors if not supplemented with other funding source(s).

Development Fees

Up-front fees provide immediate source of cash.

Fees for new projects tied to need for new facilities to support them.

May ultimately be less expensive to developer than installing individual facilities; therefore, may be acceptable.

If coupled with credit for work done by developer, provides incentive to mitigate impacts.

Works well for primarily large projects.

May be difficult to implement (general resistance to "impact" fees).

Careful rate design necessary. If O&M involved, funds should be earmarked for maintenance for facilities on their properties.

Only covers improvements necessitated by new development; therefore may not be appropriate for highly developed areas.

Those paying for improvements may not be within same basin as those benefiting.

Not steady enough to fund O&M indefinitely.

**Special Assessments/
Tax Districts**

Dedicated funding source. From legal and policy standpoint, may be best method of financing capital if benefits limited area.

Have authority to utilize variety of funding mechanisms: user charges, special property assessments, dev't fees, etc.

Likely to be short-term (additional assessments likely).

Those paying for improvements may not be within same basin as those benefiting.

Not easily understood by public

**User Fees/Stormwater
Utility**

Stable funding source allows accurate forecasting of revenues.

Link costs to damages avoided.

Fees likely to be low.

Dedicated funding source allows flexibility in setting funding priorities, long-term strategies.

Allows utility to differentiate rates based on varying levels of service, drainage basin, other specific features.

Rates create incentive to protect resource.

Dedicated funding source enhances ability to secure grant, bond monies for projects

Ease of implementation and administration highly dependent on establishing equitable, cost-based user fees.

Implementation, start-up time may be significant, depending on structure of public works or other existing department from which fees are administered.

Proven "track record" required to issue revenue bonds – may have to rely on other sources, or "pay-as-you-go" strategy for several years

Will require significant public education/support building efforts to gain acceptance for level of fees to cover requirements.

Administrative costs may be significant, depending on existing administrative resources

3.2.6 Implementing the Program

Once the framework for local stormwater management program has been established, it is important to develop a plan and schedule for implementing the program. A concerted effort should be made to inform the public of the community's stormwater management needs, of the fact that a plan of action for local stormwater management has been developed, and that all parties must share responsibility for solving the problems.

In developing stormwater policy tools and procedures, a local government should always make sure that any policy under consideration meets the following requirements:

- Have sufficient legal authority
- Be consistent with other guidance
- Be short, clear and to the point
- Have a sound technical basis
- Be properly staffed and provided financial resources
- Be backed by appropriate administrative procedures and technical support
- Be folded into the community with appropriate training and indoctrination
- Be strongly enforced

Implementation of a comprehensive stormwater management program is not a quick or painless process. It requires the commitment of the community, trained individuals and effective leadership to ensure that the program meets its long-term goals and objectives. Some of the elements of a “successful” stormwater management program include the following:

- Strong institutional motivation to act on the problem
- Political and/or grassroots support for action
- Skilled personnel
- Dedicated funding source
- An environment of institutional cooperation and a long-term commitment to work together
- Targeting strategy / process to maximize use of limited resources

3.2.7 Conclusion

Effective local stormwater management programs are built upon numerous institutional, economic and technical factors. Setting up a functional program requires outlining problems and goals, determining the required program components and priorities, identifying and obtaining stable funding, and implementing the program. Finally, it should be remembered that stormwater management solutions and programs must be tailored to each communities' particular circumstances and needs.

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IMPLEMENTING STORMWATER MANAGEMENT REQUIREMENTS FOR DEVELOPMENT

4.1 Overview

Adoption of a comprehensive and integrated set of stormwater management requirements for new development and redevelopment projects is one of the key components of a comprehensive local stormwater management program. Performance requirements and minimum standards for controlling runoff from development are critical to addressing both the water quantity and quality impacts of post-construction urban stormwater and are a required component of NPDES municipal stormwater programs.

Minimum stormwater management standards must also be supported by a set of design and management tools and an integrated design approach for implementing both structural and nonstructural stormwater controls. The following elements of a local toolbox for addressing development activities are described in this chapter:

- Stormwater Better Site Design – The first step in addressing stormwater management begins with the site planning and design process. The goal of better site design is to reduce the amount of runoff and pollutants that are generated from a development site and provide for some nonstructural on-site treatment and control of runoff by implementing a combination of approaches collectively known as *stormwater better site design practices*. These include maximizing the protection of natural features and resources, developing a site design which minimizes impact, reducing overall site imperviousness, and utilizing natural systems for stormwater management.
- Unified Stormwater Sizing Criteria – An integrated set of design criteria for stormwater quality and quantity management which addresses the entire range of hydrologic events. These criteria allows the site engineer to calculate the stormwater control volumes required for water quality, downstream channel protection, and overbank and extreme flood protection.
- Stormwater Credits for Better Site Design – A set of stormwater “credits” can be used to provide developers and site designers an incentive to implement better site design practices that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site. The credit system directly translates into cost savings to the developer by reducing the size of structural stormwater control and conveyance facilities.
- Downstream Assessments – Peak flow downstream assessments can be required to ensure that a proposed development is not adversely impacting downstream properties after the stormwater management requirements have been addressed. These assessments can also potentially be used to waive the need for detention for overbank and extreme flood control.
- Guidance on Structural Stormwater Controls – This Manual recommends a set of structural stormwater controls that can be used to meet stormwater management water quantity and quality goals. Specific technical guidance on how to select, size, design, construct and maintain structural controls (as provided in Volume 2) must be provided by a community in requiring the use of structural measures.

- **Stormwater Management Site Plans** – Communities can require the preparation of a *stormwater management site plan* for development activities. A stormwater site plan is a comprehensive report that contains the technical information and analysis to allow a local review authority to determine whether a proposed new development or redevelopment project meets the local stormwater regulatory requirements.

Figure 4.1-1 illustrates how these design tools would be used in the development process to address the local stormwater management requirements.

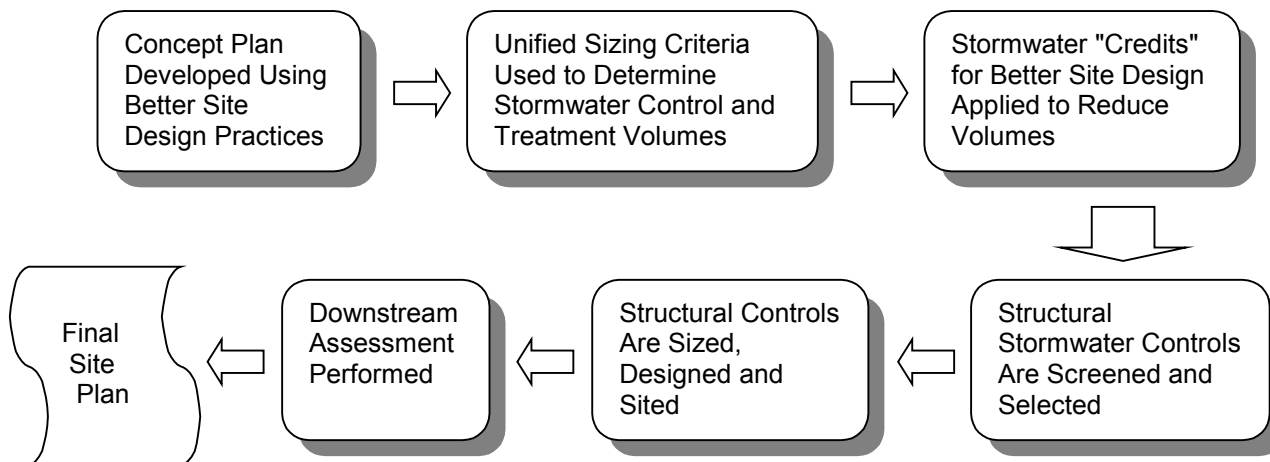


Figure 4.1-1 Typical Stormwater Management System Design Process

4.2 Minimum Standards for Development

4.2.1 Introduction

This section presents a comprehensive set of minimum performance standards for stormwater management for development activities. These recommended standards provide Georgia communities with an integrated approach to address both the water quality and quantity problems associated with stormwater runoff due to urban development. They are designed to assist local governments in complying with regulatory and programmatic requirements for various state and Federal programs including the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit program and the National Flood Insurance Program under FEMA.

These minimum standards are ideally built into a community's development ordinances and supported by the plan review process. They may be adopted by local jurisdictions as stormwater management development requirements and/or may be modified to meet local or watershed-specific stormwater management goals and objectives.

The goal of stormwater management requirements for areas of new development and significant redevelopment is to reduce the impact of post-construction stormwater runoff on the watershed. This can be achieved by (1) maximizing the use of site design and nonstructural methods to reduce the generation of runoff and pollutants; (2) managing and treating stormwater runoff through the use of structural stormwater controls; and (3) implementing pollution prevention practices to limit potential stormwater contaminants. The minimum stormwater management standards presented here incorporate these concepts and cover the entire cycle of development from site planning through long-term maintenance of stormwater management facilities.

4.2.2 Applicability

It is recommended that the stormwater management standards listed below be required for any new development and redevelopment site that meets one or more of the following criteria:

- (1) New development that includes the creation or addition of 5,000 square feet or greater of new impervious surface area, or that involves land disturbing activity of 5,000 square feet of land or greater.
- (2) Redevelopment that includes the creation or addition of 5,000 square feet or greater of new impervious surface area, or that involves land disturbing activity of 1 acre or more.
- (3) Any commercial or industrial new development or redevelopment, regardless of size, with a Standard Industrial Classification (SIC) code that falls under the NPDES Industrial Stormwater Permit program, or a hotspot land use as defined below.

In addition, redevelopment sites that involve land disturbing activity of 5,000 square feet or greater, but less than 1 acre, are required to meet Minimum Standard 8 (to meet state and NPDES construction erosion and sediment control requirements) and should be required to meet Minimum Standards 2, 9 and 10 to the maximum extent practicable.

Definitions

New development is defined as land disturbing activities, structural development (construction, installation or expansion of a building or other structure), and/or creation of impervious surfaces on a previously undeveloped site.

Redevelopment is defined as structural development (construction, installation or expansion of a building or other structure), creation or addition of impervious surfaces, replacement of impervious surface not part of routine maintenance, and land disturbing activities associated with structural or impervious development. Redevelopment does not include such activities as exterior remodeling.

A *hotspot* is defined as a land use or activity on a site that produces higher concentrations of trace metals, hydrocarbons or other priority pollutants than are normally found in urban stormwater runoff. Examples of hotspots include gas stations, vehicle service and maintenance areas, salvage yards, material storage sites, garbage transfer facilities, and commercial parking lots with high-intensity use.

Exemptions

The following development activities are suggested to be exempted from the minimum stormwater management standards:

- (1) Developments that do not disturb more than 5,000 square feet of land;
- (2) Individual single family residential lots. (Single family lots that are part of a subdivision or phased development project should not be exempt from the minimum standards); and
- (3) Additions or modifications to existing single-family structures

Additional Requirements

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. Furthermore, these sites may need to utilize or restrict certain structural controls in order to protect a special resource or address certain water quality or drainage problems identified for a drainage area.

4.2.3 Minimum Stormwater Management Standards

The following standards are the recommended minimum stormwater management performance requirements for new development or redevelopment sites falling under the applicability criteria above.

(The word “shall” in brackets is provided for local jurisdictions that wish to adopt these standards as part of their stormwater management ordinances)

A detailed technical explanation of each minimum standard is provided in Volume 2, Section 1.2.

❑ **Minimum Standard #1 – Use of Better Site Design Practices for Stormwater Management**

Site designs should preserve the natural drainage and treatment systems and reduce the generation of additional stormwater runoff and pollutants to the fullest extent practicable.

❑ **Minimum Standard #2 – Stormwater Runoff Quality**

All stormwater runoff generated from a site should [shall] be adequately treated before discharge. Stormwater management systems (which can include both structural stormwater controls and better site design practices) should [must] be designed to remove 80% of the average annual post-development total suspended solids (TSS) load and be able to meet any other additional watershed- or site-specific water quality requirements.

It is presumed that a stormwater management system complies with this performance standard if:

- It is sized to capture and treat the prescribed water quality treatment volume, which is defined as the runoff volume resulting from the first 1.2 inches of rainfall from a site; and
- Appropriate structural stormwater controls are selected, designed, constructed, and maintained according to the specific criteria in this Manual.
- Runoff from hotspot land uses and activities is adequately treated and addressed through the use of appropriate structural stormwater controls and pollution prevention practices.

❑ **Minimum Standard #3 – Stream Channel Protection**

Stream channel protection should [shall] be provided by using all of the following three approaches: (1) 24-hour extended detention storage of the 1-year, 24-hour return frequency storm event; (2) erosion prevention measures such as energy dissipation and velocity control; and (3) preservation of the applicable stream buffer.

❑ **Minimum Standard #4 – Overbank Flood Protection**

Downstream overbank flood protection should [shall] be provided by controlling the post-development peak discharge rate to the predevelopment rate for the 25-year, 24-hour return frequency storm event. If control of the 1-year, 24-hour storm (Minimum Standard #3) is exempted, then overbank flood protection should [shall] be provided by controlling the post-development peak discharge rate to the predevelopment rate for the 2-year through the 25-year return frequency storm events.

❑ **Minimum Standard #5 – Extreme Flood Protection**

Extreme flood protection should [shall] be provided by controlling and/or safely conveying the 100-year, 24 hour return frequency storm event such that flooding is not exacerbated. Existing and future floodplain areas should be preserved as possible.

❑ **Minimum Standard #6 – Downstream Analysis**

A downstream hydrologic analysis should [shall] be performed to determine if there are any additional impacts in terms of peak flow increase or downstream flooding while meeting Minimum Standards #1 through 5. This analysis should [shall] be performed at the outlet(s) of the site, and downstream at each tributary junction to the point(s) in the conveyance system where the area of the portion of the site draining into the system is less than or equal to 10% of the total drainage area above that point.

❑ **Minimum Standard #7 – Groundwater Recharge**

Annual groundwater recharge rates should be maintained to the extent practicable through the use of nonstructural methods.

❑ **Minimum Standard #8 – Construction Erosion and Sedimentation Control**

Erosion and sedimentation control practices shall be utilized during the construction phase or during any land disturbing activities.

❑ **Minimum Standard #9 – Stormwater Management System Operation and Maintenance**

The stormwater management system, including all structural stormwater controls and conveyances, should [shall] have an operation and maintenance plan to ensure that it continues to function as designed.

❑ **Minimum Standard #10 – Pollution Prevention**

To the maximum extent practicable, the development project should [shall] implement pollutant prevention practices and have a stormwater pollution prevention plan.

❑ **Minimum Standard #11 – Stormwater Management Site Plan**

The development project should [shall] prepare a stormwater management site plan for local government review that addresses Minimum Standards #1 through 10.

4.3 Stormwater Better Site Design Practices

4.3.1 Introduction

The first step in addressing stormwater management begins with the site planning and design process. Development projects can be designed to reduce their impact on watersheds when careful efforts are made to conserve natural areas, reduce impervious cover and better integrate stormwater treatment. By promoting a combination of these nonstructural approaches collectively known as *stormwater better site design practices*, a community can help developers reduce the amount of runoff and pollutants that are generated from a development or redevelopment site and provide for some nonstructural on-site treatment and control of runoff. The goals of better site design include:

- Managing stormwater (quantity and quality) as close to the point of origin as possible and minimizing collection and conveyance
- Preventing stormwater impacts rather than mitigating them
- Utilizing simple, nonstructural methods for stormwater management that are lower cost and lower maintenance than structural controls
- Creating a multifunctional landscape
- Using hydrology as a framework for site design

Better site design for stormwater management includes a number of site design techniques such as preserving natural features and resources, effectively laying out the site elements to reduce impact, reducing the amount of impervious surfaces, and utilizing natural features on the site for stormwater management. The aim is to reduce the environmental impact “footprint” of the site while retaining and enhancing the owner/developer’s purpose and vision for the site. Many of the better site design concepts can reduce the cost of infrastructure while maintaining or even increasing the value of the property.

Better site design concepts can be viewed as both water quantity and water quality management tools and can reduce the size and cost of required structural stormwater controls—sometimes eliminating the need for them entirely. The site design approach can result in a more natural and cost-effective stormwater management system that better mimics the natural hydrologic conditions of the site, has a lower maintenance burden and provides for more sustainability.

4.3.2 Suite of Stormwater Better Site Design Practices

Listed below are the stormwater better site design practices and techniques recommended in this Manual. Each of the practices listed here are covered in more detail with examples in Volume 2, Section 1.5. Figures 4.3-1 and 4.3-2 illustrate the use of some of these better site design principles for a residential and office park example, respectively.

Conservation of Natural Features and Resources

The first step in the better site design process is to identify and preserve the natural features and resources that can be used in the protection of water resources by reducing stormwater runoff, providing runoff storage, reducing flooding, preventing soil erosion, promoting infiltration, and removing stormwater pollutants. Some of the natural features that should be taken into account include:

- Areas of undisturbed vegetation
- Floodplains and riparian areas
- Ridgetops and steep slopes
- Natural drainage pathways
- Intermittent and perennial streams
- Aquifers and recharge areas
- Wetlands
- Soils
- Other natural features or critical areas

Delineation of natural features is typically done through a comprehensive site analysis and inventory before any site layout design is performed. Approaches that should be followed in conserving natural features and resources include:

- Preserving Undisturbed Natural Areas
- Preserving Riparian Buffers
- Avoiding Floodplains
- Avoiding Steep Slopes
- Minimizing Siting on Porous or Erodible Soils

Lower Impact Site Design Techniques

After conservation areas have been delineated, there are additional opportunities in the preliminary stages of a site design for avoiding downstream impacts from the development. These primarily deal with the location and configuration of lots or structures on the site and include the following recommendations and options:

- Fitting the Design to the Terrain
- Reducing the Limits of Clearing and Grading
- Locating Development in Less Sensitive Areas
- Utilizing Open Space Development and/or Nontraditional Lot Designs for Residential Areas
- Considering Creative Development Design

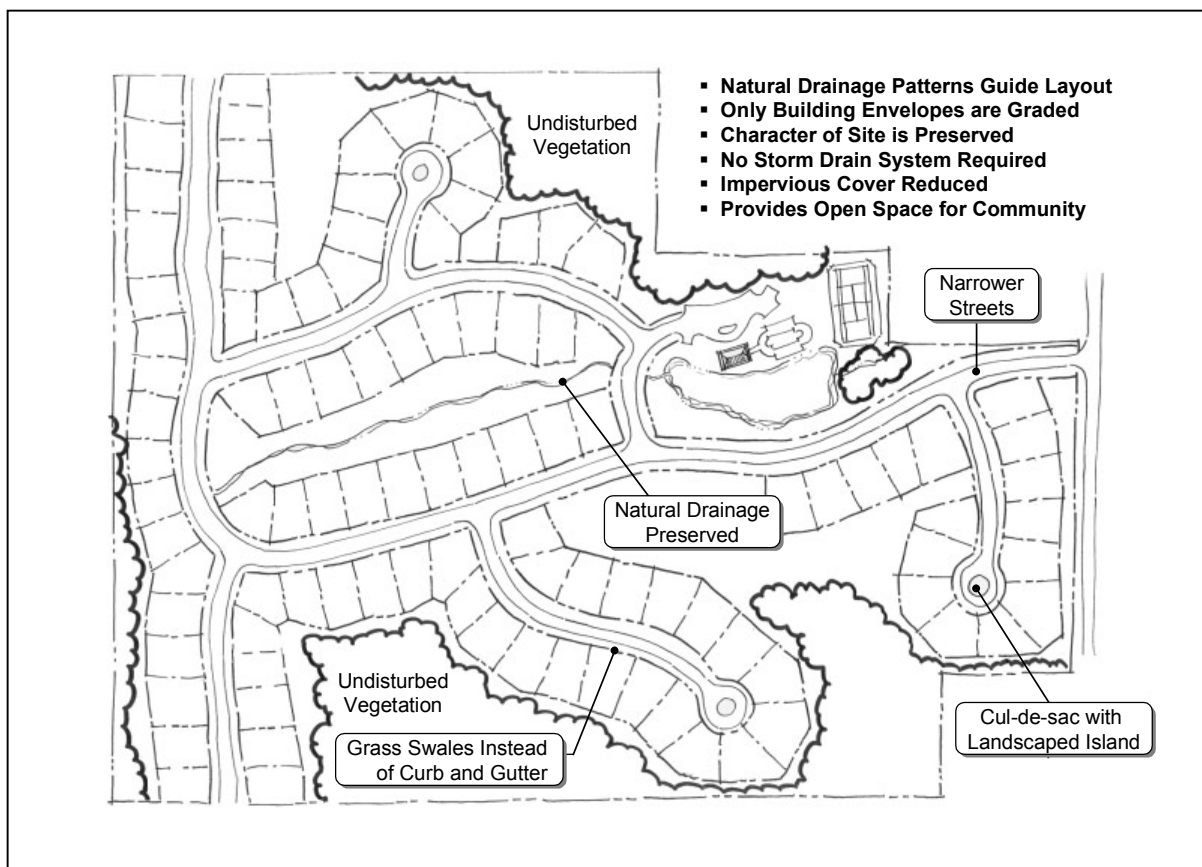
Reduction of Impervious Cover

Reducing the area of total impervious surface on a site directly reduces the volume of stormwater runoff and associated pollutants that are generated. It can also reduce the size and cost of necessary infrastructure. Some of the ways that impervious cover can be reduced in a development include:

- Reducing Roadway Lengths
- Reducing Roadway Widths
- Reducing the Footprint of Buildings
- Reducing the Parking Footprint
- Reducing Setbacks and Frontages
- Fewer or Alternative Cul-de-sacs



Figure 4.3-1 Comparison of a Traditional Residential Subdivision Design (above) and an Innovative Site Plan Developed Using Better Site Design Practices (below).



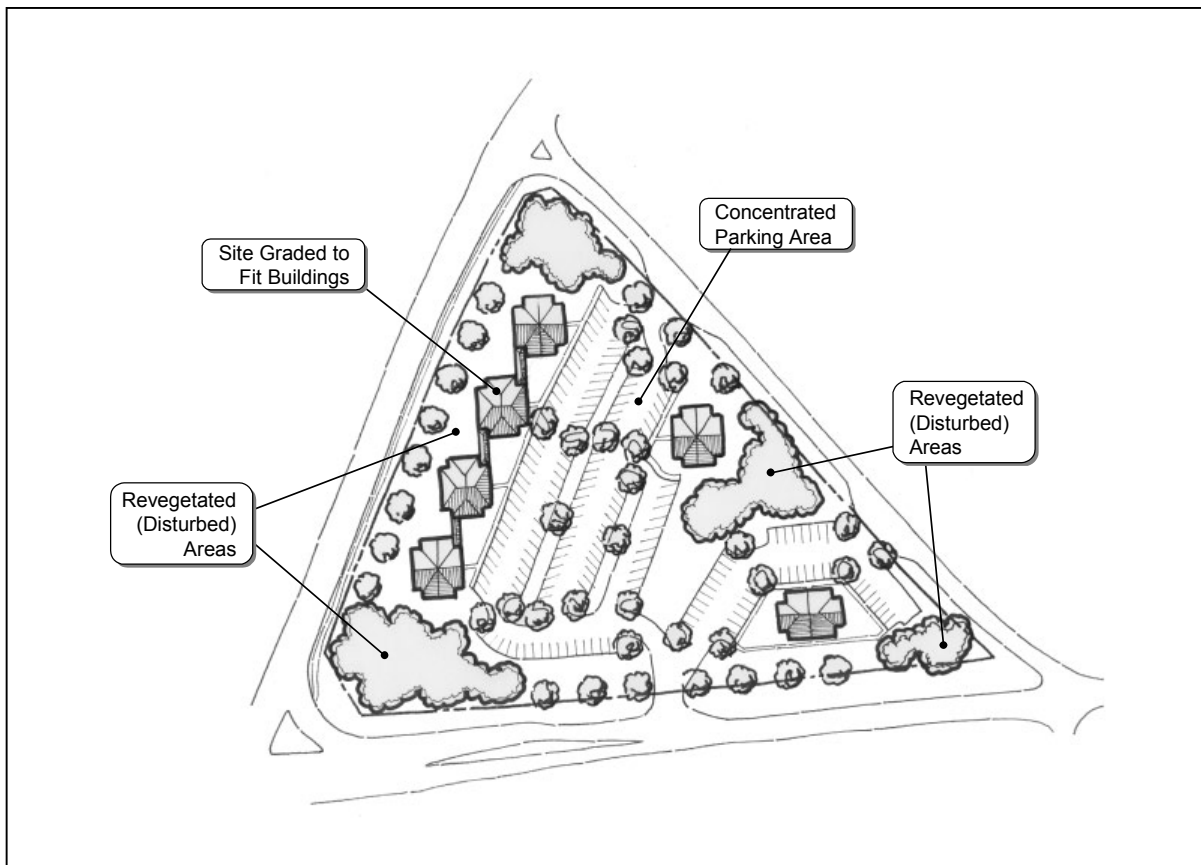
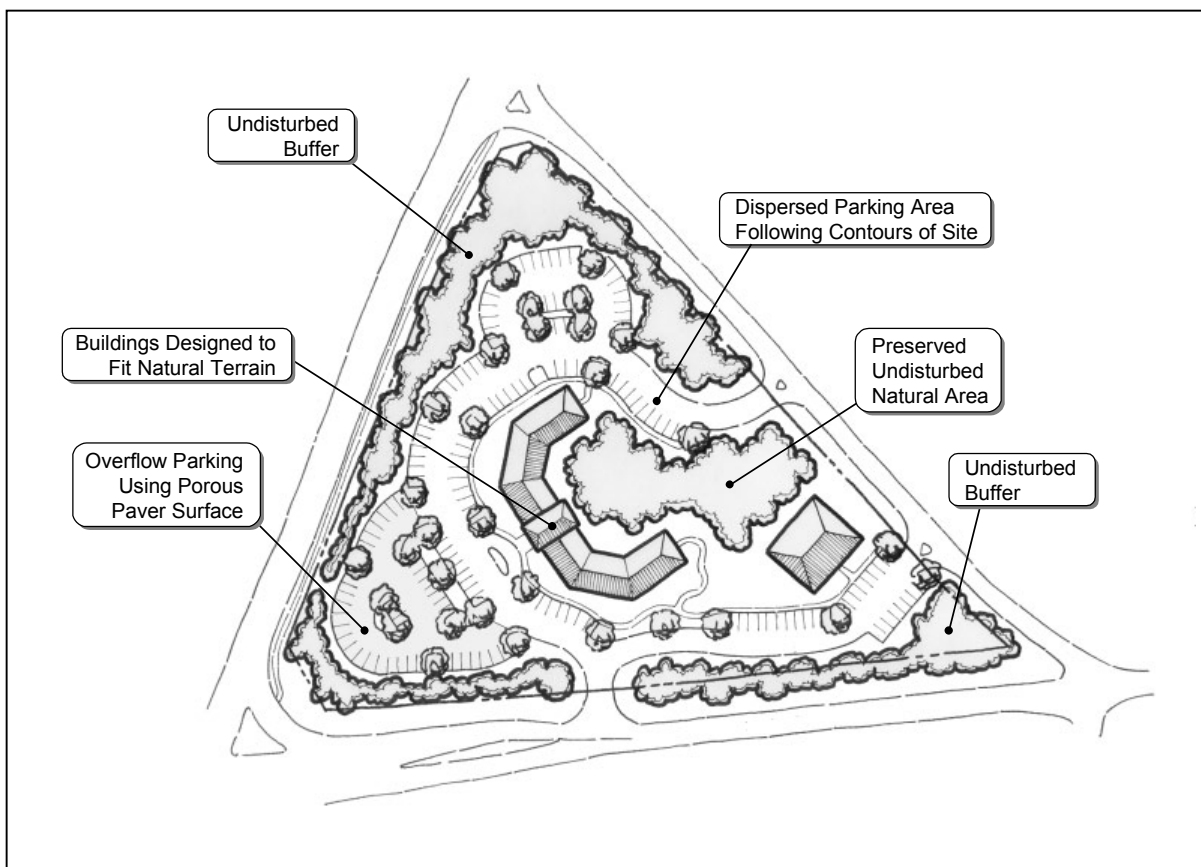


Figure 4.3-2 Comparison of a Traditional Office Park Design (above) and an Innovative Site Plan Developed Using Better Site Design Practices (below).



Utilization of Natural Features for Stormwater Management

Traditional stormwater drainage design tends to ignore and replace natural drainage patterns and often results in overly efficient hydraulic conveyance systems. Structural stormwater controls are costly and often can require high levels of maintenance for optimal operation. Through use of natural site features and drainage systems, careful site design can reduce the need and size of structural conveyance systems and controls. Some of the methods of incorporating natural features into an overall stormwater management site plan include the following:

- Using Buffers and Undisturbed Areas
- Using Natural Drainageways Instead of Storm Sewer Systems
- Use Vegetated Swales Instead of Curb and Gutter
- Draining Runoff to Pervious Areas

4.3.3 Implementing Stormwater Better Site Design

Communities should actively promote the use of stormwater better site design as a way to both protect watersheds and water resources, and implement cost-effective and lower maintenance stormwater management. However, in order to make better site design a reality, local jurisdictions will often need to review their regulations, development rules, community plans and review procedures to ensure that they support the better site design concepts outlined above.

Often, communities have in place development rules that work against better site design and create needless impervious cover and unnecessary environmental impact. Examples include the minimum parking ratios that many communities require for retail or commercial development and zoning restrictions that limit cluster development designs. Some of the policy instruments that need to be reviewed for compatibility with the better site design principles include:

- Zoning Ordinances and Procedures
- Subdivision Codes
- Stormwater Management or Drainage Criteria
- Tree Protection or Landscaping Ordinance
- Buffer and Floodplain Regulations
- Erosion and Sediment Control Ordinance
- Grading Ordinance
- Street Standards or Road Design Manual
- Parking Requirements
- Building and Fire Regulations and Standards
- Septic/Sanitary Sewer Regulations
- Local Comprehensive Plan

Below is a set of questions that can be used to review a community's local development codes and ordinances with the goal of making it easier to implement stormwater better site design. The questions are organized by better site design category.

Table 4.3-1 Questionnaire for Reviewing Local Development Regulations to Evaluate Compatibility with Stormwater Better Site Design Practices

Conservation of Natural Features and Resources	Land Conservation Incentives • Does the community have a viable greenspace program? • Are there any incentives to developers or landowners to preserve non-regulated land in a natural state (density bonuses, conservation easements, stormwater credits or lower property tax rates)?
	Natural Area Conservation • Is there an ordinance or requirements for the preservation of natural vegetation on development sites?

Table 4.3-1 continued

Conservation of Natural Features and Resources (continued)	Tree Conservation Does the community have a tree protection ordinance?
	Stream Buffers - Is there a stream buffer ordinance in the community that provides for greater buffer requirements than the state minimums? - Do the stream buffer requirements include lakes, freshwater wetlands, or steep slopes? - Do the stream buffer requirements specify that at least part of the buffer be maintained with undisturbed vegetation?
	Floodplains Does the community restrict or discourage development in the full buildout 100-year floodplain?
	Steep Slopes Does the community restrict or discourage building on steep slopes?
Lower Impact Site Designs	Fitting Site Designs to the Terrain Does the community provide preconsultation meetings, joint site visits, or technical assistance with site plans to help developers best fit their design concepts to the topography of the site and protect key site resources?
	Clearing and Grading Are there development requirements that limit the amount of land that can be cleared in a multi-phase project?
	Locating Development in Less Sensitive Areas Does the community actively try to plan and zone to keep development out of environmental sensitive areas?
	Open Space Development - Are open space or cluster development designs allowed? - Are the submittal or review requirements for open space designs greater than those for conventional development? - Are flexible site design criteria (e.g. setbacks, road widths, lot sizes) available for developers who utilize open space or cluster design approaches? - Does a minimum percentage of the open space have to be managed in an undisturbed natural condition? - Does the community have enforceable requirements to establish associations that can effectively manage open space?
	Nontraditional Lot Designs Are nontraditional lot designs and shapes allowed?
	Creative Development Design Does the community allow and/or promote Planned Unit Developments (PUD's) which give the developer or site designer additional flexibility in site design?
Reduction of Impervious Cover	Roadway Length Do road and street standards promote the most efficient site and street layouts that reduce overall street length?
	Roadway Width What is the minimum pavement width allowed for streets in low density residential developments that have less than 500 average daily trips (ADT)?
	Building Footprint Does the community provide options for taller buildings and structures which can reduce the overall impervious footprint of a development?

Table 4.3-1 continued

Reduction of Impervious Cover (continued)	Parking Footprint • What is the minimum parking ratio for a professional office building (per 1000 ft² of gross floor area)? • What is the minimum parking ratio for shopping centers (per 1000 ft² of gross floor area)? • What is the minimum required parking ratio for single family homes? • If mass transit is provided nearby, are parking ratios reduced? • What is the minimum stall width for a standard parking space? • What is the minimum stall length for a standard parking space? • Are at least 30% of the spaces at larger commercial parking lots required to have smaller dimensions for compact cars? • Is the use of shared parking arrangements promoted? • Are there any incentives to developers to provide parking within structured decks or ramps rather than surface parking lots? • Can porous surfaces be used for overflow parking areas? • Is a minimum percentage of a parking lot required to be landscaped? • Is the use of bioretention islands and other structural control practices within landscaped areas or setbacks allowed?
	Setbacks and Frontages • What is the minimum requirement for front, rear and side setbacks for a one-half acre residential lot? • What is the minimum frontage distance for a one-half acre residential lot?
	Alternative Cul-de-sacs • What is the minimum radius allowed for cul-de-sacs? • Can a landscaped island be created within a cul-de-sac? • Are alternative turnarounds such as "hammerheads" allowed on short streets in low density residential neighborhoods?
	Utilization of Natural Features for Stormwater Management
	Using Buffers and Undisturbed Areas • Are requirements in place and guidance provided in using level spreaders to promote sheet flow of runoff across buffers and natural areas?
	Using Natural Drainageways • Are storm sewer systems required for all new developments? Are natural systems allowed?
	Using Vegetated Swales • Are curb and gutters required for residential street sections? • Are there design standards for the use of vegetated swales instead of curb and gutter?
	Rooftop Runoff • Can rooftop runoff be permanently designed to discharge to pervious yard areas? • Do current grading or drainage requirements allow for temporary ponding of runoff on lawns or rooftops?

The publication "*Better Site Design: A Handbook for Changing Development Rules in Your Community*" from the Center for Watershed Protection (www.cwp.org) provides additional guidance on implementing better site design practices.

4.4 Unified Stormwater Sizing Criteria

4.4.1 Introduction

This section presents an integrated approach for meeting the stormwater runoff quality and quantity management requirements found in the minimum standards for development (see section 4.2) by addressing the key adverse impacts of stormwater runoff from a development site. The purpose is to provide a framework for designing a stormwater management system to:

- Remove stormwater runoff pollutants and improve water quality (Minimum Standard #2);
- Prevent downstream streambank and channel erosion (Minimum Standard #3);
- Reduce downstream overbank flooding (Minimum Standard #4); and
- Safely pass or reduce the runoff from extreme storm events (Minimum Standard #5)

The *Unified Stormwater Sizing Criteria* is an integrated set of criteria or design standards that allow the site engineer to size and design structural stormwater controls to address all of these objectives. There are four criteria, one for each of the goals above, which are summarized in Table 4.4-1 below.

Table 4.4-1 Summary of the Statewide Stormwater Sizing Criteria for Stormwater Control and Mitigation	
<u>Sizing Criteria</u>	<u>Description</u>
Water Quality	Treat the runoff from 85% of the storms that occur in an average year. For Georgia, this equates to providing water quality treatment for the runoff resulting from a rainfall depth of 1.2 inches. Reduce average annual post-development total suspended solids loadings by 80%.
Channel Protection	Provide extended detention of the 1-year storm event released over a period of 24 hours to reduce bankfull flows and protect downstream channels from erosive velocities and unstable conditions.
Overbank Flood Protection	Provide peak discharge control of the 25-year storm event such that the post-development peak rate does not exceed the predevelopment rate to reduce overbank flooding.
Extreme Flood Protection	Evaluate the effects of the 100-year storm on the stormwater management system, adjacent property, and downstream facilities and property. Manage the impacts of the extreme storm event through detention controls and/or floodplain management.

Each of the unified stormwater sizing criteria are intended to be used in conjunction with the others to address the overall stormwater impacts from a development site. When used as a set, the unified criteria control the entire range of hydrologic events, from the smallest runoff producing rainfalls to the 100-year storm. Figure 4.4-1 graphically illustrates the relative volume requirements of each of the unified stormwater sizing criteria as well as demonstrates that the criteria are "stacked" upon one another, i.e., the extreme flood protection volume requirement also contains the overbank flood protection volume, the channel protection volume and the water quality treatment volume.

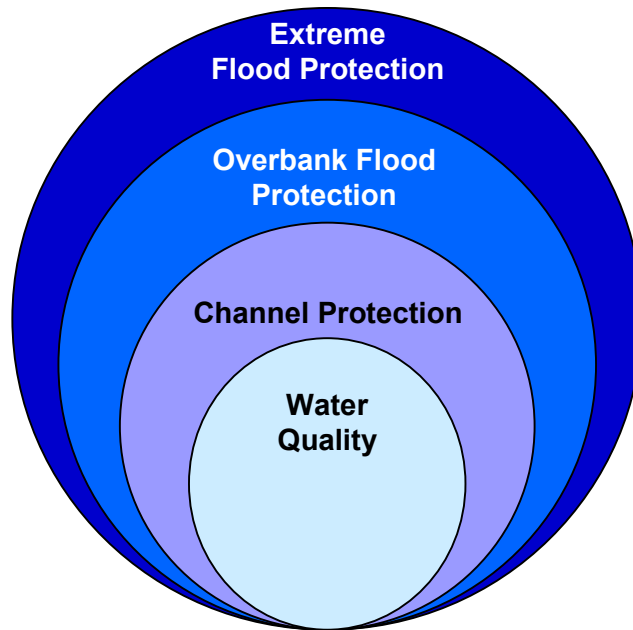


Figure 4.4-1 Representation of the Unified Stormwater Sizing Criteria

The following sections describe each of the four unified stormwater sizing criteria in more detail.

4.4.2 Water Quality (WQ_v)

Hydrologic studies show that small-sized, frequently occurring storms account for the majority of rainfall events that generate stormwater runoff. Consequently, the runoff from these storms also accounts for a major portion of the annual pollutant loadings. Therefore, by treating these frequently occurring smaller rainfall events and a portion of the stormwater runoff from larger events, it is possible to effectively mitigate the water quality impacts from a developed area.

A water quality treatment volume is specified to size structural control facilities to treat these small storms up to a maximum runoff depth and the "first flush" of all larger storm events. For Georgia, this maximum depth was determined to be the runoff generated from the 85th percentile storm event (i.e., the storm event that is greater than 85% of the storms that occur within an average year).

Based on a rainfall analysis, a value of 1.2 inches for the 85th percentile storm was selected as an average for the entire state. Thus, the statewide Water Quality Volume (WQ_v) criterion is equal to the runoff from the first 1.2 inches of rainfall. A stormwater management system designed for the WQ_v will treat the runoff from all storm events of 1.2 inches or less, as well as the first 1.2 inches of runoff for all larger storm events. The Water Quality volume is directly related to the amount of impervious cover and is calculated using the formula below:

$$WQ_v = \frac{1.2R_vA}{12}$$

where: WQ_v = water quality volume (in acre-feet)
 R_v = 0.05 + 0.009(I) where I is percent impervious cover
 A = site area in acres

TSS Reduction Goal

The recommended approach to meeting local NPDES requirements of removing stormwater pollutants to the “maximum extent practicable” is through the use of a percentage removal performance goal. This Manual adopts the goal of treating the WQ_v from a site to reduce post-development total suspended solids (TSS) loadings by 80%, as measured on an average annual basis. This performance goal is based upon U.S. Environmental Protection Agency (EPA) guidance and has been adopted nationwide by many local and statewide agencies.

TSS was chosen as the representative stormwater pollutant for measuring treatment effectiveness for several reasons:

1. The use of TSS as an “indicator” pollutant is well established.
2. Sediment and turbidity, as well as other pollutants of concern that adhere to suspended solids, are a major source of water quality impairment due to urban development in Georgia watersheds.
3. A large fraction of many other pollutants of concern are either removed along with TSS, or at rates proportional to the TSS removal.
4. The 80% TSS removal level is reasonably attainable using well-designed structural stormwater controls (for typical ranges of TSS concentration found in stormwater runoff).

TSS is a good indicator for many stormwater pollutants. However, the removal performance for pollutants that are soluble or that cannot be removed by settling will vary depending on the structural control practice. For pollutants of specific concern, individual analyses of specific pollutant sources and the appropriate removal mechanisms should be performed.

It is recommended that treatment of the WQ_v be provided at all developments where stormwater management is mandatory. Further explanation of the Water Quality Volume and how it is calculated for various situations can found in Volume 2.

4.4.3 Channel Protection (CP_v)

The increase in the frequency and duration of bankfull flow conditions in stream channels due to urban development is the primary cause of streambank erosion and the widening and downcutting of stream channels. Therefore, channel erosion downstream of a development site can be significantly reduced by storing and releasing stormwater runoff from the channel-forming runoff events (which corresponds approximately to the 1-year storm event) in a gradual manner to ensure that critical erosive velocities and flow volumes are not exceeded.

The Channel Protection sizing criterion specifies that 24 hours of extended detention be provided for runoff generated by the 1-year, 24-hour rainfall event to protect downstream channels. The required volume needed for 1-year extended detention, or Channel Protection Volume (denoted CP_v), is roughly equivalent to the required volume needed for peak discharge control of the 5- to 10-year storm.

The reduction in the frequency and duration of bankfull flows through the extended detention of the CP_v is presumed to reduce the bank scour rate and severity. Therefore, these criteria should be applied wherever upstream development can increase the natural flows to downstream feeder streams, channels, ditches and small streams. It might be waived by a community for sites that discharge directly into larger streams, rivers, wetlands, lakes, or estuaries where the reduction in the smaller flows will not have significant impact on streambank or channel integrity.

This criterion should be paired with an effective streambank inspection and restoration program designed to identify and protect any locations where erosion occurs, through the use of bio-engineering and other streambank protection and stabilization techniques.

The procedure for determining the CP_v as well as additional information on its application under specific circumstances is provided in Volume 2.

4.4.4 Overbank Flood Protection (Q_{p25})

The purpose of overbank flood protection is to prevent an increase in the frequency and magnitude of damaging out-of-bank flooding (i.e. flow events that exceed the capacity of the channel and enter the floodplain). It is intended to protect downstream properties from flooding at middle-frequency storm events.

The Overbank Flood Protection criterion specifies that the post-development 25-year, 24-hour storm peak discharge rate (denoted Q_{p25}) not exceed the pre-development (or undisturbed natural conditions) discharge rate. This is achieved through detention of runoff from the 25-year event. Smaller storm events (e.g., 2-year and 10-year) are effectively controlled through the combination of the extended detention for the 1-year event (channel protection CP_v control) and the control of Q_{p25} for overbank channel protection. In addition, larger storms (> 25-year) are partially attenuated through the control of Q_{p25} .

Note: Control of Q_{p25} is not intended to serve as a stand-alone design standard, but is intended to be used in conjunction with the channel protection AND extreme flood protection criteria. If detention is designed for only the 25-year storm, smaller runoff events will simply pass through the outlet structure with little attenuation. Therefore, if the channel protection criterion is not used, then peak flow attenuation of the 2-year (Q_{p2}) through the 25-year (Q_{p25}) return frequency storm events should be required by the community.

This criterion may be adjusted by a local jurisdiction for areas where all downstream conveyances are designed to handle runoff from the full build-out 25-year storm, or where it can be demonstrated that no downstream flooding will occur as a result of a proposed development, potentially through the use of a downstream analysis (see section 4.6). In this case, the overbank flood protection criterion may be waived by a local jurisdiction in lieu of provision of safe and effective conveyance to a major river system, lake, wetland, estuary, or tidal waters that have capacity to handle flow increases at the 25-year level.

The procedure for determining Q_{p25} as well as additional information on its application under specific circumstances is provided in Volume 2.

4.4.5 Extreme Flood Protection (Q_f)

The intent of the extreme flood protection is to prevent flood damage from infrequent but large storm events, maintain the boundaries of the mapped 100-year floodplain, and protect the physical integrity of the structural stormwater controls as well as downstream stormwater and flood control facilities.

The Extreme Flood Protection criterion specifies that all stormwater management facilities be designed to safely handle the runoff from the 100-year, 24-hour return frequency storm event, (denoted Q_f). There are two basic approaches to employ this criterion in a community:

- (1) Require control of Q_f through on-site or regional structural stormwater controls to maintain the existing 100-year floodplain. This is done where residences or other structures have already been constructed within the 100-year floodplain fringe area; or
- (2) Require that the on-site conveyance system be designed to safely pass Q_f and allow it to discharge into a receiving water whose protected full buildout floodplain is sufficiently sized to account for extreme flow increases without causing damage.

The first approach attempts to maintain the existing 100-year floodplain through the use of structural controls to mitigate Q_f . This approach might be used when residences or other structures have already been constructed within the 100-year floodplain fringe area, and growth in the width of the floodplain due to upstream development would be undesirable. In this case the 100-year storm must be controlled through the use of flow controls (regional and on-site detention) and, as a last resort, local flood protection (levees, floodwalls, floodproofing, etc.) and/or channel enlargements. Stormwater master plans are a necessity to attempt to insure public safety for the extreme storm event.

The second approach attempts to keep flood-susceptible development out of the full buildout floodplain through a combination of regulatory controls, stormwater master planning, and incentives. This approach recognizes that the impacts of new development might not be able to be completely mitigated at the extreme flood level and provides a much greater assurance that local flooding will not be a problem, because people and structures are kept out of harm's way.

Under (1) the design criteria for storage facilities must include the 100-year storm. Under (2), it may be possible to waive on-site control of Q_f if the downstream flow conveyance and floodplain can handle the increase through provision of expanded floodplain areas.

It is recommended that during stormwater system design that Q_f be routed through the drainage system and stormwater management facilities to determine the effects on the facilities, adjacent property, and downstream areas. Emergency spillways of structural controls should be designed appropriately to safely pass the resulting flows.

Additional information on the Q_f criterion and its application is provided in Volume 2.

4.4.6 Incorporating the Unified Stormwater Sizing Criteria Into Development Requirements

The unified stormwater sizing criteria are engineering performance criteria for controlling and treating stormwater runoff from post-construction development. These criteria directly correspond to the requirements found in the Minimum Stormwater Management Standards #2 through #5. As such, they need to be included in a community's development regulations, ideally in a stormwater management ordinance that specifies all of the provisions for handling post-construction runoff.

Technical guidance and support on the calculation of the unified stormwater sizing criteria, as well as guidance on how to meet these criteria, must also be provided. Volume 2 of the Manual provides information to assist design engineers in planning and designing stormwater management facilities to meet the minimum stormwater management standards and the unified stormwater sizing criteria.

4.5 Stormwater Site Design Credits

4.5.1 Introduction

Non-structural stormwater control practices are increasingly recognized as a critical feature in every site design. As such, a set of stormwater "credits" has been developed that allows a community to provide developers and site designers an incentive to implement better site design practices that can reduce the volume of stormwater runoff and minimize the pollutant loads from a site (see Section 4.3). The credit system directly translates into cost savings to the developer by reducing the size of structural stormwater control and conveyance facilities.

The basic premise of the credit system is to recognize the water quality benefits of certain site design practices by allowing for a reduction in the water quality treatment volume (WQ_v). If a developer incorporates one or more of the credited practices in the design of the site, the requirement for capture and treatment of the water quality volume will be reduced.

The better site design practices that provide stormwater credits are listed in Table 4.5-1. Site-specific conditions will determine the applicability of each credit. For example, stream buffer credits cannot be taken on upland sites that do not contain perennial or intermittent streams.

It should be noted that better site design practices and techniques that reduce the overall impervious area on a site already implicitly reduce the total amount of stormwater runoff generated by a site (and thus reduce WQ_v) and are not further credited under this system.

Table 4.5-1 Summary of Better Site Design Practices that Provide for Site Design Stormwater Credits	
Practice	Description
Natural area conservation	Undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics.
Stream buffers	Stormwater runoff is treated by directing sheet flow runoff through a naturally vegetated or forested buffer as overland flow.
Use of vegetated channels	Vegetated channels are used to provide stormwater treatment.
Overland flow filtration/infiltration zones	Overland flow filtration/infiltration zones are incorporated into the site design to receive runoff from rooftops and other small impervious areas.
Environmentally sensitive large lot subdivisions	A group of site design techniques are applied to low and very low density residential development.

For each potential credit, there is a minimum set of criteria and requirements which identify the conditions or circumstances under which the credit may be applied. The intent of the suggested numeric conditions (e.g., flow length, contributing area, etc.) is to avoid situations that could lead to a credit being granted without the corresponding reduction in pollution attributable to an effective site design modification.

Site designers should be encouraged to utilize as many credits as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many credits are combined (e.g., disconnecting rooftops and protecting natural conservation areas). However, credits cannot be claimed twice for an identical area of the site (e.g. claiming credit for stream buffers and disconnecting rooftops over the same site area).

Due to local safety codes, soil conditions, and topography, some of these site design credits may be restricted by a community.

4.5.2 Site Design Credit #1: Natural Area Conservation

A stormwater credit may be granted when undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. Under this credit, a designer would be able to subtract conservation areas from total site area when computing water quality volume requirements. An added benefit will be that the post-development peak discharges will be smaller, and hence water quantity control volumes (CP_v , Q_{p25} , and Q_f) will be reduced due to lower post-development curve numbers or rational formula "C" values.

Rule: Subtract conservation areas from total site area when computing water quality volume requirements.

Recommended Local Criteria:

- Conservation area cannot be disturbed during project construction
- Shall be protected by limits of disturbance clearly shown on all construction drawings
- Shall be located within an acceptable conservation easement instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the

natural area vegetation shall be managed and boundaries will be marked
[Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management], and

- Shall have a minimum contiguous area requirement of 10,000 square feet

4.5.3 Site Design Credit #2: Stream Buffers

This credit may be granted when stormwater runoff is effectively treated by a stream buffer. Effective treatment constitutes treating runoff through overland flow in a naturally vegetated or forested buffer. Under the proposed credit, a designer would be able to subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements. In addition, the volume of runoff draining to the buffer can be subtracted from the channel protection volume. The design of the stream buffer treatment system must use appropriate methods for conveying flows above the annual recurrence (1-yr storm) event.

Rule: Subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements.

Recommended Local Criteria:

- The minimum undisturbed buffer width shall be 50 feet
- The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces
- The average contributing slope shall be 3% maximum unless a flow spreader is used
- Runoff shall enter the buffer as overland sheet flow. A flow spreader can be supplied to ensure this, or if average contributing slope criteria cannot be met
- Not applicable if overland flow filtration/groundwater recharge credit is already being taken
- Buffers shall remain unmanaged other than routine debris removal

4.5.4 Site Design Credit #3: Vegetated Channels

This credit may be granted when vegetated (grass) channels are used for water quality treatment. Under the proposed credit, a designer would be able to subtract the areas draining to a grass channel from total site area when computing water quality volume requirements. A vegetated channel may be able to fully meet the water quality volume requirements for certain kinds of low-density residential development (see low impact development credit). An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

Note: This credit should not be granted if grass channels are being used as a limited application structural stormwater control towards meeting the 80% TSS removal goal for WQ_v treatment.

Rule: Subtract the areas draining to a vegetated (grass) channel from total site area when computing water quality volume requirements.

Recommended Local Criteria:

- The credit shall only be applied to moderate or low density residential land uses (3 dwelling units per acre maximum)
- The maximum flow velocity for water quality design storm shall be less than or equal to 1.0 feet per second
- The minimum residence time for the water quality storm shall be 5 minutes
- The bottom width shall be a maximum of 6 feet. If a larger channel is needed use of a compound cross section is required
- The side slopes shall be 3:1 (horizontal:vertical) or flatter
- The channel slope shall be 3 percent or less

4.5.5 Site Design Credit #4: Overland Flow Filtration/Groundwater Recharge Zones

This credit may be granted when “overland flow filtration/infiltration zones” are incorporated into the site design to receive runoff from rooftops or other small impervious areas (e.g., driveways, small parking lots, etc). This can be achieved by grading the site to promote overland vegetative filtering or by providing infiltration or “rain garden” areas. If impervious areas are adequately disconnected, they can be deducted from total site area when computing the water quality volume requirements. An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

Rule: If impervious areas are adequately disconnected, they can be deducted from total site area when computing the water quality volume requirements.

Recommended Local Criteria:

- Relatively permeable soils (hydrologic soil groups A and B) should be present
- Runoff shall not come from a designated hotspot
- The maximum contributing impervious flow path length shall be 75 feet
- Downspouts shall be at least 10 feet away from the nearest impervious surface to discourage “re-connections”
- The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or structural stormwater control
- The length of the “disconnection” shall be equal to or greater than the contributing length
- The entire vegetative “disconnection” shall be on a slope less than or equal to 3 percent
- The surface imperviousness area to any one discharge location shall not exceed 5,000 square feet
- For those areas draining directly to a buffer, either the overland flow filtration credit –or– the stream buffer credit can be used

4.5.6 Site Design Credit #5: Environmentally Sensitive Large Lot Subdivisions

This credit may be granted when a group of environmental site design techniques are applied to low and very low density residential development (e.g., 1 dwelling unit per 2 acres [du/ac] or lower). The credit can eliminate the need for structural stormwater controls to treat water quality volume requirements. This credit is targeted towards large lot subdivisions and will likely have limited application.

Rule: Targeted towards large lot subdivisions (e.g. 2 acre lots and greater). The requirement for structural practices to treat the water quality volume treatment requirements shall be waived.

Recommended Local Criteria:

For Single Lot Development:

- Total site impervious cover (including roadways/driveway) is less than 15%
- Lot size shall be at least two acres
- Rooftop runoff is disconnected in accordance with the criteria in Credit #4
- Grass channels are used to convey runoff versus curb and gutter

For Multiple Lots:

- Total impervious cover footprint (including streets) shall be less than 15% of the area
- Lot areas should be at least 2 acres, unless clustering is implemented. Open space developments should have a minimum of 25% of the site protected as natural conservation areas and shall be at least a half-acre average individual lot size.
- Grass channels should be used to convey runoff versus curb and gutter (see Credit #3)
- Overland flow filtration/infiltration zones should be established (see Credit #4)

4.5.7 Implementing Stormwater Site Design Credits

Each community needs to select, define and implement stormwater credits that best meet its economic, social, and resource protection needs. The specific calculation of site design credits may be allowed to vary depending on circumstances. Volume 2, Section 1.5 provides a number of examples of how these credits can be calculated. The credit can be expressed as a volume, or a fraction representing the water quality volume met by the credit.

The definition of each stormwater credit, as well as the criteria and conditions for its use, should be explicitly written into the community's development regulations, ideally the stormwater management ordinance. In addition, technical assistance and guidance on the stormwater site design credits should be provided.

4.6 Downstream Assessments

4.6.1 Introduction

The purpose of the overbank flood protection and extreme flood protection criteria is to protect downstream properties from flood increases due to upstream development. These criteria require the designer to control peak flow at the outlet of a site such that post-development peak discharge equals pre-development peak discharge. It has been shown that in certain cases this does not always provide effective water quantity control downstream from the site and may actually exacerbate flooding problems downstream. The reasons for this have to do with (1) the timing of the flow peaks, and (2) the total increase in volume of runoff. Further, due to a site's location within a watershed, there may be very little reason for requiring overbank flood control from a particular site. This section outlines a suggested procedure for determining the impacts of post-development stormwater peak flows and volumes on downstream flows that a community can require as part of a developer's stormwater management plan.

4.6.2 Reasons for Downstream Problems

Flow Timing

If water quantity control (detention) structures are indiscriminately placed in a watershed and changes to the flow timing are not considered, the structural control may actually increase the peak discharge downstream. The reason for this may be seen in Figure 4.6-1. The peak flow from the site is reduced appropriately, but the timing of the flow is such that the combined detained peak flow (the larger dashed triangle) is actually higher than if no detention were required. In this case, the shifting of flows to a later time brought about by the detention pond actually makes the downstream flooding worse than if the post-development flows were not detained.

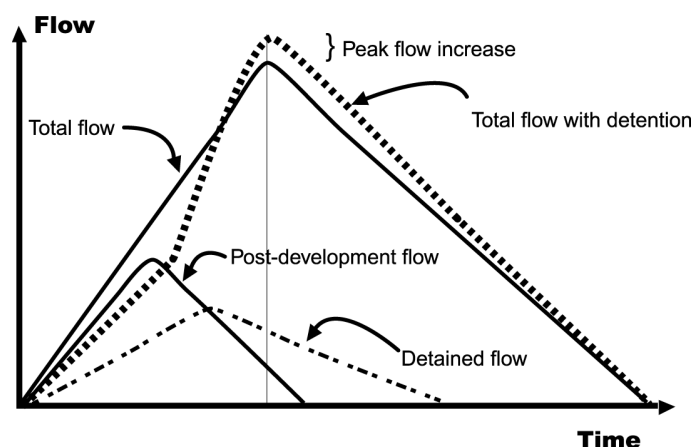


Figure 4.6-1 Detention Timing Example

Increased Volume

An important impact of new development is an increase in the total runoff volume of flow. Thus, even if the peak flow is effectively attenuated, the longer duration of higher flows due to the increased volume may combine with downstream tributaries to increase the downstream peak flows.

Figure 4.6-2 illustrates this concept. The figure shows the pre- and post-development hydrographs from a development site (Tributary 1). The post-development runoff hydrograph meets the flood protection criteria (i.e., the post-development peak flow is equal to the pre-development peak flow at the outlet from the site). However, the post-development combined flow at the first downstream tributary (Tributary 2) is higher than pre-development combined flow. This is because the increased volume and timing of runoff from the developed site increases the combined flow and flooding downstream. In this case, the detention volume would have to have been increased to account for the downstream timing of the combined hydrographs to mitigate the impact of the increased runoff volume.

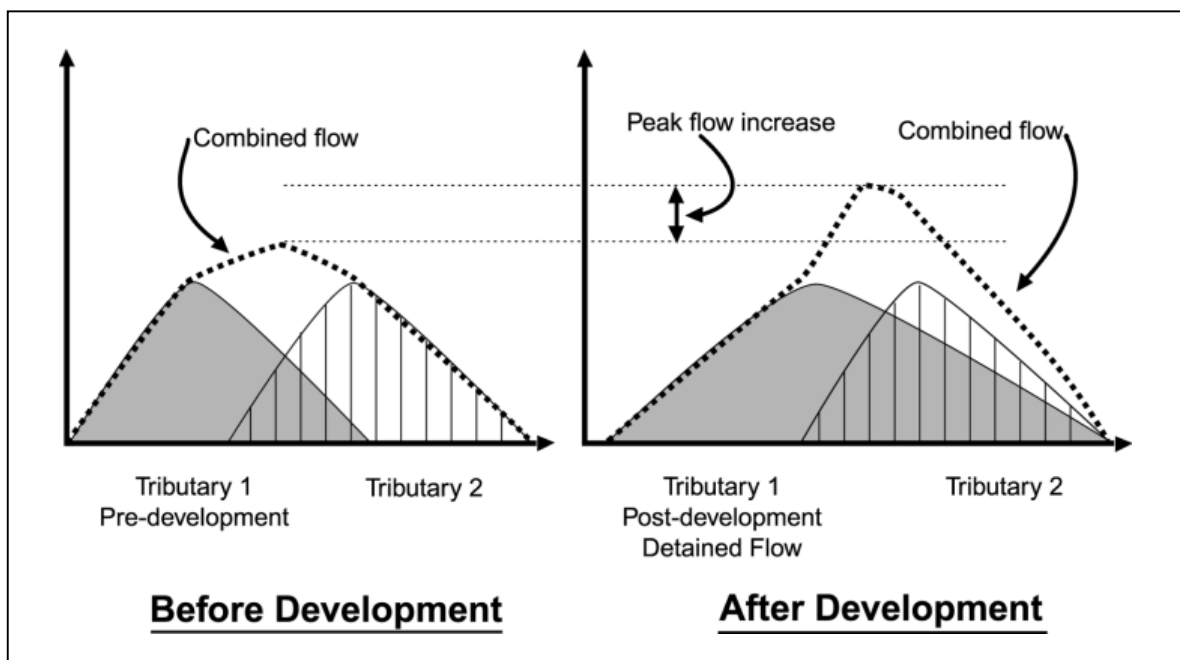


Figure 4.6-2 Effect of Increased Post-Development Runoff Volume with Detention on a Downstream Hydrograph

4.6.3 Downstream Assessments: The "Ten-Percent" Rule

Potential problems such as those described above are quite common, but can be avoided through the use of a downstream analysis of the effects of a planned development. Studies have shown that if a developer is required to assess the impacts of a development downstream to the point where the developed property is 10% of the total drainage area, and there are no adverse impacts on peak flow increase, then there is assurance that there will not be significant increases in flooding problems further downstream. For example, for a 10-acre site the assessment would have to take place down to a point where the total accumulated drainage area is 100 acres.

This sort of downstream assessment is sometimes warranted, particularly for large sites or developments that will have a potential to dramatically impact downstream areas. While this assessment does require some additional labor on the part of the design engineer, it also provides the opportunity for a community to potentially waive or reduce the detention requirements for overbank flood protection and extreme flood protection.

4.6.4 Adopting a Downstream Assessment Requirement

It is estimated that perhaps one-fourth to one-third of all requirements for overbank flood control may be eliminated or reduced by adoption of a downstream assessment requirement, while those control structures that are required will be effective in limiting downstream impacts. Some communities may choose to require a fee to be paid in lieu of detention if water quantity control requirements are waived, with revenues going toward stormwater system maintenance and improvement.

The downstream assessment provision can be combined with other options such as requiring channel or stormwater infrastructure improvements downstream in lieu of the overbank/extreme flood control requirements. This gives the local community an effective and flexible tool to combat both unnecessary development expense and ineffective regulatory controls.

In terms of proper administration of the requirement, a proposed development would submit, as part of a preliminary drainage study, the downstream assessment showing both pre-development and post-development flows, assessing flow increases, and proposing a method to mitigate any increase at the site outlet and throughout the conveyance system to the 10% point. This analysis should be performed after any stormwater credits for site design have been taken into consideration. Actual calculations do not need to be made except at tributary combine points, or at any structure thought to be undersized if there is a flow increase that will be mitigated with drainage system improvements rather than detention. Special consideration should be made of the conditions directly below the outlet to determine whether or not channel protection volumes need to be controlled even if overbank and extreme flood protection has been waived.

4.7 Guidance on Structural Stormwater Controls

4.7.1 Introduction

The impacts of stormwater runoff from development cannot be completely mitigated by land use and nonstructural approaches. Therefore, a community must develop a program to require the use of structural stormwater control measures on new development and redevelopment sites. Structural stormwater controls (sometimes referred to as *structural best management practices* or *BMPs*) are constructed stormwater management facilities designed to treat stormwater runoff and/or mitigate the effects of increased stormwater runoff peak rate, volume, and velocity due to urbanization.

Volume 2 recommends a number of structural stormwater controls for Georgia that can be used for meeting the minimum stormwater management standards for development and the unified stormwater sizing criteria. These recommended controls are divided into three categories: *general application*, *limited application*, and *detention* structural controls. The next several pages describe the structural controls recommended for use in Georgia communities.

4.7.2 Recommended Structural Stormwater Control Practices for Georgia Communities

General Application Controls

General application 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 (WQ_v) and are presumed to be able to remove 80% of the total annual average TSS load in typical post-development urban runoff when designed, constructed and maintained in accordance with recommended specifications. Several of the general application structural controls can also be designed to provide water quantity control; i.e., downstream channel protection (CP_v), overbank flood protection (Q_{p25}) and/or extreme flood protection (Q_r). General application controls are the recommended stormwater management facilities for a site wherever feasible and practical.

There are six types of general application controls, which are summarized below. Detailed descriptions of each structural control along with design criteria and procedures are provided in Volume 2, Section 3.2.

Stormwater Ponds

Stormwater ponds are constructed stormwater retention basins that have a permanent pool (or micropool) of water. Runoff from each rain event is detained and treated in the pool. Pond design variants include:

- Wet Pond
- Wet Extended Detention Pond
- Micropool Extended Detention Pond
- Multiple Pond Systems

Stormwater Wetlands

Stormwater wetlands are constructed wetland systems used for stormwater management. Stormwater wetlands consist of a combination of shallow marsh areas, open water and semi-wet areas above the permanent water surface. Wetland design variants include:

- Shallow Wetland
- Extended Detention Shallow Wetland
- Pond/Wetland Systems
- Pocket Wetland

Bioretention Areas

Bioretention areas are shallow stormwater basins or landscaped areas that utilize engineered soils and vegetation to capture and treat stormwater runoff. Runoff may be returned to the conveyance system, or allowed to fully or partially exfiltrate into the soil.

Sand Filters

Sand filters are multi-chamber structures designed to treat stormwater runoff through filtration, using a sand bed as the primary filter media. Filtered runoff may be returned to the conveyance system, or allowed to fully or partially exfiltrate into the soil. The two sand filter design variants are:

- Surface Sand Filter
- Perimeter Sand Filter

Infiltration Trenches

An infiltration trench is an excavated trench filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the trench.

Enhanced Swales

Enhanced swales are vegetated open channels that are explicitly designed and constructed to capture and treat stormwater runoff within dry or wet cells formed by check dams or other means. The two types of enhanced swales are:

- Dry Swale
- Wet Swale/Wetland Channel

Limited Application Controls

Limited application structural controls are those that are recommended only for limited use or for special site or design conditions. Generally, these practices: (1) cannot alone achieve the 80% TSS removal target, (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. Limited application controls are typically used for *water quality treatment only*.

Some of these controls can be used as a pretreatment measure or in series with other structural controls to meet pollutant removal goals. Limited application structural controls should be considered primarily for commercial, industrial or institutional developments.

The following limited application controls are provided for consideration in this Manual. Each is discussed in detail with appropriate application guidance in Volume 2, Section 3.3.

Biofilters

- Filter Strip
- Grass Channel

Filtering Practices

- Organic Filter
- Underground Sand Filter

Wetland Systems

- Submerged Gravel Wetland

Hydrodynamic Devices

- Gravity (Oil-Grit) Separator

Porous Surfaces

- Modular Porous Paver Systems
- Porous Concrete

Chemical Treatment

- Alum Treatment System

Proprietary Systems

- Commercial Stormwater Controls

Detention Controls

Detention structural controls are used only for providing water quantity control (channel protection, overbank flood protection, or extreme channel protection), and are typically used downstream of a general application or limited application structural control. Types of detention controls include:

- Dry Detention and Dry Extended Detention Basins
- Multi-purpose Detention Areas
- Underground Detention

A detailed discussion of each of the detention controls, as well as design criteria and procedures can be found in Volume 2, Section 3.4.

4.7.3 Suitability of Structural Stormwater Controls to Meet Stormwater Management Requirements

Table 4.7-1 summarizes the stormwater management suitability of the various structural controls in addressing each of the unified stormwater sizing criteria. Given that many structural controls cannot meet all of the sizing criteria, typically two or more controls are used in series to form what is known as a stormwater “treatment train.” Volume 2, Section 3.1 provides guidance on the use of a treatment train as well as how to calculate the pollutant removal efficiency for structural controls in series. Volume 2 also provides guidance for choosing the appropriate structural stormwater control(s) for a site as well as the basic considerations and limitations on the use of a particular structural control.

Table 4.7-1 Suitability of Structural Stormwater Controls to Meet Unified Stormwater Sizing Criteria				
Structural Stormwater Control	Water Quality Volume (WQ_v)	Channel Protection (CP_v)	Overbank Flood Protection (Q_{p25})	Extreme Flood Protection (Q_r)
<i>General Application</i>				
Stormwater Ponds	✓	✓	✓	✓
Stormwater Wetlands	✓	✓	✓	✓
Bioretention Areas	✓	☆	●	●
Sand Filters	✓	☆	●	●
Infiltration Trenches	✓	☆	●	●
Enhanced Swales	✓	☆	☆	●
<i>Limited Application</i>				
Biofilters	○	●	●	●
Filtering Practices	✓	●	●	●
Wetland Systems	✓	●	●	●
Hydrodynamic Devices	○	●	●	●
Porous Surfaces	✓	☆	●	●
Chemical Treatment	✓	●	●	●
Proprietary Systems	*	*	*	*
<i>Detention Controls</i>	●	✓	✓	✓

- ✓ = Able to meet stormwater sizing criterion (for water quality, this control is presumed to meet the 80% TSS reduction goal when sized to treat the WQ_v and designed, constructed and maintained properly)
- = Typically provides partial treatment of WQ_v. May be used in pretreatment and as part of a "treatment train"
- ☆ = Can be incorporated into the structural control in certain situations
- = Not typically able or used to meet stormwater sizing criterion
- * = 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

4.7.4 Implementing Application and Design Criteria for Structural Stormwater Controls

In order to implement a structural stormwater control program and requirements, a local government must first determine the suite of structural controls that will be allowed by the community. The recommended structural controls for Georgia communities provided in this Manual is a good starting point, as these controls were selected by a task force of local government staff and stormwater experts. Communities can allow controls not included in this Manual (including various commercial systems) at their discretion, but should not do so without independently derived information concerning performance, maintenance, and application requirements and limitations.

Once the list of allowable stormwater controls has been determined, specific application and design guidance should be developed and provided for each structural control practice, including:

-
- General Description of the Structural Stormwater Control
 - Stormwater Management Suitability
 - Pollutant Removal Capabilities and Design Removal Efficiencies
 - Application and Site Feasibility Criteria
 - Planning and Design Criteria
 - Design Procedures
 - Inspection and Maintenance Requirements
 - Construction and Materials Specifications
 - Example Schematics
 - Design Forms

This guidance should be provided in a design manual or handbook along with specific design examples. Volume 2 contains this information for many of the recommended structural controls listed above. Additional guidance in the form of training seminars and workshops is invaluable to educating the development community on the design, construction and ongoing maintenance issues involved with using structural stormwater controls.

4.8 Stormwater Management Site Plans

4.8.1 Introduction

To encourage and ensure that local stormwater guidelines and requirements are implemented, communities should implement a formal site plan preparation, submittal, and review procedure that facilitates open communication and understanding between the involved parties.

A stormwater management site plan is a comprehensive report that contains the technical information and analysis to allow a community to determine whether a proposed new development or redevelopment project meets the local stormwater regulatory requirements. This section discusses the typical contents of a stormwater management site plan and the recommended review and consultation checkpoints between the local government staff and the site developer.

The procedures and guidelines for the preparation of a site stormwater plan should be explicitly stated in a local ordinance. The ordinance, in turn, may refer to a design guidance document for additional detail. Ideally, site stormwater plans are developed with open lines of communication between the developer (and developer's engineer) and the plan reviewer. Stormwater plans are more than just the preparation of a document and maps. Instead, stormwater plans should be thought of as a process that occurs over the planning and development cycle and then continues after buildout via regular inspection and maintenance of the stormwater management system.

4.8.2 Contents of a Stormwater Management Site Plan

The following elements are recommended components for local stormwater management site plan requirements. Based on a community's prerogative, small-scale projects could be allowed to prepare a site plan that includes a defined subset of the elements outlined below.

1) Existing Conditions Hydrologic Analysis

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

2) Post-Development Hydrologic Analysis

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

3) Stormwater Management System

- Drawing or sketch of the stormwater management system including the location of non-structural site design features and the placement of existing and proposed structural stormwater controls. This drawing should show design water surface elevations, storage volumes available from zero to maximum head, location of inlet and outlets, location of bypass and discharge systems, and all orifice/restrictor sizes.
- Narrative describing that appropriate and effective structural stormwater controls have been selected
- Cross-section and profile drawings and design details for each of the structural stormwater controls in the system. This should include supporting calculations to show that the facility is designed according to the applicable design criteria.
- Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms (should include stage-storage or outlet rating curves, and inflow and outflow hydrographs)
- Documentation and supporting calculations to show that the stormwater management system adequately meets the unified stormwater sizing criteria
- Drawings, design calculations and elevations for all existing and proposed stormwater conveyance elements including stormwater drains, pipes, culverts, catch basins, channels, swales and areas of overland flow

4) Downstream Analysis

- Supporting calculations for a downstream peak flow analysis using the ten-percent rule necessary to show safe passage of post-development design flows downstream

5) Erosion and Sedimentation Control Plan

- Must contain all the elements specified in the Georgia Erosion and Sediment Control Act and local ordinances and regulations
- Sequence/phasing of construction and temporary stabilization measures
- Temporary structures that will be converted into permanent stormwater controls

6) Landscaping Plan

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

7) Operations and Maintenance Plan

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

8) Evidence of Acquisition of Applicable Local and Non-local Permits

9) Waiver Requests

4.8.3 Procedure for Reviewing Stormwater Site Plans

Section 1.3 of Volume 2 describes the general procedure in the preparation of a stormwater site plan. The following steps are intended to provide a community with a review process and checkpoints that complements the procedure from the site developer's perspective:

- (1) Pre-consultation Meeting and Joint Site Visit**
- (2) Review Stormwater Concept Plan**
- (3) Review Preliminary Stormwater Site Plan**
- (4) Review Final Stormwater Site Plan**

Additional steps to ensure compliance with the stormwater management site plan include:

- (5) Pre-construction Meeting**
- (6) Construction Inspections**
- (7) Ongoing Maintenance Inspections**

Step 1. Pre-consultation Meeting and Joint Site Visit

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

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

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

- Minimum design and performance standards for stormwater management
- Design storm frequencies
- Conveyance design criteria
- Floodplain criteria
- Buffer/setback criteria
- Wetland provisions
- Watershed-based criteria
- Erosion and sedimentation control requirements
- Maintenance requirements
- Need for physical site evaluations (infiltration tests, geotechnical evaluations, etc.)

This guidance could be provided at the pre-consultation meeting and should be detailed in various local ordinances (e.g., subdivision codes, stormwater and drainage codes, etc). This information could be contained in a set of checklists which would be provided to the developer. Appendix B contains example checklists outlining the necessary steps to prepare preliminary and final stormwater management site plans.

Current land use plans, comprehensive plans, zoning ordinances, road and utility plans, watershed or overlay districts, and public facility plans should all be consulted to determine the need for compliance with other local and state regulatory requirements. Opportunities for special types of development (e.g., clustering) or special land use opportunities (e.g., conservation easements or tax incentives) should be investigated. There may also be an ability to partner with the site developer in the development of greenways or open space parks.

Step 2. Review Stormwater Concept Plan

During the concept plan stage the site designer will perform most of the layout of the site including the preliminary stormwater management system design and layout. The stormwater concept plan allows the design engineer to propose a potential site layout and gives the developer and local review authority a “first look” at the stormwater management system for the proposed development. The stormwater concept plan should be submitted to and approved by the local plan reviewer before detailed preliminary site plans are developed.

It is extremely important at this stage that stormwater design is integrated into the overall site design concept in order to best reduce the impacts of the development as well as provide for the most cost-effective and environmentally sensitive approach.

Step 3. Review Preliminary Stormwater Site Plan

The preliminary plan ensures that local requirements and criteria are being complied with and that opportunities are being taken to minimize adverse impacts from the development.

The preliminary stormwater management site plan should consist of maps, narrative, and supporting design calculations (hydrologic and hydraulic) for the proposed stormwater management system, and should include the following elements from section 4.8.2:

- **Existing Conditions Hydrologic Analysis**
- **Post-Development Hydrologic Analysis**
- **Stormwater Management System**
- **Downstream Analysis**

It should be demonstrated that appropriate and effective stormwater controls have been selected and adequately designed. The preliminary plan should also include, among other things, street and site layout, delineation of natural feature protection and conservation areas, soils data, existing and proposed topography, relation of site to upstream drainage, limits of clearing and grading, and proposed methods to manage and maintain conservation areas (e.g., easements, maintenance agreements/responsibilities, etc.)

Step 4. Review Final Stormwater Site Plan

The final stormwater management site plan adds further detail to the preliminary plan and reflects changes that are requested or required by the local review authority. The final stormwater site plan should include all of the revised elements from the preliminary plan as well as the following items:

- **Erosion and Sedimentation Control Plan**
- **Landscaping Plan**
- **Operations and Maintenance Plan**
- **Evidence of Acquisition of Applicable Local and Non-local Permits**
- **Waiver Requests**

This process may be iterative. The reviewer should ensure that all submittal requirements have been satisfactorily addressed and permits, easements, and pertinent legal agreements (e.g., maintenance agreements, performance bond, etc.) have been obtained and/or executed.

The completed final stormwater site plan should be submitted to the local review authority for final approval prior to any construction activities on the development site. Approval of the final plan is the last major milestone in the stormwater planning process. The remaining steps are to ensure that the plan is installed, implemented, and maintained properly.

Step 5. Pre-construction Meeting

This step ensures that the contractor, engineer, inspector, and plan reviewer can be sure that each party understands how the plan will be implemented on the site. A pre-construction meeting should occur before any clearing or grading is initiated on the site. This is the appropriate time to ensure that natural feature protection areas and limits of disturbance have been adequately staked and adequate erosion and sediment control measures are in place.

Step 6. Construction Inspections

Project sites should periodically be inspected during construction by local agencies to ensure that conservation areas have been adequately protected and that stormwater control and conveyance facilities are being constructed as designed. Inspection frequency may vary with regard to site size and location; however, monthly inspections are a good target. In addition it is recommended that some inspections occur after larger storm events (e.g., 0.5 inches and greater). The inspection process can prevent later problems that result in penalties and added cost to developers.

An added benefit of a formalized and regular inspection process is that it should help to motivate contractors to internalize regular maintenance of sediment controls as part of the daily construction operations. If necessary, a community can consider implementing a penalty system, whereby fines can be assessed or even stop work orders issued.

A final inspection is needed to ensure that the construction conforms to the intent of the approved design. Prior to issuing an occupancy permit and releasing any applicable bonds, the review authority should ensure that: (1) temporary erosion control measures have been removed; (2) stormwater controls are unobstructed and in good working order; (3) permanent vegetation cover has been established in exposed areas; (4) any damage to natural feature protection and conservation areas has been restored; (5) conservation areas and buffers have been adequately marked or signed; and (6) any other applicable conditions.

Record drawings of the structural stormwater controls and drainage facilities should also be acquired by the community, as they are important in the long-term maintenance of the facilities. The review authority should keep copies of the drawings and associated documents and develop a local stormwater control inventory and data storage system. With geographic information systems (GIS) becoming more widely used, much of these data can be stored electronically.

Step 7. Ongoing Maintenance Inspections

Ongoing inspection and maintenance of a project site's stormwater management system is often the weakest component of stormwater plans. It needs to be clearly detailed in the stormwater site plan which entity has responsibility for operation and maintenance of all structural stormwater controls and drainage facilities. Often, the responsibility for maintenance is transferred from the developer and contractor to the owner. Communication about this important responsibility is usually inadequate; therefore communities may need to consider ways to notify property owners of their responsibilities. For example, notification can be made through a legal disclosure upon sale or transfer of property or public outreach programs may be instituted to describe the purpose and value of maintenance.

Ideally, preparation of maintenance plans should be a requirement of the stormwater site plan preparation and review process. A maintenance plan should outline the scope of activities, schedule, and responsible parties. Vegetation, sediment management, access, and safety issues should also be addressed. It is important that the maintenance plan contains the necessary provisions to ensure that vegetation establishment occurs in the first few years after construction. In addition, the plan should address testing and disposal of sediments that will likely be necessary.

Annual inspections of stormwater management facilities should be conducted by an appropriate local agency. Where chronic or severe problems exist, the local government should have the authority to remedy the situation and charge the responsible party for the cost of the work. This authority should be well established in an ordinance.

WATERSHED-BASED STORMWATER PLANNING

5.1 Stormwater Master Planning

5.1.1 Introduction

Stormwater master planning is an important tool with which communities can assess and prioritize both existing and potential future stormwater problems, as well as use to consider alternative stormwater management solutions. A stormwater master plan is prepared to consider, in detail, what stormwater management practices and measures are to be provided for an urban drainage area or a large development project.

Stormwater master plans are most often used to address specific single functions such as drainage provision, flood mitigation, cost/benefit analysis, or risk assessment. These plans prescribe specific management alternatives and practices. Multi-objective stormwater master planning broadens this traditional definition to potentially include land use planning and zoning, water quality, habitat, recreation, and aesthetic considerations. The most broad type of stormwater master plan is the comprehensive watershed plan which is described in detail in this chapter.

For any stormwater master plan, it is important at the outset to: (1) clearly identify and quantify the objectives and issues the plan will address; (2) recognize the constraints (technical, political, legal, financial, social, physical) that limit the possible solutions; and (3) develop a clear technical approach that will address the key issues and needs while staying within the constraints to potential solutions.

5.1.2 Types of Stormwater Master Planning

There are several basic types of stormwater master plans that can be prepared. Below are descriptions of representative examples of master plans.

Flood assessment master plans

Flood assessment is the simplest form of stormwater master planning, where only the essential components, alignments, and functions of a drainage system are analyzed. The focus of these studies is on water quantity control and flood prevention and/or mitigation.

Frequently, a flood assessment study analyzes both existing conditions and projected future buildout conditions. The study is based upon estimates (usually modeled) of peak and total discharges for selected return frequency runoff events. The selected events should be based on local standards. Both the hydrology and hydraulics of the system are analyzed to determine water surface profiles and elevations. This, in turn, assists in determining probable locations where impacts can be expected to occur. Frequently, an alternatives analysis will be performed as part of the master plan to provide potential solutions to mitigating the flood impacts. This typically involves the modeling of proposed modifications or development scenarios.

Examples include examining the effects of detention on flooding and providing improved flood protection (e.g., flood proofing structures, levies, etc). A local community might develop HEC-1

and HEC-RAS models for the hydrology and hydraulics of a watershed for the purposes of estimating the full buildout floodplain and regulating new development on this basis rather than the ever-changing “existing conditions” approach.

Flood study cost/benefit analysis master plans

Another type of master planning builds on a flood assessment master plan to determine acceptable risks and the associated costs. Using information developed in the flood analysis, economic and/or environmental impacts can be assessed. This initially entails establishing a relation between water surface elevation and associated damage (often referred to as stage-damage curves). Based on this relationship, an acceptable level of risk is determined, from which design discharges and associated water surface profiles and elevations are established. Acceptable levels of risk might be based upon the likelihood of loss of human life, impacts to residences, impacts to non-residence structures, or damage to utilities. This information then helps determine the ultimate drainage infrastructure that will be needed to achieve the planning goals. Both a formal benefit-cost analyses or a more subjective “cost-effectiveness” approach could be used. Based on the design criteria, preliminary designs can be developed which in turn yield initial cost estimates for the infrastructure.

For example, a community might look at different flood protection strategies along a stream and estimate the costs and flood damage savings for each alternative in an effort to select the most appropriate solution(s) for that community.

Water quality master plans

Master planning for stormwater quality is becoming increasingly important, as nonpoint source loads are a critical component of watershed-wide water quality assessments. For many Georgia communities it is necessary to be able to estimate pollutant loads from stormwater runoff for TMDLs, as well as for the expansion of wastewater treatment facilities. A water quality master plan can provide the foundation from which to develop broader water quality assessments. Stormwater quality studies will typically analyze water quality impacts to receiving waters (and groundwater, particularly in karst regions) and develop structural and nonstructural strategies to reduce or minimize the pollutant loads. Studies usually involve the development, calibration, and verification of a water quality model. The level of model sophistication can vary from simple to complex. Often, a cost/benefit analysis will be performed as a component of the water quality study to quantify the efficacy of various strategies.

For example, a community might develop a simple spreadsheet-based loading model to perform planning level analyses of loadings of pollutants, potential removal by stormwater controls, and the impacts of development strategies—or they use a more complex continuous simulation water quality model and supporting monitoring to develop a combination of point and non-point source loading estimates in support of a watershed assessment or TMDL.

Biological/habitat master plans

Biological/habitat master planning is similar to a water quality master plan. However, rather than focusing on water chemistry, the focus is on the aquatic biological communities and supporting habitats. Biological assessments are being implemented on a more frequent basis to assess overall water body health. Biological studies provide the ability to assess both acute and long-term effects of nonpoint source impacts to a receiving water in the absence of continuous monitoring data. The resulting data can be used in the design and development of habitat improvement and stream restoration projects, riparian buffers, structural control retrofits, etc.

For example, a community may desire to improve the quality and aesthetics of a stream. Biological monitoring and habitat assessment establishes the baseline health of the stream and can be compared to a reference stream in the area. This information is assessed to determine causes of impairment (often paired with chemical monitoring) and methods to reduce impairment are investigated. The plan might then include riparian corridor planning, land use zoning changes, and planned habitat restoration.

Comprehensive watershed master plans

The comprehensive watershed approach is the most general type of stormwater master planning as well as the most extensive. The intent of comprehensive watershed plan is to assess existing water resources health and to make informed land use and stormwater planning decisions based on the current and projected land use and development within the targeted watershed and its associated subwatersheds. Watershed-based water quantity and water quality goals are typically aimed at maintaining the pre-development hydrologic and water quality conditions to the extent practicable through peak discharge control, volume reduction, groundwater recharge, channel protection, and flood protection. In addition, watershed plans may also promote a wide range of additional goals include the streambank and stream corridor restoration, habitat protection, protection of historical and cultural resources, enhancement of recreational opportunities, and aesthetic and quality of life issues.

Watershed-based studies often involve a holistic approach to master planning, where hydrology, geomorphology, habitat, water quality, and biological community impacts are analyzed and solutions are developed. A detailed discussion of watershed-based master planning is provided below.

5.2 Comprehensive Watershed Planning for Georgia Communities

5.2.1 Introduction

Due to the realization that urban stormwater quantity and quality management need to be addressed at a larger scale, communities are increasingly turning towards the development of comprehensive watershed and subwatershed plans. These plans usually encompass broader management issues such as land use planning and zoning, recreational and aesthetic opportunities, water supply protection, and habitat management.

5.2.2 Scale of Watershed Management

Watersheds are typically defined according to the resource area or downstream water body of interest. Although there are no maximum size limits for defining a watershed, a manageable watershed for local planning efforts is usually no greater than 100,000 acres (~150 square miles). It is important to remember that larger watershed boundaries require the involvement of more jurisdictions and stakeholders.

It is recommended that planning take place at both the watershed and smaller “subwatershed” scales. Typically, the broad, “big picture” planning takes place at the watershed level, and the more refined objectives and implementation plans are pursued at a subwatershed level. Finally, individual projects and controls are carried out at the project or catchment level.

Often times it may be more efficient to plan at the watershed scale and to assess the effectiveness of plan implementation at the subwatershed scale, where indicator response is more apparent. For example, many of the non-traditional goals of a multi-objective watershed master plan, such as establishment of inter-jurisdictional greenways, wildlife corridors, and forest conservation areas, are easier to conceptualize and implement at the watershed scale.

A community undertaking a watershed planning effort will need to determine whether the project area under consideration is part of a larger watershed or river basin with its own management goals. If so, the community needs to ensure that the planned activities complement the broader scale efforts. On the other end of the scale, a local government must also make sure that development and neighborhood level stormwater management projects and activities are incorporated into and complement the overall watershed plan.

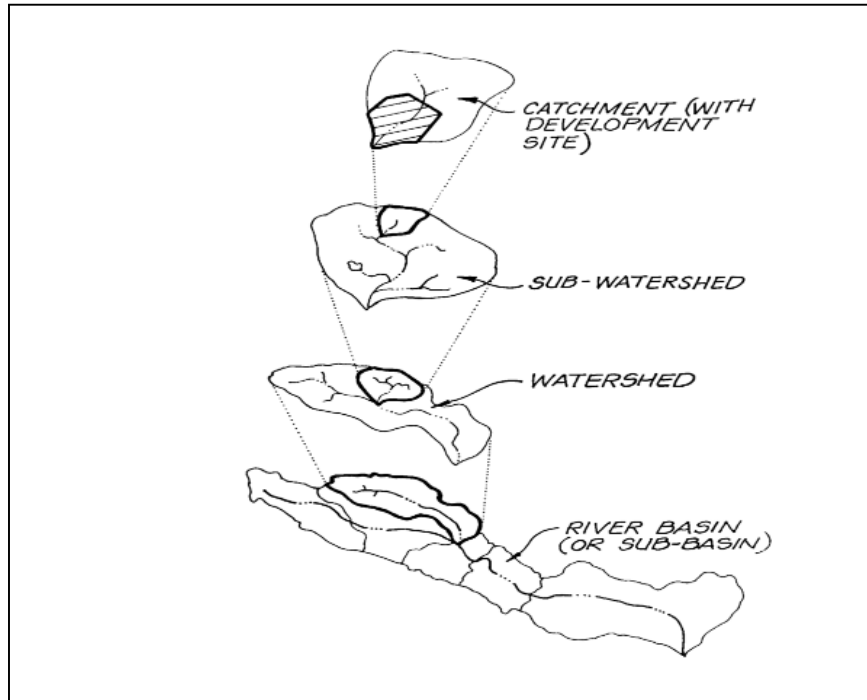


Figure 5.2-1 Watershed Management Units
(Source: Center for Watershed Protection, 1998)

Table 5.2-1 Description of the Various Watershed Management Units

Watershed Management Unit	Typical Area (square miles)	Sample Management Measures
Catchment	0 to 5	Site design measures & structural controls
Subwatershed	5 to 30	Stream classification and management
Watershed	30 to 150	Watershed-based development standards
River Basin	Greater than 150	Basinwide planning

5.2.3 The Watershed Planning Process

Watershed and subwatershed plans provide a framework for managers and decision-makers to determine what the goals and strategies of the plan should be and how and where various management and protection tools need to be implemented to achieve the goals and strategies. Developing watershed and subwatershed plans should ideally occur in a rapid, cost effective manner. A suggested eight-step approach to watershed planning is presented below. It is important to remember throughout the process that it is critical to have public involvement and “buy in.” Without community support, it may be difficult to implement a plan.

Step 1. Identify initial goals and establish a baseline

Prior to initiating a watershed plan, some broad goals should be identified that define the purpose of the plan initiative. For example, a goal of a plan may be to preserve and maintain a high quality segment of stream in a community, protect drinking water quality in a water supply watershed, or meet a water quality TMDL. Other goals may be a response to negative impacts being observed within a watershed such as property flooding or channel erosion and degradation. Prior to addressing the initial goals, it is necessary to gather basic information to determine a starting point to develop the plan. Information about possible stakeholders, current land use and impervious cover, and technical (e.g., previous hydrologic/hydraulic studies, floodplain studies, water quality studies, etc.), staffing, and financial resources can help guide the first steps of the plan. Once the broad goals have been identified and defined, specific tasks that may need to be performed include:

Task 1: Define Watershed and Subwatershed Boundaries

Defining the watershed and subwatershed boundaries sets the stage for completing the rest of the watershed baseline. The product of this task is a simple map that outlines the boundaries of the watershed and each of its subwatersheds. Producing this map is a necessary first step to answering questions such as “Which political jurisdictions and citizens should participate in this watershed planning effort?” and “What are the land use patterns in the watershed and each of its subwatersheds?”



Figure 5.2-2 Example of a Watershed Map with Subwatersheds Delineated

(Source: 1998, City of Atlanta. Metro Atlanta Urban Watershed Initiative Guidance Document)

Task 2: Identify Possible Stakeholders

Early on, it is important to identify the partners, or stakeholders, that will be involved in some way to make watershed plans happen. Early stakeholder involvement guides the development of the watershed plan to incorporate the needs of the community and promote resource protection. By involving possible stakeholders early on in the process, managers can gauge who wants to participate in developing the plan, what they can offer to the process, or what obstacles participants may present. Stakeholders might include other government agencies, businesses and industry, nonprofits, and neighborhood leaders and interested citizens.

The watershed and subwatershed boundaries delineated in Task 1 are a good place to start identifying possible stakeholders. A quick review of the map helps determine which jurisdictions and neighborhoods fall within the watershed boundaries. Direct outreach to citizens living within the watershed boundaries can also spark interest within the community. Stakeholders can provide resources, expertise, or knowledge to guide the development of the plan. Also, it is important to include stakeholders from the local development community since some decisions of the plan, such as new ordinances or zoning, will directly impact them. It is also wise at this time to look beyond the boundaries of the watershed under study to see how the plan may help achieve the broad water resource goals of larger river basins.

Task 3: Estimate Existing Land Use and Impervious Cover

Estimating existing subwatershed land cover is a recommended baseline task in preparing a watershed plan, since this data can be used in modeling stormwater runoff and estimating pollutant loadings. Existing impervious cover provides an estimate of current conditions in each subwatershed and serves as an important benchmark to assess future land use changes. Land use and impervious cover percentages can be used to initially categorize subwatersheds, help managers set expectations about what can be achieved in each subwatershed, and guide decisions in the watershed.

Task 4: Assemble Historical Monitoring Data in the Watershed

Good monitoring data that accurately characterizes the resource quality in a subwatershed are needed throughout the watershed planning process. Historical monitoring or modeling data are often available from past efforts (see example in Figure 5.2-3 below). For example, the Georgia DNR-WRD (Wildlife Resources Division) may possess fishery data and water quality data that may have been collected for a host of regulatory programs. Collecting historical data may significantly reduce the costs of initial baseline monitoring. Historical data may also provide information about the response of the water resource to land use change over time. This record can help managers evaluate current decisions in the context of the impacts of past decisions on the resource.

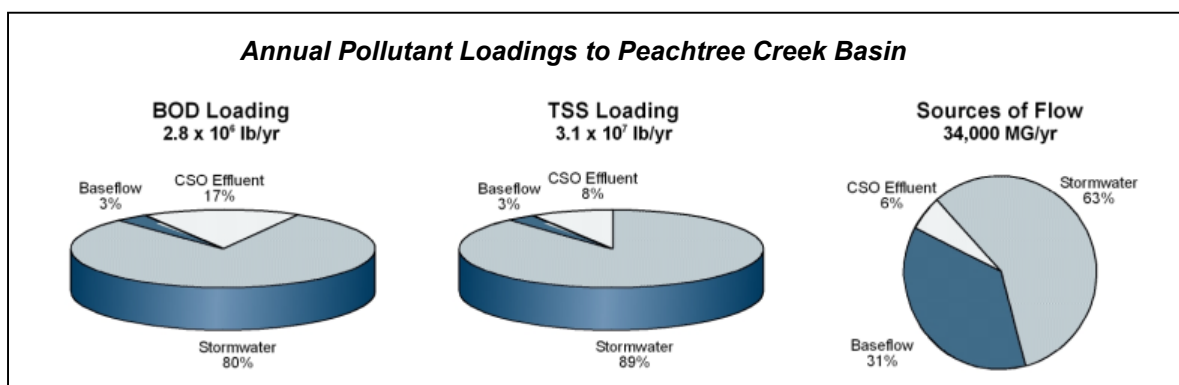


Figure 5.2-3 Use of Monitoring Data to Identify Problems and Issues
(Source: 1998, City of Atlanta. Metro Atlanta Urban Watershed Initiative Guidance Document)

Task 5: Assess Existing Mapping Resources

Maps depicting current conditions—including land use, potential pollution sources, problem areas, etc.—in each subwatershed, as well as management decisions made during the planning process, are an integral part of the watershed plan. The effort to produce these maps depends on what data are already mapped, and in what form. Also, some field measurements may not be required if recent maps of these features already exist.

Regional development authorities, state agencies, universities or environmental agencies may already have some maps, either in paper or digital form. The Georgia GIS Data Clearinghouse (www.gis.state.ga.us) is a good source of existing digital GIS data. Stakeholders are also a source to find existing mapping resources. Assigning one individual or a small group the task of assembling and manipulating mapping data is an effective way to set this baseline.

Task 6: Conduct an Audit of Local Watershed Protection Capability

The final element of the watershed baseline is a critical evaluation of the local capability to implement watershed protection tools and management alternatives. This evaluation or audit examines whether existing local programs, regulations, and staff resources are capable of implementing the watershed plan. If not, it identifies key areas that need to be improved. The scope of the audit can include an analysis of local master plans, ordinances, the development review process, performance criteria for stormwater controls and management practices, program funding, and staffing levels. The effort needed for the watershed audit depends to a great extent on the size and complexity of the local program(s), the number of staff employed, and the pace of development activity.

Step 2. Set up a watershed management structure

Establish the institutional organization responsible for the overall management and implementation of the watershed plan. Choosing the most effective watershed management structure to guide the development of the watershed and subwatershed plans is one of the more complex decisions a community or watershed planning team confronts. Successful watershed planning requires a strong organization to act as the driving force to focus the resources of a diverse group of stakeholders to implement the plan.

It is crucial to choose a watershed management structure that can be sustained over the life of the watershed planning and implementation process, as well as to revisit and update the plan as project goals are achieved or circumstances change.

A core set of features are needed to make watershed management structures effective:

- Adequate permanent staff to perform facilitation and administrative duties
- A consistent, long-term funding source to ensure a sustainable organization
- Including all stakeholders in planning efforts
- A core group of individuals dedicated to the project who have the support of local governmental agencies
- Local ownership of the watershed plan fostered throughout the process
- A process for monitoring and evaluating implementation strategies
- Open communication channels to increase cooperation between organization members

The first two features, permanent staffing and long-term funding, are probably the most important. Clearly, having a permanent staff and adequate funding go hand in hand. Regardless of the size, a successful management structure should define inter-agency and governmental partnerships and agreements needed to support the organization over the long term.

Step 3. Determine budgetary resources available for planning

Conduct an analysis to determine what level of staffing, financial and other resources are available to conduct the plan. Balance the available resources against the estimated cost of developing the plan.

One of the most important challenges confronting a community or watershed planning group is how to develop watershed and subwatershed plans within existing budget constraints. The watershed planning team needs to identify what sources of funding are available and to develop budgets for the subwatershed and watershed plans. Several current and future revenue sources may be available to finance the development of a watershed plan. This revenue may include both staff time and general funds. In early meetings, it is important to get clear commitments from each involved agency or group as to what resources they can commit to the watershed planning effort. Substantial savings can be realized if volunteers are available to conduct some of the analyses, if existing staff time is reallocated to work on the plan, or if the plan is part of a larger planning effort where some costs can be shared.

Step 4. Project future land use change in the watershed and its subwatersheds

Forecast future development, land use, and impervious cover in each subwatershed. This analysis will influence the goal setting process in Step 5.

As previously mentioned, land use in a watershed and its individual subwatersheds has a strong influence on water quality and aquatic ecosystems. In this step, it is recommended that the community forecast future land use and impervious cover based on available planning information such as future land use plans or master plans. Local comprehensive plans required under state law can be a valuable source of information for future land use projections.

Impervious cover projection is one indicator that can be used to determine if the quality of water resources will degrade from current conditions. If the analysis indicates that impervious cover will increase to such an extent that it will likely cause subwatershed quality to decline, a management plan to mitigate these future impacts should be developed.

Step 5. Fine tune goals for the watershed and its subwatersheds

Use known information about impacts to the watershed, and the goals of larger drainage units (e.g., river basins), to refine and develop goals for the watershed. In addition, determine objectives for each subwatershed to achieve watershed goals. The general goals identified in Step 1 should be added to and modified to reflect the results and inferences of the data collected and analyses performed in Steps 1– 4.

Goal setting is among the most important steps in watershed planning, and the management structure should ensure full involvement from stakeholders at this stage. Goal setting should proceed from the broad basin and sub-basin goals to the more specific goals needed for the watershed. These goals, in turn, need to be translated into even more specific objectives for each individual subwatershed. To set appropriate and achievable goals, the watershed planning team needs to perform several tasks, including:

Task 1: Interpret Goals at the River Basin Level That May Impact the Watershed

Watershed plans should be developed within the context of regional water resource management goals for river basins. Georgia EPD should be consulted early in the process to assist managers with these goals. Although not every river basin goal or objective may impact the watershed plan, managers should be aware of larger basin plan, and consider them when developing their own goals and objectives. Some examples of river basin goals that may directly influence the goal setting process at the watershed level include:

- Flood control
- Meeting state water quality standards / designated use
- Wildlife habitat enhancement
- Greenway establishment

Task 2: Develop Specific Goals for the Watershed

The goals set at the watershed level are the “bottom line” of the watershed plan. While these goals may be similar to those developed at the river basin level, they are usually more specific and quantifiable. Examples of watershed goals include:

1. Reduce flood damage from current levels
2. Reduce pollutant loads from the current level
3. Maintain or enhance the overall aquatic diversity in the watershed
4. Maintain or improve the current channel integrity in the watershed
5. Prevent development in the floodplain
6. Allow no net loss of wetlands
7. Maintain a connected buffer system throughout the watershed
8. Accommodate economic development in the watershed
9. Promote public awareness and involvement

These goals apply to the watershed as a whole, but may not always apply to every subwatershed within it. In addition, a watershed plan may have more unique multi-objective goals, such as developing a trail system for walking, biking, and jogging, preserving historically significant areas, and establishing outdoor education programs to foster community awareness and involvement. With diverse goals such as these, the importance of broad-based stakeholder involvement becomes all the more apparent.

Task 3: Assess if Subwatershed Management Objectives Can Be Met with Existing Zoning

Controlling and managing land use is an important tool to meet watershed management objectives. If a target development or impervious cover goal has been established for a watershed, managers will need to review current zoning and/or projected future land use to determine if these goals can be met. One method is to conduct a buildout analysis of current zoning to determine the projected land use and/or impervious cover in each subwatershed. This analysis can be used to identify which management objectives can be met with existing zoning.

Task 4: Determine if Land Use Patterns Can Be Shifted Among Watersheds

If the current zoning is not compatible with the management objectives, development may need to be shifted to other watersheds or subwatersheds. One way to accomplish this goal is by upgrading the zoning in watersheds that are designated to accommodate growth, while downzoning those watersheds that exceed the management goals. The effect is to shift development away from the streams and other water resources that will be most impacted by development, and toward areas where there is not as great of an impact. Other possible options include preserving undisturbed conservation areas (e.g., through land trusts, conservation easements, etc.) in a watershed, or by implementing strategies to reduce impervious cover.

The process described above is not simple. While controlling land use may be the most effective way to protect watersheds and subwatersheds, it can also be the most controversial recommendation in a watershed or subwatershed plan. Any change in zoning will require input from citizens, the development community, and local government. Furthermore, actually changing zoning can take a long time. Communities will need to use the legal tools they have available to change zoning appropriately, such as transfer of development rights, overlay zones, and floating zones.

Step 6. Develop watershed and subwatershed plans

A watershed plan is a detailed blueprint to achieve objectives established in the last step. A typical plan may include: revised zoning, stormwater design criteria and requirements, potential regional structural stormwater control locations, description of new programs proposed, stream buffer widths, monitoring protocols, and estimates of budget and staff needed to implement the plan. The four tasks needed to establish the watershed plan include:

Task 1: Select Watershed Indicators

Indicator monitoring provides timely feedback on how well aquatic resources respond to management efforts. Simple indicators can be selected to track changes in stream geometry, biological diversity, habitat quality, and water quality. For example, macroinvertebrate sampling is a relatively quick and inexpensive method to assess biological diversity. It can also be used to qualitatively assess aquatic habitat and water quality. A wide range of indicators can be used to assess the performance of management plans. The most appropriate indicators will depend largely on the management categories of the individual watersheds.

Task 2: Conduct Watershed-Wide Analyses and Surveys, if Needed

In some situations, a watershed plan may need to incorporate special analyses at the watershed level to supplement basic monitoring and analyses. A manager may decide to include a flood management analysis, pollutant load reduction analysis, or recreational greenway analysis. Other analyses that may be desirable include:

- Fishery and habitat sampling
- Stream reconnaissance surveys
- Stormwater structural control performance monitoring
- Bacteria source surveys
- Stormwater outfall surveys
- Detailed wetland identification
- Pollution prevention surveys
- Nutrient budget calculations
- Surveys of potential contaminant source areas
- Hazardous materials surveys
- Stormwater retrofit surveys
- Shoreline littoral surveys
- In-lake monitoring
- Hydro-geologic studies to define surface/groundwater interactions

Task 3: Prepare Subwatershed and Aquatic Corridor Management Maps

Maps that present the plan in a clear, uncomplicated manner are a key product of the subwatershed planning process. Maps range from highly sophisticated GIS maps to simple overlays of USGS quadrangle sheets. Mapping can generally be conducted at two scales, the subwatershed scale and the aquatic corridor scale.

Subwatershed maps represent an entire subbasin on a single map, and should be a component of all watershed plans. These maps represent the natural features and institutional information needed to produce a watershed plan. Aquatic corridor maps are produced at a much finer scale than subwatershed maps, and represent only the area immediately adjacent to the stream corridor or shoreline. Aquatic corridor maps are highly recommended, particularly when stream buffers or floodplain development limits are an important consideration in the watershed plan.

Task 4: Adapt and Apply Watershed Protection Tools

Just as different goals need to be established depending on a watershed's management category, so do the various tools used to protect that resource. For example, while structural stormwater controls are recommended as a component of all management plans, the types of controls used will be different depending on the specific characteristics of a given watershed. The suite of watershed protection tools will be presented later in this chapter. An example of a watershed plan presenting different management control alternatives for its subbasins is shown in Figure 5.2-4.

Step 7. Adopt and implement the plan

Determine what steps are needed to effectively implement the plan. Implementation of the recommendations of a local watershed management plan can take place through a number of related mechanisms:

- In some communities the watershed or master plan is adopted (often by reference) in its stormwater ordinance and essentially becomes an overlay district wherein development decisions must follow plan recommendations for various parts of the watershed. In others it is not mandatory, but is referred to when rezoning and plans approval decisions are made by staff and zoning boards.
- The local long-term capital improvement plan can be derived from the recommendations of the plan. Special assessment districts, fee-in-lieu charges, system development charges, or other funding mechanisms can be established to help pay for specific improvements identified in the plan.
- Comprehensive plans can be modified to incorporate the recommendations of the watershed or stormwater master plan into long-term land use planning, transportation plans, etc. Parks and open space plans can use the results of the plan to insure the multi-objective nature of the plans are implemented combining engineering function with aesthetics and recreational opportunities.

Subbasin/Scenario	Control Alternative													
	Stormwater Detention	Quantity (ac)	Streambank Restoration	Quantity (lf)	Riparian Zone Restoration	Quantity (lf)	Pool Development	Quantity (each)	Upland Water Quality Detention	Enhanced Erosion Control	Major Creek Clean-up	Enhanced Removal of Illicit Connections	Development Controls	Capital Cost (\$M)
Upper North Fork Peachtree Creek Subbasin														
Scenario 1-Rehab Tribs and Main Stem	X	120	X	286,740	X	430,110	X	70				X		51.2
Henderson Mill Creek Subbasin														
Scenario 1-Rehab Tribs and Main Stem	X	58	X	66,685	X	80,020								18.7
Lower North Fork Peachtree Creek Subbasin														
Scenario 1-Rehab Tribs with Industrial Source Control	X	212	X	250,300	X	216,925	X	264	X		X	X		78.7
Scenario 2-Rehab Tribs and Main Stem	X	212	X	313,315	X	271,540	X	442			X	X		78.3
Burnt Fork Creek Subbasin														
Scenario 1-Rehab Tribs and Main Stem	X	50	X	73,070	X	77,130					X	X		18.5
Peavine Creek Subbasin														
Scenario 1-Rehab Tribs and Main Stem			X	58,815	X	67,860	X	75						2.2
South Fork Peachtree Creek Subbasin														
Scenario 1-Rehab Main Stem	X	189	X	24,885	X	62,215	X	104						54.9
Scenario 2-Rehab Tribs and Main Stem	X	189	X	61,890	X	92,515	X	124						56.6
Tanyard Creek Subbasin (Stormwater Area)														
Scenario 1-Rehab Tribs	X	17	X	10,880	X	24,175	X	0		X		X		5.2
Scenario 2-Rehab Tribs and Main Stem	X	17	X	17,580	X	39,060	X	48		X		X		5.5
Clear Creek Subbasin (Stormwater Area)														
Scenario 1-Rehab Tribs	X	32	X	27,230	X	17,020	X	0		X		X		10.7
Scenario 2-Rehab Tribs and Main Stem	X	32	X	48,485	X	30,300	X	22		X		X		12.0
Peachtree Creek Subbasin														
Scenario 1-Rehab Main Stem	X	120	X	67,540	X	75,045	X	167				X		37.1
Scenario 2-Rehab Tribs and Main Stem	X	120	X	97,305	X	223,875	X	228				X		38.9
Note: ac = acre; lf = linear foot; \$M = million dollars - Pool development involves the placement of boulders in the stream to allow the formation of pools downstream of the boulder cluster. - "0" value indicates that alternative was found to be impractical due to intermittent flows.														

Table 5.2-2 Example of Subwatershed Management Alternatives from a Watershed Plan
 (Source: 1998, City of Atlanta. Metro Atlanta Urban Watershed Initiative Guidance Document)

- Some communities use the computer models of the drainage system developed in a watershed or master plan in a real-time format as tools to assist in decision making about the need for detention, downstream impact assessment, zoning approvals, etc.
- An ad hoc inter-staff team is often effective in coordinating the provisions of the plan across local government departments.
- Various recommendations in the plan may be implemented through non-profit citizen groups who "adopt" the watershed. These groups can be instrumental in gaining public acceptance and involvement, carrying out the recommendations of the plan, obtaining funding, and providing surveillance and reporting of watershed activities.

The best ways to ensure that a plan is implemented are to incorporate the right stakeholders, realistically assess budgetary resources, develop a scientifically and economically sound plan, and mandate its use in the development process. A good plan in itself does not guarantee implementation. As the plan is being developed, and afterwards, watershed planners need to work to ensure that local governments have both the regulatory authority and the resources to implement the plan. It is important that the plan is not isolated from other government planning and construction activities.

The implementation of a watershed plan typically costs about ten times as much as the planning process. Some stable funding source needs to be identified to support plan implementation. One of the greatest costs of watershed implementation is the staff resources needed to continue monitoring in the watershed, design and build structural controls and retrofits, and enforce the ordinances and laws that might be called for in the plan.

Step 8. Revisit and update the plan

Periodically update the plan based on new development in the watershed or results from monitoring data.

A one-time watershed study only identifies what problems exist in a watershed. Many local governments, for one reason or another, take on watershed planning without realizing that it is an ongoing process rather than a report.

Each subwatershed or watershed plan should be prepared with a defined management cycle of five to seven years. Individual plans are prepared in an alternating sequence, so that a few are started each year with all plans within a given region or jurisdiction ideally being completed within a five to seven year time span. A management cycle helps balance workloads of watershed staff and managers, by distributing work evenly throughout the cycle's time period.

5.3 Integration of Site and Watershed-Level Stormwater Planning

5.3.1 Introduction

Integrating site level development and watershed level planning can be a significant institutional challenge. It is likely that local governments will need to reevaluate their standard operating procedures for stormwater management and evolve towards a less compartmentalized mentality that strives for open communication between departments and agencies. In addition, inter-jurisdictional cooperative efforts are often needed, where communication and consensus building among stakeholders is critical.

Many local stormwater programs already have both development requirements and watershed level planning components. However, the challenge is to develop a set of incentives and/or requirements that site planners and engineers will adopt and follow in order to comply with watershed level planning efforts. In addition, watershed plans should be developed and implemented in a manner that considers the potential adverse impacts of site development. In other words, watershed protection measures should coincide with the development cycle (i.e., planning, design, construction, and post-construction).

5.3.2 Using the Local Review Process to Comply with Watershed Plans

An important, yet frequently overlooked, task facing local regulators and plan reviewers is to ensure that local review requirements are tied to the watershed plan. There are four major occasions during the site development process where local regulators should check for agreement and consistency with existing watershed plans. These checks serve as an enforcement mechanism for watershed plan implementation. The five key review occasions are:

- Pre-consultation Meeting and Joint Site Visit
- Stormwater Management Concept Plan Submittal
- Preliminary / Final Stormwater Site Plan Submittal
- Permit Acquisition
- Final Record / As-Built Plat

These recommended checkpoints are directly applicable to the procedure for preparing and reviewing stormwater management site plans that is covered in Chapter 4. By utilizing this series of checkpoints throughout the local review process, communities can help to ensure that existing watershed plans are consistently referred to and that necessary measures can be taken to comply with the goals and objectives of the plans. Multiple checkpoints also provide some assurance that the sometimes diverse goals and objectives of a watershed plan are adequately reviewed by qualified and appropriate regulators.

Pre-consultation Meeting and Joint Site Visit

The primary purpose of this checkpoint is to ensure that the proposed land use of the development project is consistent with the goals and objectives of the watershed plan. This step allows the local review authority to outline any specific stormwater management requirements from the watershed plan, as well as any opportunities for site resource conservation and improved stormwater management on the development site and within the subwatershed.

Stormwater Management Concept Plan Submittal

It is recommended that a stormwater management concept plan be prepared, reviewed, and approved by the local review authority. At this review checkpoint, qualified staff should ensure that the preliminary designs being proposed not only meet all of the on-site stormwater management requirements of the local jurisdiction, but that the plan also considers broader issues associated with applicable watershed plans. For example, if fecal bacteria loads are a concern within the watershed, the plan reviewer should look to see that proposed stormwater control practices have a demonstrated ability to provide adequate bacteria removal. From a flood control standpoint, the reviewer would ensure that there are no conflicts with the proposed development and mapped floodplain boundaries from the watershed plan.

Preliminary / Final Stormwater Site Plan Submittal

At this checkpoint, the local review authority must confirm that the proposed stormwater management system from the concept plan has been adequately designed and analyzed to meet the watershed plan goals. For example, a watershed plan may have structural stormwater control maintenance goals. If maintenance agreements are not already a component of the local stormwater management criteria, this would be a case where the reviewer could require specific maintenance conditions for the development.

Permit Acquisition

There are a host of permits that may be required for a development project, such as clearing and grading, building, construction NPDES erosion and sediment control, wetlands, floodplain, etc. The permitting stage is another important checkpoint to ensure consistency with watershed plans, as permitting authorities are often part of a separate local department. In some cases, permitting will involve state and federal agencies (e.g., Corps of Engineers 404 wetlands permits). By definition, there are criteria that must be met for a permit to be issued; however, it should not be presumed that these criteria are consistent with, or as stringent as, the goals and objectives of a watershed plan.

In some cases, it may be desirable to have conditions attached to a permit so that the goals of the watershed plan can be met. For example, a watershed may have historically experienced significant sediment loading from uncontrolled construction sites, and consequently, a goal of the watershed plan is to promote construction site phasing by limiting the amount of contiguous cleared area to a specified number of acres. Under this scenario, the issuer of the clearing and grading permit might place a condition on the permit that restricts the amount of land cleared at a given time.

Final Record / As-Built Plat

A final method to ensure that the goals of a watershed plan are being implemented at the site level through the review process is to record any significant easements, buffers, or resource protection areas on the final record plat or as-built (i.e., legal document). This helps to maintain important protection areas through any land acquisition or transfer deals. Protection areas that might be recorded on a final plat include conservation easements, riparian buffer zones, and other open space conservation areas.

5.4 Inter-jurisdictional Watershed Planning

Because watershed boundaries do not coincide with political jurisdictions, more than one city or county must often be involved in watershed planning efforts. Successful watershed management can only occur if all jurisdictions within a watershed boundary are involved at some level and committed to the same set of goals.

The challenge is to develop effective inter-jurisdictional watershed plans that are proactive, well-defined, well-funded, and adequately staffed. The key ingredients to meet the challenge are:

- Develop a broad-based consensus for the need to protect and manage the specified watershed. Establish a memorandum of understanding (MOU) or a memorandum of agreement between interested/concerned jurisdictions and agencies.
- Obtain some level of funding commitments from signatory parties.
- Establish a technical committee to develop and coordinate watershed management efforts.
- Consistently evaluate and update the watershed plan efforts.

An example of an inter-jurisdictional watershed planning effort in Georgia is the Big Haynes Watershed Protection Program. The Big Haynes Creek Watershed is an 82 square mile watershed located about 20 miles east of Atlanta in Gwinnett, Newton, Rockdale and Walton Counties (see Figure 5.4-1). The watershed drains into the Big Haynes Reservoir, the water supply source for Rockdale County and the city of Conyers.

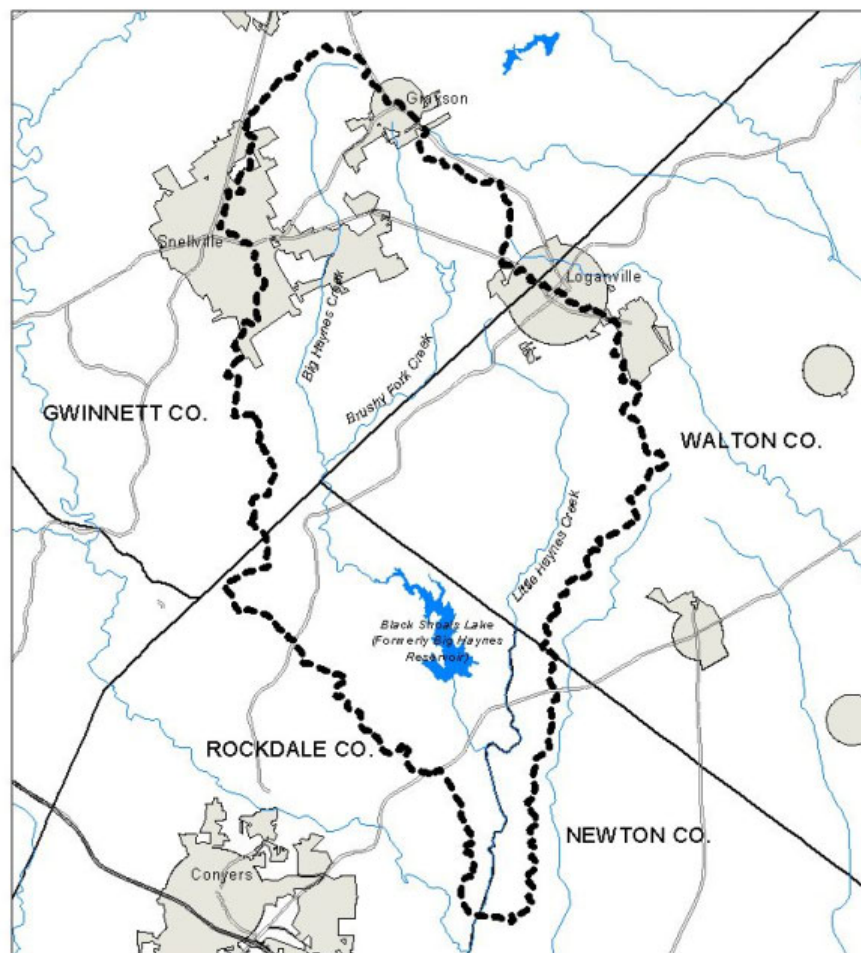


Figure 5.4-1 Big Haynes Creek Watershed

The reservoir watershed was urbanizing rapidly and faced pollution problems from stormwater runoff. Rockdale County provided protection measures for the creek, which was first identified as a possible water source in the 1970's, by establishing three-acre minimum zoning in the proposed reservoir watershed. However, a major obstacle to protection is that about 76 percent of the 82 square mile watershed is controlled by jurisdictions outside Rockdale County. The challenge facing these governments was, and is, to develop and implement a plan to maintain a high quality water supply source while also allowing continued economic and population growth in an area facing significant development pressure.

To develop more flexible standards than the State EPD's 25% impervious cover rule while still providing water quality protection, the governments in the watershed and the Atlanta Regional Commission committed to conduct and finance a watershed study and the development of a watershed management plan in 1991. The study recommendations included a 2020 land use scenario as well as options for the local governments in developing their own watershed protection measures.

Following the study's completion, the participating governments signed an inter-governmental agreement in September 1995 creating the Big Haynes Watershed Council as well as a supporting Technical Advisory Committee to oversee enactment of study recommendations, review effectiveness of the watershed protection program, and to meet on mutual concerns. In 1999, the Watershed Council began a study of regional stormwater ponds through a federal grant that may eventually result in a demonstration project for regional ponds in the watershed. Big Haynes serves as a good model as to how local, regional, and state governments can cooperatively work to achieve specific water resource protection goals.

5.5 Implementation of Watershed Plans

5.5.1 Introduction

Watershed plan implementation is an involved process that requires the simultaneous consideration of many issues including watershed management and protection tools, stakeholder involvement, cost, and the assessment of plan performance. The following discussion provides detail about key components of plan implementation.

5.5.2 Tools of Watershed Management and Protection

Once a watershed management plan has been developed, a community requires the necessary means to implement the plan and accomplish its goals. The following toolbox can provide a local government with some of the methods and mechanisms that can be used to achieve watershed plan goals. Though each of these tools will generally be used in some form in every watershed, they will most likely be applied in different ways in various communities and from one watershed to the next.

1. Land Use Planning / Zoning

Zoning and land use planning are the most widely used tools for managing growth and development that communities have at their disposal. The watershed management plan can be adopted by the community and referred to when rezoning and plans approval decisions are made by staff and zoning boards. This can be used to preserve sensitive areas, maintain or reduce the impervious cover within a given subwatershed, and redirect development toward subwatersheds that can support a particular type of land use and/or density.

A wide variety of land use planning and/or zoning techniques can be used to manage land use and impervious cover within a watershed. These techniques are summarized in Table 5.5-1.

Table 5.5-1 Land Use Planning Techniques

<u>Land Use Planning Technique</u>	<u>Description</u>	<u>Use as a Watershed Protection Measure</u>
Watershed-Based	Zoning restrictions specific to a particular watershed or subwatershed.	Can be used to protect water resources in a particular watershed and/or relocate development.
Overlay Zoning	Superimposes additional regulations or specific development criteria within specific mapped districts.	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to limit potential stormwater runoff and pollutants from a given site or watershed.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district	Can be used to require additional levels of performance within a watershed or at the site level.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness and may promote urban sprawl.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated “sending area” to a designated “receiving area.”	May be used in conjunction with watershed based zoning to restrict development in areas and encourage development in areas capable of accommodating increased densities.
Limiting Infrastructure Extensions	A conscious decision is made to limit or deny extending infrastructure (such as public sewer, water, or roads) to designated areas to avoid increased development in these areas.	May be used as a temporary method to control growth in a targeted watershed or subwatershed. Usually delays development until the economic or political climate changes.

2. Land Acquisition and Conservation

Land acquisition and land conservation are important elements of any watershed management program. They allow a community to protect critical environmental areas and stormwater management resources. There are several techniques that can be used to conserve land, which provide a continuum ranging from absolute protection to very limited protection. Representative land conservation techniques include land purchases, land donations, conservation easements, and public sector stewardship. A community can also promote the protection of conservation areas on individual site developments by advocating the better site design concepts described in Volume 2 of the Manual.

The Georgia Greenspace Program was established in 2000 to assist cities and counties in preserving open community greenspace which can be used for natural resource protection. More information can be found at www.state.ga.us/dnr/greenspace

3. Riparian Buffers and Greenways

The creation of a riparian buffer system is key in mitigating flood impacts and protecting water quality and streambanks in urban areas. Technically speaking, a buffer is a type of land conservation area, but it has added importance in a stormwater management sense in its ability to provide water quality, flood prevention and channel protection benefits.

Buffers create a natural "right of way" for streams that protect aquatic ecosystems and provide a safe conduit for potentially dangerous and damaging floodwaters. Buffers provide water quality benefits and protection for streams, rivers and lakes. Buffers also serve as valuable park and recreational systems that enhance the general quality of life for residents. Finally, buffers can provide valuable wildlife habitat and act as wildlife corridors for smaller mammals and bird species that are present in urban areas.

Establishing a comprehensive and contiguous buffer system, or "greenway," should be a goal of virtually all watershed plans. To achieve this goal, effective and clear guidance and enforcement must occur at the site level, especially for smaller headwater streams.

4. Better Site Design Techniques

A community can promote a suite of better site design practices and techniques to reduce the amount of stormwater runoff and pollutants generated in a watershed, as well as to provide for nonstructural treatment and control of runoff. The watershed plan should specify which better site design techniques are most applicable in individual subwatersheds to meet the plan's goals and objectives.

5. Structural Stormwater Controls

Structural stormwater controls are constructed stormwater management facilities designed to treat stormwater runoff and/or mitigate the effects of increased stormwater runoff peak rate, volume, and velocity due to urbanization. A watershed plan needs to ensure that stormwater controls are being properly designed, constructed, and maintained in the watershed. Watershed plans can help to determine if special or additional criteria are required for the selection and design of structural controls, and can provide guidance on the location of potential regional facilities or necessary structural control retrofits within the watershed.

6. Erosion and Sediment Control

Construction site erosion and sediment control is a critical component in reducing the total suspended solid (TSS) loading to receiving waters and improving overall water quality in a watershed. Thus, a watershed plan should include provision for full implementation of an erosion and sediment control program and enforcement of state and federal requirements. Better site design practices that reduce the total area that is cleared and graded should be promoted. Diligent plan review and strict construction enforcement are key to the success of local E&S programs.

7. Elimination of Non-Stormwater Discharges

In some watersheds, non-stormwater discharges such as combined sewer overflows (CSO's) and greywater from commercial entities and illicit connections can contribute significant pollutant loads to receiving waters. Key program elements in a watershed plan include inspections of private septic systems, repair or replacement of failing systems, utilizing more advanced on-site septic controls, identifying and eliminating illicit connections from municipal stormwater systems, and spill prevention.

8. Watershed Stewardship Programs

The goal of watershed stewardship is to increase public understanding and awareness about the watershed plan and goals. A watershed public information and education program strives to increase stakeholder awareness of their role in the protection of water resources, promote better stewardship of private lands, and develop funding to sustain watershed management efforts.

Basic programs that communities should consider to promote greater watershed stewardship include:

- Watershed and stormwater/nonpoint source pollution education
- Pollution prevention
- Adopt-A-Stream programs
- Watershed maintenance and cleanup activities

5.5.3 Stakeholder Involvement Techniques

Stakeholder involvement and interaction is essential to the implementation of watershed plans. A citizen advisory committee (CAC) is an important feature of an effective watershed management structure. A typical CAC is open to broad citizen participation and provides direct feedback to the management structure on public attitudes and awareness in the watershed. Meaningful involvement by a CAC is often critical to convince the community and elected leaders of the need for greater investment in watershed protection.

Some of the possible functions of a citizen's advisory committee are:

- Organize media relations and increase watershed awareness:
 - press releases
 - informational flyers
 - watershed awareness campaigns
 - liaison between citizen groups and government agencies
- Provide input on workable stewardship programs
- Coordinate programs to engage watershed volunteers, such as:
 - stream monitoring
 - stream clean-ups
 - adopt-a-stream programs
 - tree planting days
 - storm drain stenciling
- Explore funding sources to support greater citizen involvement

Another common feature of an effective watershed management structure is the reliance on a technical advisory committee (TAC) to support the overall watershed planning effort. A TAC is routinely made up of a public agency staff and independent experts who have expertise in scientific matters. Some of the possible functions of a technical advisory committee are:

- Evaluate current and historic monitoring data and identify data gaps
- Coordinate agency monitoring efforts within the watershed to fill these gaps
- Interpret scientific data for the whole watershed management organization
- Assess and coordinate currently approved implementation projects

Various recommendations in a watershed plan may be implemented through non-profit citizen groups who “adopt” the watershed. These groups can be instrumental in gaining public acceptance and involvement, carrying out the recommendations of the plan, obtaining funding, and providing surveillance and reporting of watershed activities.

5.5.4 Cost (Budget)

As with the watershed planning process, a serious challenge confronting a community is how to implement watershed and subwatershed plans within existing budget constraints. As part of the planning effort the watershed planning team will need to identify the sources of funding that are available and develop budgets for both the subwatershed and watershed plan implementation efforts. Many of the local program funding mechanisms discussed in Chapter 3 are also applicable to watershed plan implementation efforts.

5.5.5 Performance Monitoring and Assessment

There are several different monitoring techniques or indicators that can be used to assess the performance of a watershed plan. The range of monitoring extends from the more complex chemical or toxicity testing methods to more simplified physical or biological techniques. Table 5.5-3 provides a list of watershed monitoring techniques or indicators that can be used in watershed monitoring, as well as the initial planning process. The list covers a wide range of alternatives that can be utilized to assess positive and/or negative trends in water quality, aquatic integrity and watershed health.

Regardless of the specific indicators selected, it is important to use scientifically valid assessment techniques, quality controls, and valid sampling protocols to ensure that results are repeatable, consistent, and compatible with other data collection efforts.

To effectively monitor the performance of the watershed plan, it is recommended that water quality and biological monitoring be performed on an aggregate basis at key locations in the watershed and not on a site by site basis. Monitoring for the NPDES MS4 program and numerous other studies have confirmed the extreme variability of stormwater quality and physical stream/habitat conditions due to many influencing factors. These factors are most variable at a single individual site. At the larger watershed level, however, some of the variability is dampened allowing for a better evaluation of plan implementation on stream and watershed health.

Table 5.5-3 Potential Watershed Indicators

Water quality indicators:

Water quality pollutant monitoring
Toxicity testing of contaminants
Non-point source loadings
Frequency of water quality violations
Sediment contamination
Human health criteria

Biological indicators:

Fish assemblage
Macro-invertebrate assemblage
Single species indicator
Composite indicators
Other biological indicators

Programmatic indicators:

Number of illicit connections identified/corrected
Number of structural controls installed, inspected,
and maintained
Permitting and compliance

Physical and hydrological indicators:

Stream widening/downcutting
Physical habitat changes affecting
biodiversity
Impacted dry weather flows
Increased flooding frequencies
Stream temperature changes

Social indicators:

Public attitude surveys
Industrial/commercial pollution
prevention
Public involvement and monitoring
User perception

Site indicators:

Structural control performance
monitoring
Industrial site compliance monitoring

5.6 Regional vs. On-site Stormwater Management

5.6.1 Introduction

Using individual, on-site structural stormwater controls for each development is the typical approach in most communities for controlling stormwater quantity and quality, as is described in Chapter 4. The developer finances the design and construction of these controls and, initially, is responsible for all operation and maintenance. However, the local government is likely to become responsible for maintenance activities if the owner fails to carry them out.

A potential alternative approach is for a community to install a few strategically located regional stormwater controls in a subwatershed rather than require on-site controls (see Figure 5.6-1). For this Manual, regional stormwater controls are defined as facilities designed to manage stormwater runoff from multiple projects and/or properties through a local jurisdiction-sponsored program, where the individual properties may assist in the financing of the facility, and the requirement for on-site controls is either eliminated or reduced.

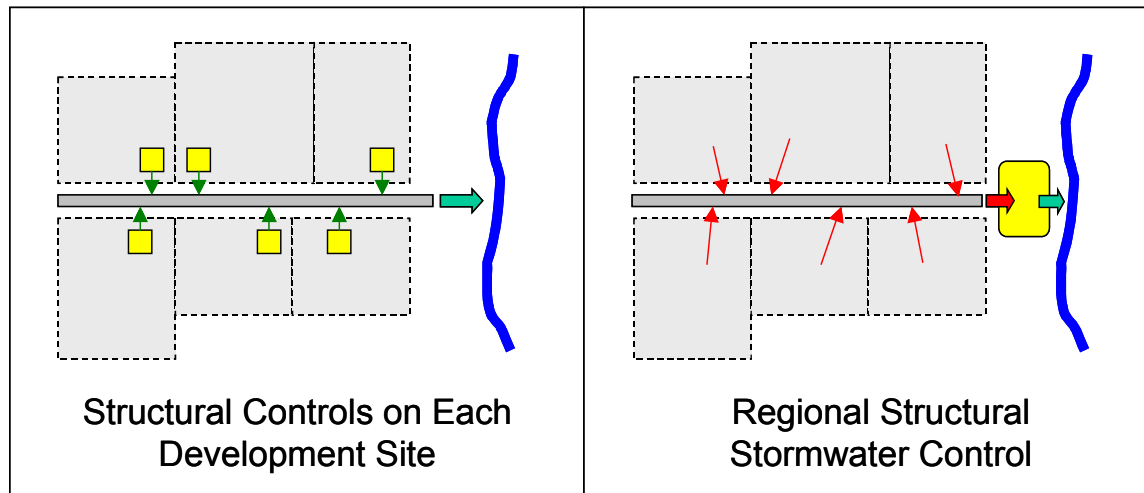


Figure 5.6-1 On-site Versus Regional Stormwater Management

5.6.2 Advantages and Disadvantages of Regional Stormwater Controls

Regional stormwater facilities are significantly more cost-effective because it is easier and less expensive to build, operate, and maintain one large facility than several small ones. Design and construction of regional controls are estimated to cost from \$1,250 to \$2,000 per acre of residential development and \$1,750 to \$2,500 per acre of nonresidential development. Regional stormwater controls are generally better maintained than individual site controls because they are large, highly visible and typically the responsibility of the local government. In addition, a larger facility poses less of a safety hazard than numerous small ones because it is more visible and is easier to secure.

There are also several disadvantages to regional stormwater controls. In many cases, a community must provide capital construction funds for a regional facility, including the costs of land acquisition. However, if a downstream developer is the first to build, that person could be required to construct the facility and later be compensated by upstream developers for the capital construction costs and annual maintenance expenditures. Conversely, an upstream developer may have to establish temporary control structures if the regional facility is not in place before construction. Maintenance responsibilities generally shift from the homeowner or developer to the local government when a regional approach is selected. The local government would need to establish a stormwater utility or some other program to fund and implement stormwater control. Finally, a large in-stream facility can pose a greater disruption to the natural flow network and is more likely to affect wetlands within the watershed.

Below are summarized some of the “pros” and “cons” of regional stormwater controls.

Advantages of Regional Stormwater Controls

- **Reduced Construction Costs** – Design and construction of a single regional stormwater control facility can be far more cost-effective than numerous individual on-site structural controls.
- **Reduced Operation and Maintenance Costs** – Rather than multiple owners and associations being responsible for the maintenance of several storm water facilities on

their developments, it is simpler and more cost effective to establish scheduled maintenance of a single regional facility.

- **Higher Assurance of Maintenance** – Regional stormwater facilities are far more likely to be adequately maintained as they are large and have a higher visibility, and are typically the responsibility of the local government.
- **Maximum Utilization of Developable Land** – Developers would be able to maximize the utilization of the proposed development for the purpose intended by minimizing the land normally set aside for the construction of stormwater structural controls.
- **Retrofit Potential** – Regional facilities can be used by a community to mitigate existing developed areas that have insufficient or no structural controls for water quality and/or quantity, as well as provide for future development.
- **Other Benefits** – Well-sited regional stormwater facilities can serve as a recreational and aesthetic amenity for a community.

Disadvantages of Regional Stormwater Controls

- **Location and Siting** – Regional stormwater facilities may be difficult to site, particularly for large facilities or in areas with existing development.
- **Capital Costs** – The community must typically provide capital construction funds for a regional facility, including the costs of land acquisition.
- **Maintenance** – The local government is typically responsible for the operation and maintenance of a regional stormwater facility.
- **Need for Planning** – The implementation of regional stormwater controls requires substantial planning, financing, and permitting. Land acquisition must be in place ahead of future projected growth.

For in-stream regional facilities:

- **Water Quality and Channel Protection** – Without on-site water quality and channel protection, regional controls do not protect smaller streams upstream from the facility from degradation and streambank erosion.
- **Ponding Impacts** – Upstream inundation from a regional facility impoundment can eliminate floodplains, wetlands, and other habitat.

5.6.3 Important Considerations for the Use of Regional Stormwater Controls

If a community decides to implement a regional stormwater control, then it must ensure that the conveyances between the individual upstream developments and the regional facility can handle the design peak flows and volumes without causing adverse impact or property damage. Full-buildout conditions in the regional facility drainage area should be used in the analysis.

In addition, unless the system consists of completely man-made conveyances (i.e. storm drains, pipes, concrete channels, etc) then on-site structural controls for water quality and downstream channel protection will need to be required for all developments within the regional facility's drainage area. Federal water quality provisions do not allow the degradation of water bodies from untreated stormwater discharges, and it is U.S. EPA policy to not allow regional stormwater controls that would degrade stream quality between the upstream development and the regional facility. Further, without adequate channel protection, aquatic habitats and water quality in the channel network upstream of a regional facility may be degraded by streambank erosion if they are not protected from bankfull flows and high velocities.

Based on these concerns, both the EPA and the U.S. Army Corps of Engineers have expressed opposition to *in-stream* regional stormwater control facilities. In-stream facilities should be avoided if possible and will likely be permitted on a case-by-case basis only.

It is important to note that siting and designing regional facilities should ideally be done within a context of a stormwater master planning or watershed planning to be effective.

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FLOODPLAIN MANAGEMENT

6.1 Local Floodplain Management and Stormwater Management

6.1.1 Introduction

Floodplain management involves the designation of flood-prone areas and the limiting of their uses to those compatible with a given degree of risk. It is also aimed at minimizing modifications to streams, reducing flood hazards, and protecting the water quality of streams. As such, floodplain management can be seen as a subset of the larger consideration of surface water and stormwater management within a local community.

Stormwater management has traditionally been involved with the protection of downstream areas from flooding by mitigating the cause of increased flows, whereas floodplain management has dealt with mitigating the effects of floodwaters. However, new emphasis on water quality, nonstructural approaches and watershed management have caused stormwater management and floodplain management to overlap, particularly in regard to the use of riparian areas for mitigating stormwater quantity and quality. The development of riparian buffers and greenway corridors along streams and rivers can preserve floodplain areas and protect their function in safely conveying floodwaters and protecting water quality. Floodplain regulations and development restrictions, particularly when based upon the full build-out 100-year floodplain, can greatly reduce future flooding impacts, preserve habitat, and may allow communities to waive stormwater quantity control requirements for larger storm events.

The concepts related to floodplain management have broadened and matured in parallel with those of stormwater management. Prior to the mid-1960's, flood control in Georgia and elsewhere had been seen primarily as a structural control program wherein dams, levees and other flood control works were constructed to keep floodwaters away from developed areas. Beginning in 1966, the focus has steadily shifted toward protecting property and human life from flood waters through floodplain regulations, flood insurance, public education, post disaster assistance, the community rating system (CRS) and other flood loss reduction strategies often administered as part of a local stormwater management program.

Since the early 1970's, with the passage of the Flood Disaster Protection Act, most communities in Georgia have adopted, at a minimum, a floodplain ordinance and programmatic requirements to be eligible for the Federal flood insurance program. By the late 1980's, communities began to include the restoration and preservation of the natural values of floodplain areas into their floodplain management programs. Today the focus of floodplain management has broadened to include the notion that floodplains are only one component of an overall watershed-based water resource management program.

6.1.2 Floodplain Management Goals

Floodplain management is a decision-making and regulatory process, the goal of which is to achieve the wise use of local floodplains. "Wise use" means to define and make choices among often competing demands for floodplain locations. It includes the responsibility to regulate uses that are compatible with, and balance: (1) the need to preserve the natural and beneficial

functions of floodplains, (2) allow for economic development where necessary and appropriate, and (3) minimize risk to human life and risk of property damage. Local floodplain policy should be developed based upon the following principles:

- Floodplain management should balance economic development, environmental quality, and health and safety.
- Development in flood prone areas, or adversely affecting floodplains, should be avoided unless it is considered necessary for the public interest.
- New developments adjacent to floodplains should not increase the risk of flooding for other properties.
- Capital and operating costs of floodplain management should be shared equitably among the public and specific beneficiaries instead of being borne by floodplain landowners.
- Consideration should be given to a combination of structural and non-structural tools to reduce flood damages.
- The floodplain should be considered in the context of the collective needs of the local community and as a part of a larger watershed.

6.2 National Flood Insurance Program

6.2.1 Background

In response to worsening flooding problems, Congress created the National Flood Insurance Program (NFIP) in 1968 to reduce flood losses and disaster relief cost by guiding future development away from flood hazard areas where practicable, requiring flood-resistant design and construction and transferring costs of losses to floodplain occupants through flood insurance premiums.

The National Flood Insurance Program has played a critical role in fostering and accelerating the principles of floodplain management. Flood insurance is available to floodprone communities through the NFIP, which is administered by the Federal Emergency Management Agency (FEMA). Prior to the NFIP, flood insurance was generally unavailable from the private sector and most communities did not regulate floodplain development.

The NFIP was broadened and modified by the Flood Disaster Protection Act of 1973, which requires the purchase of flood insurance as a condition for receiving any form of federal or federally related financial assistance, such as mortgage loans from federally insured lending institutions. Many communities have established floodplain management programs and adopted floodplain management statutes and regulations that go beyond NFIP requirements.

The National Flood Insurance Reform Act (NFIRA), signed into law in 1994, strengthened the NFIP by providing for mitigation insurance and establishing a grant program for state and community flood mitigation planning projects. The NFIRA also codified the Community Rating System (CRS), established objectives for CRS and directs that credits may be given to communities that implement measures to protect natural and beneficial floodplain functions and manage the erosion hazard. The CRS is an incentive program whereby communities that exceed the minimum requirements of the NFIP secure reductions in the flood insurance premiums for their residents.

6.2.2 NFIP Program Requirements

For flood insurance purposes, the *floodplain* is defined as the area inundated by the one-percent chance (100-year) flood [see Figure 6.2-1]. Within these outer boundaries there is another area, termed the *floodway*, in which the depths of flow and high velocities are such that construction of structures within these boundaries would entail unacceptable risk of loss and obstruction of the free flow of the waterbody. The area between the floodway and the outer edge of the 100-year floodplain is termed the *flood fringe*.

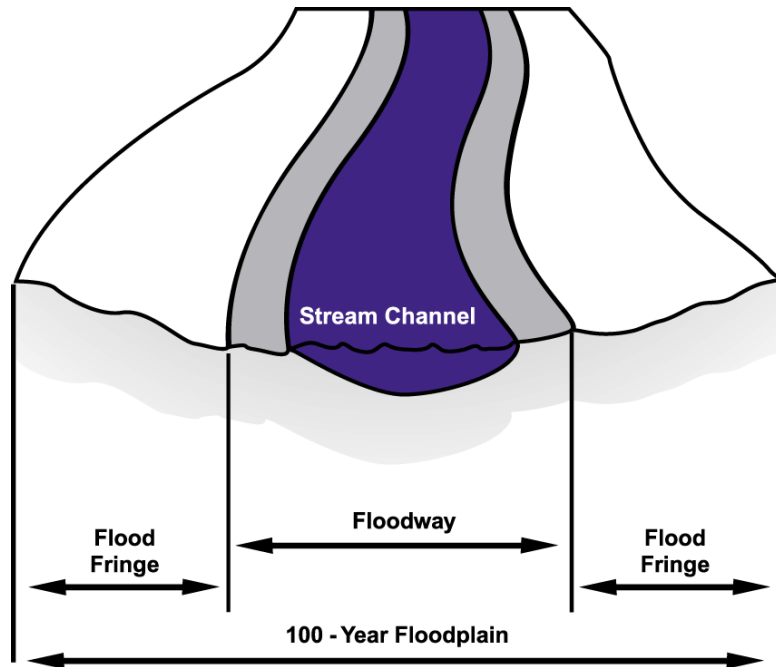


Figure 6.2-1 Floodplain Definitions

Minimum program requirements for communities under the NFIP include:

- Permitting for all proposed new development (includes new buildings, improvements to buildings, filling, grading, or any other human-caused change to the land);
- Reviewing subdivision proposals to assure that they will minimize flood damage;
- Anchoring and floodproofing structures to be built in known flood prone areas;
- Safeguarding new water and sewer lines from flooding; and
- Enforcing risk zone, base flood elevation, and floodway requirements after the flood insurance map for the area becomes effective.

Figure 6.2-2 shows an example of a FEMA flood map used in the NFIP. Penalties for non-participation in the federal program involve reduced or denial of access to federal disaster funding and home loans, higher flood insurance rates, or loss of ability to obtain any flood insurance. Information on the Georgia National Flood Insurance Program can be obtained by contacting the Georgia DNR Floodplain Management Unit (see Appendix A for contact information).

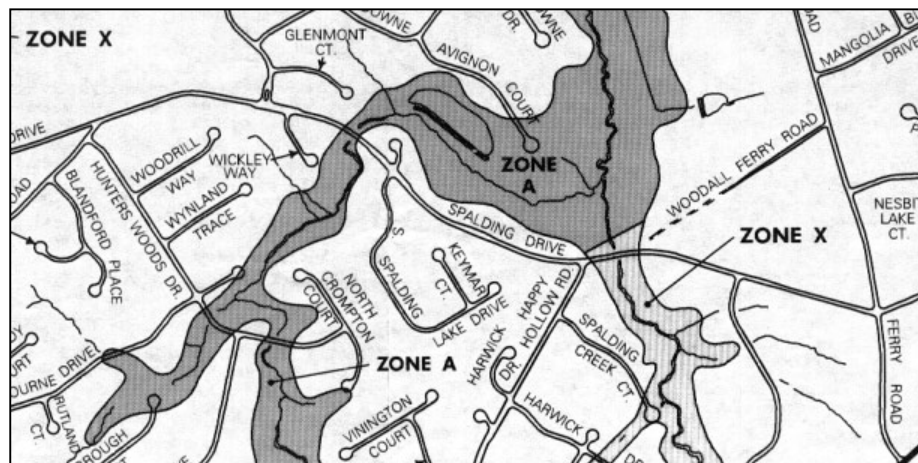


Figure 6.2-2 Example of a FEMA Flood Risk Map

6.2.3 Shortcomings of the NFIP

While almost all communities in Georgia participate in the NFIP, the minimum requirements of the Federal program are generally seen as having several inherent weaknesses including:

- Little or no action to reduce damages in existing flood prone areas
- The tendency for the program to actually stimulate development in floodplain areas due to reduction of fears of substantial losses from flood damage
- Little or no coverage for the smaller feeder and headwaters streams
- The tendency for flood boundaries to shift over time as increased runoff from new development increases the floodplain width. This results in structures thought to be beyond the area of flooding being in danger.
- Maps are not updated with broader insurance zones

Local communities add to the problems inherent in the NFIP through incomplete floodplain management including:

- Adopting land use regulations for flood hazard areas, such as those required to participate in the NFIP, and then failing to enforce them (for example, issuing permits that do not comply with the ordinance, or unwisely overruling the professional staff that administers the ordinance)
- Taking the position of doing only the minimum necessary to meet Georgia or Federal requirements, and not integrating the broader issues of community health and safety, watershed and water quality management, and quality of life
- Agreeing to maintain a flood control or other project built with state or federal assistance, and then failing to provide for the maintenance in the community budget
- Taking "piecemeal" approaches that may correct one problem area but create a worse problem elsewhere.

It should be remembered that the NFIP is not designed to be a comprehensive floodplain management program but simply to reduce flood losses and provide for subsidized flood insurance. The NFIP should serve as the beginning of a broader floodplain management program. The next section provides guidance and approaches for developing a more comprehensive program.

6.3 Strategies and Tools for Improved Floodplain Management

6.3.1 Introduction

Many Georgia communities are seeking ways to break out of the cycle of ever increasing flooding, damage to older floodplain structures, streambank stability problems, loss of floodplain habitat, and increasing erosion and sedimentation problems. Approaches to deal with these problems range from individual actions to comprehensive multi-objective management plans that integrate a wide range of community desires and goals dealing with floodplain areas. Table 6.3-1 summarizes a variety of floodplain management approaches.

6.3.2 Developing an Effective Local Floodplain Management Program

Most local programs have at their heart the objective of ensuring that flood levels are not increased, that public and private flood losses are minimized, and that natural and beneficial values of floodplains are preserved. This is typically accomplished through a combination of:

1. Restricting or prohibiting uses which are dangerous to health, safety and property due to water or erosion hazards or which result in damaging increases in erosion or in flood heights or velocities;

Table 6.3-1 Approaches to Effective Local Floodplain Management

1. Preventive activities keep flood problems from getting worse. The use and development of floodprone areas is limited through planning, land acquisition, or regulation. They are usually administered by building, zoning, planning, and/or code enforcement departments.

Planning and zoning	Buffer requirements
Open space preservation	Stormwater management requirements
Floodplain regulations	Drainage system maintenance

2. Property protection activities are usually undertaken by property owners on a building-by-building or parcel basis. They include:

Relocation	Floodproofing
Acquisition	Sewer backup protection
Building elevation	Insurance

3. Natural resource protection activities preserve or restore natural areas or the natural functions of floodplain and watershed areas. They are usually implemented by parks and recreation departments, public works, or conservation agencies and organizations.

Wetlands protection	Riparian zone / buffer restoration
Streambank restoration	Erosion and sediment control
Coastal barrier protection	

4. Emergency services measures are taken during a flood to minimize its impact. These measures are the responsibility of city or county emergency management staff and the owners or operators of major or critical facilities.

Flood warning	Critical facilities protection
Flood response	Health and safety maintenance

5. Structural projects keep floodwaters away from an area with a levee, reservoir, or other flood control measure. They are usually designed by engineers and managed or maintained by public works staff.

Reservoirs	Channel modifications
Levees/floodwalls/seawalls	Beach nourishment
Diversions	Storm sewers

6. Public information activities advise property owners, potential property owners, and visitors about the hazards, ways to protect people and property from the hazards, and the natural and beneficial functions of local floodplains.

Map information	Library
Outreach projects	Technical assistance
Real estate disclosure	Environmental education

2. Requiring that uses vulnerable to floods, including facilities that serve such uses, be protected against flood damage at the time of initial construction;
3. Controlling the alteration of natural floodplains, stream channels and natural protective barriers which are involved in the accommodation of flood waters;
4. Controlling filling, grading, dredging and other development which may increase flood damage erosion;
5. Preventing or regulating the construction of flood barriers which will unnaturally divert flood waters or which may increase flood hazards to other lands; and
6. Seeking ways to reduce loss of natural floodplain areas and enhance natural benefits of floodplains in areas facing development.

Below are some of the ways that a community can improve its floodplain management program through a combination of structural and non-structural means making use of technology and tools.

Strategies to Keep Out of Floodprone Areas

- **Planning and regulatory floodplains** – Use two floodplain definitions in which the full buildout floodplain is used for location and elevation of new construction, while the current condition FEMA maps are used for the Federal flood insurance program.
- **Use buildout floodplain for regulation** – Regulate new development on the basis of full buildout floodplains based on a master plan, even if the FEMA maps are not updated.
- **Land use limitations** – Limit the types of uses allowable in the floodplain to those necessary uses that are functionally dependent on being close to the water and those that would not be substantially damaged by flooding. Use the master plan and GIS capability to influence rezoning decisions before they are approved.
- **Provide incentives for staying out of the floodplain** – Develop the ability to make dedication of floodplain areas attractive to developers through transferable development rights, tax credits for conservation designs, partnering with developers to establish greenways along streams, or other approaches.

Strategies to Reduce Damage Due to Flooding

- **Implement a comprehensive floodproofing program** – Seek to reduce the amount of damage to local residents and nonresidential structures located in the present floodplain through a combined capital improvement program, floodproofing, voluntary and attractive property acquisition, and homeowner education and warning (as appropriate). Develop a cost-shared floodproofing program for nonresidential structures that experience only shallow flooding and an elevation program for residential structures.
- **Enhanced first floor elevation requirements** – Implement a requirement to raise the first finished floor of all floodplain structures one foot (or more) above the full buildout 100-year flood elevation.
- **Maximize floodplain flow capacity** – Minimize floodplain infill and enhance and maintain the conveyance of streams in floodprone areas on a priority basis.
- **Require effective stormwater quantity management** – Ensure that upstream developments, remote from the floodplain or adjacent to it, mitigate the stormwater runoff impacts of their development downstream to the point that the impacts are insignificant (see Chapter 4).
- **Develop a flooding mitigation plan** – Develop a during- and post-flood mitigation and assistance plan that protects citizens from the risk of driving or falling into flood waters (e.g. traffic barricades in place well ahead of deep water conditions). The plan should seek to eliminate repetitive loss properties and seek to floodproof those damaged by flooding.

Strategies to Preserve and Restore Open Space and Natural Features

- **Innovative density trading away from flood prone areas** – Provide the ability and incentive to dedicate floodplain areas while retaining the ability to construct the same number of homes on a tract of land as without dedication. This is often integrated with a community greenway program or other riparian buffers requirements.
- **Extension of floodplain management to smaller streams** – Extend the floodplain program to feeder streams and to areas above the upper limit of mapped areas, and require backwater calculations on all streams not mapped.
- **Flood prone property and land acquisition** – Acquire flood prone properties, perhaps as part of a community open space or greenway program, and construct open space parks in their place.
- **Mandatory new construction floodplain dedication** – Require the dedication of floodplain lands and buffers for the purposes of flood protection, pollution reduction, and multi-objective riparian corridor recreation.

Strategies to Use Technology for Better Information Management Support

- **Downstream impact assessment** – Implement a mandatory requirement to assess and mitigate the impacts of proposed new developments downstream to a point where the impact is negligible (see Section 4.6). Mitigation can include the purchase of a flood easement, on-site controls, system improvements, etc. This might also include the development of watershed master plans for the purposes of solving floodplain problems and avoiding exacerbating problems.
- **Aggressive map maintenance** – Require mandatory letters of map amendment or revision for all new floodplain developments, or a mandatory requirement for backwater profiles to be privately developed for proposed developments along all streams. Map estimated full buildout floodplain.
- **On-line GIS and models** – Implement the use of GIS and on-line models in assessing new developments as they are proposed and prior to re-zoning request approvals. The city or county would work with the developer in coming up with an alternative that reduces impacts and preserves floodplain areas while maintaining economic viability.
- **Make floodplain maps accessible** – Make the community's most current floodplain boundaries available on the Internet for easy access. Identify those persons in the floodplain and notify them of the availability and advisability of flood insurance.

6.3.3 Watershed / Inter-jurisdictional Issues

Ideally, floodplains are managed at the watershed level. Activities that result in runoff anywhere within the watershed can increase the incidence and magnitude of floods downstream. If other jurisdictions contribute to a community's flood problems or detract from their floodplain resources, then intergovernmental cooperation and coordination is a critical consideration.

Regulatory consistency and coordinated flood response will ensure that land uses and flood analyses are compatible. There are many ways communities can pool their resources—technical, financial, and personnel—for flood damage reduction studies, hydrologic and hydraulic watershed modeling, and a variety of floodplain and flood mitigation projects.

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STORMWATER SYSTEM OPERATION & MAINTENANCE

7.1 Local Stormwater Operations and Maintenance Programs

7.1.1 Introduction

An essential component of a comprehensive stormwater management program is the ongoing operation and maintenance of the various components of the stormwater drainage, control, and conveyance systems. Failure to provide effective maintenance can reduce the hydraulic capacity and the pollutant removal efficiency of stormwater controls and conveyance systems.

The question is not whether stormwater management system maintenance is necessary in a community. Rather, the question is how a community's maintenance programs will be budgeted, staffed, and administered, and who has responsibility for managing inspections, scheduling periodic required maintenance, and funding remedial work. Ideally, a local program should address operations and maintenance concerns proactively instead of reacting to problems that occur such as flooding or water quality degradation.

Operations and maintenance activities can include cleaning and maintenance of catch basins, drainage swales, open channels, storm sewer pipes, stormwater ponds, and other structural controls. Street sweeping and certain other pollution reduction activities such as illicit discharge identification and removal also fall under operations and maintenance activities. Stormwater system operations and maintenance can also include the retrofitting of existing development to meet water quality and/or water quantity goals and streambank restoration.

A clear assignment of stormwater inspection and maintenance responsibilities, whether they be accomplished by the local government, land owners, private concerns, or a combination of these, is essential to ensuring that stormwater management systems function as they were intended. It is imperative that communities require the maintenance of private stormwater systems and develop the necessary legal framework to ensure compliance.

7.1.2 Key Maintenance Program Components

Most people expect that stormwater conveyance and control facilities will continue to function correctly as designed forever. However, it is inevitable that deterioration of the stormwater infrastructure will occur once it becomes operational. On-going maintenance is a vital part of ensuring the operational success of stormwater management facilities, and is critical to achieving an extended service life of continuous operation as designed.

There are three key components to adequately maintaining a community's stormwater management infrastructure:

- Inventory of stormwater system components;
- Periodic and scheduled inspections; and
- Maintenance scheduling and performance

System Inventory

Without knowledge of the type and locations of stormwater infrastructure components, no comprehensive maintenance plan can be developed. Necessary information required in a stormwater management system inventory are facility and conveyance locations, elevations, outfalls, contributing drainage, receiving drainage, control structures, material types, vegetative species and any other pertinent information necessary to defining the kind of maintenance required for the facility or conveyance. This type of information is easily incorporated into a GIS system database. Included in the database can be dates on previous inspections, inspection findings, maintenance dates, specific tasks performed, and digital photos of the structure or conveyance. The system inventory process is a costly and intensive effort. It is absolutely imperative, however, for any effective long-term and cost-effective maintenance program. See Chapter 9 for a more in-depth discussion of stormwater system inventories and geographic information tools.

Inspections

It is clear that an inspection program is necessary to ensure a stormwater facility or conveyance remains operational. Inspections should be performed on a regular basis and scheduled based on the stormwater control type and characteristics. In addition, inspections should occur after major rainfall events for those components deemed to be critically affected by the resulting runoff. Not all inspections can be conducted by direct human observation. For subsurface systems video equipment may be required. There may be cases where other specialized equipment is necessary. The inspection program is tailored to address the operational characteristics of the system.

It is not mandatory that all inspectors be trained engineers, but they should have some knowledge or experience with stormwater systems. Trained stormwater engineers should, however, direct them. Inspections by registered engineers should be performed where routine inspection has revealed a question of structural or hydraulic integrity affecting public safety.

The inspection process should document observations made in the field. Comments should be archived on structural conditions, hydraulic operational conditions, evidence of vandalism, condition of vegetation, occurrence of obstructions, unsafe conditions, and build-up of trash, sediments and pollutants. This is also an efficient way to take water quality measurements required for monitoring programs and to incorporate them into the inspection history. The inspection data should be ideally incorporated into the GIS, if possible, as it allows spatial identification of where maintenance activities are required. Trends may be identified in this way that can assist a community in tracking down specific problem system components.

Maintenance Scheduling and Performance

Maintenance activities can be divided into two types: scheduled and corrective. Scheduled maintenance tasks are those that are typically accomplished on a regular basis and can generally be scheduled without referencing inspection reports. These items consist of such things as vegetation maintenance (such as grass mowing) and trash and debris removal. These tasks are required at well-defined time intervals and can be considered a given for most, if not all, stormwater structural facilities. A permanent maintenance crew is typically put under a fixed scope of responsibility to address these items.

Corrective tasks consist of items such as sediment removal, stream bank stabilization, and outlet structure repairs that are done on an as-needed basis. These tasks are typically scheduled based on inspection results or in response to complaints. Corrective maintenance sometimes calls for more specialized expertise and equipment than for scheduled tasks. For example, a task such as sediment removal from a stormwater pond requires specialized equipment for which not every jurisdiction is willing to invest. Therefore, some maintenance tasks might be effectively handled on a contract basis with an outside entity specializing in that field. In addition, some corrective maintenance may also require a formal design and bid process to accomplish the work.

7.2 Implementing An Effective Operation and Maintenance Program

7.2.1 Maintenance Responsibility

Communities must make decisions concerning the construction, operation and maintenance of the stormwater management infrastructure. For which parts of the stormwater system should the local government be responsible? What services should the local government provide to various parts of a stormwater management system? How do we define exactly what makes up the stormwater management system? And how do we transform our current maintenance policies to a newer definition of responsibility?

Unmaintained stormwater facilities will eventually fail operationally. A major contributor to unmaintained facilities is a lack of clear ownership and responsibility definition. In order for an inspection and maintenance program to be effective, the roles for each responsibility must be clearly defined prior to construction of a system. The lead role in determining what responsibilities belong to whom lies with the local government. Several different approaches are possible and are briefly described below. A community must determine which approach best suits its capabilities, both physically and financially.

Limited local responsibility

The narrowest approach for communities to take in defining responsibilities for stormwater systems would be for the local government to accept responsibility only for property owned by the community. This would include the right-of-way and any other publicly owned land such as local facilities and parks. With this approach, the community would not be involved with any stormwater systems on private property, except for possible regulatory action.

While this approach may seem most easily defined, there are some drawbacks. Parties who have little knowledge or funding to maintain stormwater systems, own many of the stormwater system components that are on private land. For example, many residential subdivisions contain a stormwater pond, frequently located on one of the less desirable lots. The homeowners association is typically the owner of such a pond. These groups generally have little understanding of the purpose of the pond and how it operates, and have even less funding available to repair and maintain it. The stormwater pond will typically fall into disrepair and become overgrown with vegetation and lose any viable functionality. Many light commercial stormwater systems also fall into this same state for the same reasons.

If a community decides to use the approach of limited local responsibility, the local government will have to put forth some effort to prevent these drawbacks from occurring. It may be possible for the community to make this approach work with a proactive inspection program to review private systems, and a strong public education program to insure that owners understand their responsibility and perform their required duties. Private owners should also be made aware of the need to plan how they will fund their maintenance programs. For the residential example above, dues to the homeowners association could be earmarked for maintenance.

Expanded local responsibility

In addition to maintaining and operating publicly owned stormwater systems, the community may determine that it should maintain and operate some of the private portions of the system. This approach could be chosen in an attempt to eliminate the problems mentioned above.

The difficulty with expanding the responsibility of the local government is in determining where to end local responsibility and how to fund the extra responsibilities. These decisions must be made in a fair and equitable manner. One option for this approach would be for the community to accept operation and maintenance responsibilities for all residential stormwater systems, but not for any commercial or industrial systems.

Comprehensive local responsibility

The opposite of a limited approach would be a comprehensive approach, where the community conducts all operation and maintenance activities for stormwater systems within its jurisdictional boundaries. This type of approach may be deemed to be the best approach if the community has serious nonpoint source pollution issues, especially if there is a possibility of regulatory action by the federal or state government. This type of approach would also be well suited to the community that has a stormwater utility in place and/or operates and maintains regional stormwater management systems instead of a myriad of small on-site systems. Because of the inherent problems associated with private maintenance responsibilities, the most efficient organizational structure would be to give the jurisdiction ownership or easement access to the stormwater system. This would place the responsibility for the overall stormwater system with one entity. A comprehensive and cohesive program could be developed and implemented by the jurisdiction for inspection and maintenance.

The most difficult aspect of this approach may be how it would be funded. Options for funding could include a stormwater utility fee based on the amount of stormwater and pollution contributed by each site, or a tax that would pay for the facilities that served the general public. Of the above given approaches to local responsibility, each community must determine the amount of responsibility and effort it is willing to commit in order to provide adequate stormwater management. A local government could choose one of the approaches described above, or could choose some point between. Whichever approach is chosen, the decision must be carefully considered and open for change with time and experience. A stormwater management system should have ownership and maintenance responsibilities clearly defined from the initial stages of design. It should be clear and unequivocal what entity has responsibility for each portion of the system.

7.2.2 Level of Service

In addition to determining the extent of responsibility that a community is willing to assume, a decision must be made about how the stormwater system will serve the community. This decision determines the *level of service* (or LOS) that the system must achieve. The level of service is defined two ways: performance level of service and maintenance level of service.

The susceptibility of a community to flooding or water quality problems due to stormwater can be measured by assessing the performance level of service available. For example, for flooding issues, a level of service can be expressed in terms of the degree of roadway flooding and/or the extent of first floor flooding for a given hypothetical storm event. For some communities, a level of roadway service may be defined as no less than one open lane on evacuation routes during the largest one-day rain event with a 25-year recurrence interval. LOS definitions vary considerably by community and are defined as a design frequency tied to a specified condition (e.g. the 10-year storm design frequency for culvert overtopping). Compared to a flooding LOS, the concept of a water quality level of service is fairly new. A water quality LOS system might promote land use controls, followed by structural treatment measures, and may penalize untreated discharge from urban areas.

A maintenance level of service is defined by the types of services a community will provide to different parts of the drainage system or by the specific condition of the system. For example, within the right-of-way and in critical areas highly susceptible to flood damages, the maintenance level of service might include periodic inspection, priority cleaning and the highest level of emergency response. In similar right-of-way areas not susceptible to flooding, the level of service for maintenance might be much lower. A community might perform maintenance for residential structural stormwater controls, but only provide inspection and enforcement of maintenance agreements for structural controls located on non-residential parcels.

Maintenance levels of service can also be defined in terms of the condition of the system. Channel mowing may take place when the grass is about 8" high. Or culverts might be cleaned out when they are, on average, 20% blocked with sediment. In these cases inspection of the systems drives work orders rather than flooding complaints.

The extent or responsibility and level of service combine to define the capital project (construction or land acquisition) and operation and maintenance programs. For example, it might be that on private land a local government is only willing, and only has the resources, to perform emergency response services and to give technical advice. But in the high priority public right-of-way areas the local government may be willing to provide a much higher level of service. If a community chooses a low-level stormwater maintenance program with minimal responsibilities it should anticipate increasing complaints and an unknown but growing backlog of unmet capital construction and remedial maintenance needs. No stormwater management system can function for long without adequate attention. Maintenance avoided is simply maintenance deferred.

7.2.3 Establishing Maintenance Responsibility and Level of Service Policies

A drainage system, starting from the headwaters and moving downstream toward the mouth, carries incrementally larger and larger flows. The extent of responsibility policy seeks to define the point in this dendritic system between local government and private responsibility. The basic components and limits of that responsibility are also defined in extent of service.

The extent of responsibility will almost certainly change over time, both in terms of the local government's policies and the application of those policies. For example, in terms of routine maintenance of the systems, the extent of responsibility may consistently be limited to those components within rights-of-way and easements which allow adequate access to the facilities, but rights-of-way and easements will be added over the years, so the practical extent of responsibility will expand even if the policy does not change.

The extent of responsibility for regulatory activities must go far beyond the rights-of-way and easements to meet the local government's stormwater quantity and quality control responsibilities. Often the community must determine its regulatory extent of responsibility (through its authority for land use control) based on what must, or can, be done on private property in order to protect the general public health, safety, and welfare.

How far into the system should a local government provide service? All of the drainage system can be categorized according to location, conveyance and legal standing:

- In or outside the public right-of-way;
- Does, or does not contain significant public water; and
- Is or is not within a permanent dedicated drainage easement.

Thus, there are four "policy" categories of drainage system:

- (1) In the right-of-way;
- (2) Outside the right-of-way, carrying public water and within an easement;
- (3) Outside the right-of-way, carrying public water but not within an easement; and
- (4) Totally private systems.

Based on its definition of the system components, the community can determine how it will handle the various portions of the drainage system. Generally:

- The minimal extent of responsibility is within the public right-of-way. Every local government has a public health and safety responsibility to keep its traveled way open to traffic and free from dangerous amounts of standing water.
- Often communities also provide maintenance service, of some sort, within permanent drainage easements. This is especially the case when there is both public water and a public interest in keeping a certain drainageway functional.
- Some also have established the policy that they will provide some service to other parts of the drainage system that carry public water (i.e. downstream from the first public street). In other locations, only an inspection and enforcement service is provided outside the right-of-way and easements.
- Most communities will respond to any location whatsoever in an emergency situation.

When developing changes to a maintenance program it is helpful to remember these three basic steps:

(1) Define Program

- Determine segment category definitions
- Determine level-of-service and policy definitions
- Determine resource demands and available budget
- Develop policies for each segment category

(2) Define System

- Inventory and map stormwater management system
- Identify “official” system (right-of-way & key outside ROW segments)
- Assign segments to system

(3) Initiate Changes

- Begin changes in service
- Expand slowly as experience is gained

7.2.4 Maintenance Agreements

Whenever stormwater structural control implementation is required, maintenance requirements must be explicitly stated and enforced. There should also be some type of compliance mechanism to assure that maintenance is actually performed on a regular or as-required basis.

One method for ensuring maintenance is the implementation of a stormwater operating permit system and/or maintenance agreements. This kind of system would produce information for inclusion in a stormwater inventory database thus adding to the efficiency of a local maintenance program as well as providing a funding mechanism through permit fees. Some key aspects of these permits or maintenance agreements is the clear delineation of responsibilities, such as:

- Identification of who will perform inspection duties and how often.
- Listed duties that are to be performed by the owner, such as mowing, debris removal, and replanting of vegetation.
- Defined roles for the local government, possibly inspection, and/or modifications to the system such as resizing an orifice.
- Determination of a recourse of action to be taken if the owner does not fulfill their obligations (i.e. repayment to the local government for activities that the owner did not perform).
- Development of a pollution prevention plan by the owner.
- Requirement of a report, possibly annually, that would serve to keep the owner involved and aware of their responsibilities.

For example, a permit or maintenance agreement could specify that the local government accepts responsibility for inspecting and maintaining the stormwater system’s structural components, including the periodic removal of debris and accumulated sediments. However, vegetative and aesthetic maintenance would still rest with the private entity.

An example maintenance agreement is included in Appendix C.

7.2.5 Education

One of the most important ways to assure the regular inspection and maintenance of the stormwater infrastructure is through education programs for both private owners and the general public. The public can be helpful or detrimental to the success of the community’s stormwater management program.

A good example of the need for public education is residents who use the ditch behind their house to dispose of grass clippings and vegetative debris. This debris can then block a pipe inlet and cause flooding, or cover an infiltration trench and cause excessive runoff. Another common problem is individuals disposing of materials by discharging them into the stormwater catch basins. Citizens need to be informed that sediment, vegetative material and harmful substances should not be dumped into catch basins but must be disposed of properly. In many cases, once the public is informed of the purpose of the system and the need to properly maintain the system, they are less likely to perform acts that inhibit the system or cause adverse impacts.

An additional benefit of an educated public is the opportunity to have many more "inspectors" who will alert system operators of potential problems prior to catastrophic failure. As part of an effective education component, the public should be informed of signs to be aware of that may indicate serious problems. If a citizen is told that the dry detention pond behind his house should not have standing water at all times or should not fill to the top of the dam after every rain event, he or she would then know to alert the proper authorities and could prevent possible damage to life or property.

In addition to public education for publicly owned or operated systems, education can be very important for privately owned systems. Once stormwater structural controls are installed, the end-user or owner may not be aware of the necessity of the facilities or the consequences of a failed system. As part of the public education, it is vital that private owners be educated to understand and become proactive in the operation and maintenance of their system. It is in the best interest of the public to make the owners of private stormwater systems aware of the responsibility that goes with ownership and the effect that failure could have on public health and safety.

7.2.6 Periodic Review of Regulations and Procedures

Once a community's stormwater management operation and maintenance program has been developed and implemented, it may become apparent that changes or modifications are necessary to make the program more effective. After the initial implementation of the operation and maintenance program, review of the program should be scheduled one to two years after implementation. After the initial review, additional reviews may be scheduled in three to five-year intervals. Reviews should include input from staff members who are performing the various activities.

Following are some examples of issues that may arise during the review:

- The system inventory may not be complete or up-to-date
- Inspection scheduling may need to be revised for more or less frequent inspections for all or only specific types of systems
- Inspection checklists may need modification
- Maintenance activities may need to be modified
- Some systems or system components allowed may need to be deleted based upon experiences
- Some systems or system components allowed may need to be added based on new techniques or developments
- Additional equipment may be necessary to perform duties adequately

7.3 Stormwater Retrofitting

7.3.1 Introduction

Ideally, as land is developed structural controls are implemented to control present and future stormwater runoff impacts. However, controlling stormwater from new development and redevelopment alone will not solve existing problems. Retrofitting by definition is the process by which structural controls are constructed to serve and reduce the water quantity and quality impacts from *existing* developed areas.

Due to the fact that they are intended to serve existing problem areas, retrofits are typically the responsibility of the local government who must mitigate property flooding, reduce streambank erosion, or comply with TMDL or other water quality regulatory requirements.

Retrofits must be integrated with existing and often diverse urban development, and they assume a wider range of forms than structural controls installed during new development. Space constraints, construction costs, acquisition of easements, safety precautions, economic vitality, and property rights all compete with the need to reduce nutrient loadings in the urban environment.

7.3.2 Stormwater Retrofitting Process

Stormwater retrofitting is ideally performed as a part of an overall watershed planning and implementation effort. When applied along with other available water restoration strategies such as pollutant reduction, habitat restoration, and morphologic stabilization, retrofitting can be most effective. The following eight steps detail a “how-to” approach to retrofitting.

Step 1: Watershed Retrofit Inventory

The first step to putting a retrofit in place is locating and identifying where it is feasible and appropriate to put a proposed facility. This involves a process of identifying as many potential sites as possible. The best retrofit sites fit easily into the existing landscape, are located at or near major drainage or stormwater control facilities, and are easily accessible. Usually the first step is completed in the office using available topographic mapping, low altitude aerial photographs (where available), storm drain master plans, and land use maps (zoning or tax maps are generally acceptable).

Before venturing into the field, there are two tasks that should be performed. First, the drainage areas should be delineated, and second, the potential surface area of the facility measured. The drainage area is used to compute a capture ratio. This is the percentage of the overall watershed that is being managed by the retrofit project(s). The surface area is used to compute a preliminary storage volume of the proposed facility. These two bits of information can be used as a quick screening tool. In general, an effective retrofitting strategy must capture at least 50% of the watershed, and the minimum target storage volume for each retrofit is approximately 0.5 inch per impervious acre.

Step 2: Field Verification of Candidate Sites

Candidate retrofit sites from Step 1 are field investigated to verify that they are indeed feasible candidate sites. This field investigation involves a careful assessment of site specific information such as:

- Presence of sensitive environmental features
- Location of existing utilities
- Type of adjacent land uses
- Condition of receiving waters
- Construction and maintenance access opportunities, and most importantly,
- Evaluation of retrofit suitability

Usually a conceptual sketch is prepared and photographs are taken. During field verification, utilities should be located and an assessment made as to potential conflicts. Avoidance should be stressed due to cost considerations. It may also be appropriate to contact the appropriate utility to verify field observations and to discuss the potential facility. This may alleviate potential conflicts later.

Existing natural resources such as wetlands, streams, and forests should be evaluated as to their sensitivity. Avoidance and /or minimization of impacts where feasible should be considered. Finally, identify, review and assess adjacent land uses for consideration of structural controls that are compatible with nearby properties.

Step 3: Prioritize Sites for Implementation

Once sites have been located and determined to be feasible and practical, the next step is to set up a plan for future implementation. It is prudent to have an implementation strategy based on a predetermined set of objectives. For example, in some watersheds, implementation may be based on a strategy of reducing pollutant loads to receiving waters where the priority of retrofitting might be to go after the highest polluting land uses first. Whereas if the strategy is oriented more towards restoring stream channel morphology, priority retrofits are targeted to capture the largest drainage areas and provide the most storage. Whatever the restoration focus, it is useful to provide a scoring system that can be used to rank each retrofit site based on a uniform criteria. A typical scoring system might include a score for the following items:

- Pollutant removal capability
- Stream channel protection capability
- Flood protection control capability
- Cost of facility (design, construction and maintenance costs)
- Ability to implement the project (land ownership, construction access, permits)
- Potential for public benefit (education, location within a priority watershed, visible amenity, supports other public involvement initiatives)

Step 4: Public Involvement Process

This aspect of the process is critical if a project is to be constructed. A successful project must involve the immediate neighbors who will be affected by the changed conditions. Nearly all retrofits require modifications to the existing environment. A dry detention pond may be a very desirable area for some residents in the community. It is a community space and only rarely is there any water in the pond. A stormwater pond or wetland retrofit, on the other hand, may have large expanses of water and may have highly variable water fluctuations. Adjacent owners may resist these changes. In order to gain citizen acceptance of retrofits they must be involved in the process from the start and throughout the planning, design and implementation process. Citizens who are informed about the need for, and benefits of, retrofitting are more likely to accept projects.

Still, some citizens and citizen organizations will never support a particular project. This is why it is mandatory that there be an overall planning process which identifies projects early in the selection process and allows citizen input before costly field surveys and engineering designs are performed. Project sites and retrofit techniques that simply cannot satisfy citizen concerns may need to be dropped from further consideration.

A good retrofit program must also incorporate a good public relations plan. Slide shows or field trips to existing projects can be powerful persuasions to skeptical citizens. Every site that goes forward to final design and permitting should be presented at least once to the public through a public hearing or “town hall” type meeting.

Step 5: Retrofit Design

In the design process, the concept is converted to an engineering design and construction plan. Design of retrofit projects should incorporate the same elements as any other structural control design including, but not limited to:

- Adequate hydrologic and hydraulic modeling
- Detailed topographic mapping
- Property line establishment
- Site grading
- Structural design
- Geotechnical investigations
- Erosion and sediment control design
- Construction phasing and staging

Normal structural control design usually follows a prescribed design criteria (i.e., control of the 25-year storm or sizing for a specified water quality volume). Retrofit designers must work backwards from a set of existing site constraints to arrive at an acceptable stormwater control obtainable. This process may yield facilities that are too small or ineffective, and therefore not practical for further consideration. Designers should look for opportunities to combine projects, such as stream stabilization or habitat restoration with the retrofit in a complementary manner.

The key to successful retrofit design is the ability to balance the desire to maximize pollutant removal, channel erosion protection and flood control while limiting the impacts to adjacent infrastructure, residents or other properties. Designers must consider issues like avoiding relocations of existing utilities, minimizing existing wetland and forest impacts, maintaining existing floodplain elevations, complying with dam safety and dam hazard classification criteria, avoiding maintenance nuisance situations, and providing adequate construction and maintenance access to the site.

Retrofits can vary widely as to cost from a few thousand dollars to several hundred thousand dollars. A preliminary cost estimate should be a part of the design phase.

Step 6: Permitting

Perhaps the most difficult permitting issues for retrofit projects involve impacts to wetlands, forests and floodplain alterations. Many of these impacts are either unavoidable or necessary to achieve reasonable storage targets. The primary issues that permitting agencies are looking for is to ensure that the impacts have been minimized to the maximum extent practicable and that the benefits of the proposed project are clearly recognizable. In some instances, mitigation may also be required in order to satisfy permitting. If so, additional costs may be involved.

Step 7: Construction and Inspections

Like any design project, proper construction, inspection, and administration is integral to a successful facility. Retrofitting often involves construction of unique or unusual elements, such as flow splitters, underground sand filters, or stream diversions. Many of these practices may be unfamiliar to many contractors. Most publicly funded projects are awarded to the low bidder who may be qualified to do the work, but may never have constructed projects of this nature. Therefore, it is almost a necessity to retain the retrofit designer of record or other qualified professional to answer contractor questions, approve shop drawings, conduct regular inspections, hold regular progress meetings, conduct construction testing, and maintain construction records. As-built drawings should also be a part of the construction process. These drawings are used for maintenance purposes.

Step 8: Maintenance Plan

Always the last element and often the least practiced component of a stormwater management program, maintenance is doubly important in retrofit situations. The reasons are simple: most retrofits are undersized when compared to their new development counterparts and space is at a premium in urban areas where many maintenance provisions such as access roads, stockpiling or staging areas are either absent or woefully undersized.

7.3.3 Types of Retrofitting Techniques

Retrofitting techniques can be applied to many different situations depending on the end result required and space available. Retrofitting techniques include:

- Source Retrofit – Use of techniques that attenuate runoff and/or pollutant generation before it enters a storm drain system, i.e., reducing impervious areas, using pollution prevention practices, etc. These are used in areas where build-out prevents the establishment of a significant number of new facilities, and where redevelopment will not have a significant impact on water quality.

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- Redevelopment – Redevelopment will result in retrofit by means of new structural control facilities required by local stormwater management standards. Projected redevelopment trends, while not within the direct control of local government, are useful in predicting areas of existing development that may be mitigated in the future.
 - Existing Structural Control Retrofit – The retrofit of an existing structural control to improve its pollutant removal efficiency or storage capacity, or both.
 - Installation of Additional Stormwater Controls – Additional stormwater controls can be added for existing development or redevelopment. Consideration should be given to regional controls, rather than site-specific applications.
 - Conversion of Existing Stormwater Facilities to Water Quality Functions – Existing flood control facilities built to serve previous development may be modified to act as a water quality structural control on a regional or site-specific basis.
 - Open Channel Retrofit – Open channel retrofits are constructed within an open channel below a storm drain outfall, e.g., extended detention shallow marsh pond system.
 - Natural Channel Retrofit – Depending on the size of the channel and the area of the floodplain, a natural channel may provide several retrofit options.
 - Off-line Retrofit – Involves the use of a flow-splitter to divert the first flush of runoff to a lower open area for treatment in areas where land constraints are not present.
 - In-line Retrofit – Used where space constraints do not allow the use of diversions to treatment areas.

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STORMWATER POLLUTION PREVENTION PROGRAMS

8.1 Stormwater Pollution Prevention

8.1.1 Introduction

Stormwater pollution occurs every time runoff carries away a wide variety of contaminants as it runs across roads, parking lots, construction sites, golf courses, lawns, and other surfaces in our cities and suburbs. In addition, there are a number of other sources of pollution to stormwater and urban streams that occur during both wet and dry weather, including sewer leaks, illicit connections and septic tanks.

Stormwater pollution prevention is aimed at reducing and/or preventing the contamination of stormwater runoff at its source, *before* it has an opportunity to pollute the runoff flow and enter the conveyance system. Stormwater pollution prevention practices, also known as "source controls," are an important way to prevent water quality problems in stormwater runoff from a variety of sources. The intent of source control practices is to prevent stormwater from coming in contact with pollutants in the first place rather than using downstream structural controls to treat the runoff and remove pollutants.

Pollution prevention includes the following categories of measures:

- Materials management (use, exposure, and disposal/recycling controls)
- Spill prevention and cleanup
- Removal of illicit connections
- Prevention of illegal dumping
- Street and storm drain maintenance
- Public information and education

The next section describes several of the pollution prevention activities and programs that a community can undertake.

8.1.2 Local Stormwater Pollution Prevention Activities

Promoting Pollution Prevention Management Practices

A community should actively promote the use of stormwater pollution prevention management practices by local businesses, industries, and institutions. This is ideally done through the adoption of a compendium of pollution prevention practices by communities such as those found in Volume 3 of this Manual. Both existing and new development can be required to prepare a stormwater pollution prevention plan (SWPPP) as a condition of a business or operation permit, or as part of an overall stormwater management site plan.

Brochures and fact sheets containing relevant pollution prevention practices as well as training programs and/or videos can be made available for specific commercial and industrial categories (such as restaurants, gas stations, or concrete operations) to provide business owners and employees with the necessary tools to preventing stormwater contamination in their activities and operations.

Municipal Housekeeping

The first role of a local government is to prevent stormwater pollution by setting the example. A community should implement relevant pollution prevention practices in all areas of local government operations and activities. This can include such things as:

- Material Storage Practices
- Waste Reduction and Disposal
- Fleet Vehicle Maintenance
- Building and Grounds Maintenance
- Construction Activities

Though often associated with public works departments, housekeeping activities should be implemented across the entire spectrum of local agencies and entities, including locally-owned utilities (e.g. water and wastewater facilities and operations), parks and recreation departments, school districts, public hospitals, administrative offices, and other publicly-owned facilities.

Municipal facilities and operations should be required to prepare a stormwater pollution prevention plan as well as a spill prevention plan, if applicable. These plans should include provisions for how a department or agency plans to reduce pollutant runoff from their site, including reducing exposure of potential pollutants and removing pollutants discharged from their site. Regular visits and inspections of each facility would be performed to insure compliance with these plans. A training program and/or video on stormwater issues and pollution prevention can be developed and provided for public employees.

Hazardous Household Waste Management

Household hazardous wastes can include a wide variety of materials used in the home including paints, solvents, pesticides, herbicides and cleaners. Residents often dispose of the unused portion of these products down a drain (which goes to a wastewater treatment plant or septic tank), or may dump them in their yard, a storm drain or even a drainage ditch or stream.

Ideally, a community should establish a collection center for household hazardous wastes. Citizens would be able to drop off their wastes, which can then be categorized and disposed of at an approved hazardous waste facility. A complementary option is to encourage the use of nonhazardous or less hazardous alternatives for particular products.

Street Sweeping

Street and parking lot sweeping on a regular basis can remove sediment, debris, litter and other pollutants from road and parking lot surfaces that are potential sources of stormwater pollution. Recent improvements in street sweeper technology have enhanced the ability of present day machines to pick up the fine-grained sediment particles that carry a substantial portion of the stormwater pollutant load.

The frequency of and location of street sweeping is an important consideration for any program. How often and what roads to sweep are determined by the program budget and the level of pollutant removal the community wishes to achieve.

Dry Weather Outfall Screening / Illicit Connection Removal

A community should have an active dry weather outfall screening program to identify and eliminate illicit or illegal discharges from entering the stormwater drainage system. These discharges can include a variety of commercial, industrial or manufacturing process water

discharges, floor drains from businesses or industrial locations, or even illicit sanitary sewer connections. They are generally characterized by continuous or periodic discharges which occur during dry and wet weather and contain pollutants that should not be discharged to surface waters.

A number of different procedures can be utilized to identify illicit connections and discharges into the stormwater drainage system. Once they have been identified, they should be eliminated under the authority of existing local ordinances or by referring the matter to the appropriate state agency. Information on what are appropriate connections to the stormwater drainage system should be provided to developers and contractors to prevent future illicit connections.

Sanitary Sewer Maintenance

Leaking sanitary sewer lines located near storm sewer pipes and streams can add pathogens as well as nutrients such as nitrogen and phosphorus to stormwater and surface waters. Human waste also contributes to biological oxygen demand (BOD). Inspections and leak detection of sanitary sewer lines should be conducted on a regular basis as part of an operations and maintenance program for a local wastewater utility, public works department, or other responsible entity.

Septic Tank Maintenance

Effluent from poorly maintained or failing septic systems can rise to the surface and contaminate stormwater. Improperly maintained septic systems can be potentially significant sources of pathogens and nutrients, especially nitrogen to stormwater runoff. In order to combat this problem, communities need to promote or require the regular maintenance of septic tank systems. A local jurisdiction can track septic tanks in a database, and send out notices at the required interval for septic tank inspections and maintenance. Septic tanks can also be permitted by a local jurisdiction, with permit renewal contingent on certification of septic tank maintenance.

Landfills

Improperly maintained landfills can allow litter, nutrients, pathogens and toxic contaminants to reach or stay on the surface of the landfill, allowing runoff to carry these pollutants to nearby waterbodies. Therefore it is important that a community regulate landfills to require the appropriate management measures to keep contaminated runoff from leaving the landfill site.

Public Information and Education

Educating the general public on what causes pollution, what are the indicators of water pollution and what they can do to reduce and/or prevent pollution of stormwater runoff is a critical element of a comprehensive stormwater management program. Some areas of focus for a local public information and education program include:

- Fertilizer and Pesticide Application
- Clipping / Leaf Disposal
- Household Hazardous Waste Management
- Automotive Care / Used Motor Oil Disposal
- Pet Waste

Information can be distributed to residents and businesses through a variety of methods, including:

- Brochures and Fact Sheets
- Utility Bill Inserts
- Internet Website
- Education Programs
- Special Events
- School Curricula
- Volunteer Educators

Additionally, a community can coordinate programs to engage citizens in stormwater pollution prevention and watershed management activities, such as:

- Stream Monitoring
- Stream Clean-ups
- Adopt-a-stream Programs
- Tree Planting Days
- Storm Drain Stenciling

Pollution Reporting Hotline / Spill Response

Local citizens can be helpful eyes and ears by reporting water quality problems and polluting activities. A community should have procedures for reporting stormwater polluters and promptly responding to emergencies such as hazardous materials spills. A telephone hotline could be established for receiving calls on water pollution, polluters and spills. It would be preferable for this number to be manned 24 hours a day or extended daily hours.

INFORMATION TOOLS FOR LOCAL STORMWATER MANAGEMENT

9.1 Overview

Stormwater management is becoming increasingly complex. The simple notion of collecting runoff and sending it efficiently to the nearest stream is being replaced with considerations of stormwater quantity and quality control, infrastructure management, master planning and modeling, financing, complaint tracking, and more. Information needs are critical to a successful local program. Georgia communities need to both invest in and be aware of new and emerging technologies that can provide the ability to collect, organize, maintain and effectively use vast amounts of data and information for their community's stormwater management activities.

This chapter covers the following information tools that can be utilized by a community to assist in their stormwater management programs:

- Stormwater Management System Inventories
- Geographic Information Systems (GIS)
- Global Positioning Systems (GPS)
- Remote Sensing
- Computer Models

9.2 Stormwater Management System Inventories

9.2.1 Introduction

The development of an inventory of the stormwater system is the first step in developing a comprehensive stormwater management program. Like any other public infrastructure (water, wastewater, streets, etc.), having a knowledge of the stormwater infrastructure is important in its proper and efficient management.

Relevant information includes location and classification of storm drains; drainage networks; structural stormwater control facilities; streams, ponds and wetlands; industrial discharges and combined sewer outfalls; watershed boundaries; floodplains; existing and proposed land use and zoning; and known water quality problem areas. This information can be collected and stored on paper maps or, ideally, in an integrated municipal GIS system.

Perhaps it is easiest to understand the advantages of an inventory by stating what can be accomplished when a local city or county has effective inventory information. The uses of stormwater infrastructure inventory information include:

- Complaint Response – The ability to quickly and effectively respond to a customer complaint by having on-line current information linked to addresses, past history of the address, a site map when arriving on the scene, and other information.
- Maintenance Management – This includes a wide array of functions illustrated in Figure 9.2-1 on the next page.
- Remedial Construction – Quick turn around construction on minor systems or minor repairs to larger systems which require little design time and would be handled with unit cost open ended contracts.
- Capital Construction – Programmed construction of larger items handled with pay as you go or bonded capital funds.
- Inventory Control – Handling of drainage structures in storage locations and warehouses.
- Master Planning – System-wide analysis and planning of capital construction for problem areas and for areas facing new development
- Financial Tracking – Tracking of costs, efficiencies, crediting information, assessments, etc.
- Materials Testing – Tracking of age and relative life-cycle costs of different materials
- Legal Support Information – Tracking of easements, ownership, complaints, and other legal information
- Regulatory Control – Including NPDES monitoring reports, easements, permitting, negotiating requirements for new developments, flood insurance program, floodplain management, erosion control, permits issued, and other regulatory issues.

For each of these applications, information from an inventory serves as the basis for the program function. For example, knowing pipe sizes and general condition allows for long term budgeting and capital planning. Without this information the city or county is left to simply respond on a reactive case by case basis to needs and complaints as they occur.

9.2.2 Organizing Information

Organizing an inventory can become a complex undertaking. Considerations should include: (1) types of structures inventoried; (2) type of information needed; and (3) program / purpose for collecting the information.

The following are stormwater infrastructure components that can be included in a system-wide inventory:

- | | |
|-----------------------------|-----------------------|
| • Streams and rivers | • Stormwater controls |
| • Ditches | • Detention ponds |
| • Pipes | • Dams |
| • Culverts | • Other structures |
| • Manholes | • Easements |
| • Outfalls | • Floodplains |
| • Inlets | • Floodways |
| • Bank or stream protection | • Adjacent structures |
| • Stream enhancement | • Waters of the state |
| • Greenways, corridors | • Regulatory outfalls |
| • Junctions | • Other |

The type of information collected about stormwater infrastructure falls into several categories including:

- | | |
|-------------------------|------------------------|
| • Structure type | • Connectivity |
| • Size | • Age |
| • Material type | • Complaints |
| • Maintenance condition | • Utility credits |
| • Structural condition | • Geometry information |
| • Elevation | • Location |

Integrating the information collected for each component with the uses of the information is the next step in an infrastructure inventory. Table 9.2-1 depicts an example chart that lists of functional uses of inventory information and the types of information necessary to support those uses.

STORMWATER INVENTORY INFRASTRUCTURE INFORMATION AND USES

	Basic Information					Geometry			Condition							Admin./Mgmt. Info.				
	element number	element type	location	elevation	connectivity	size	geometry information	digital picture	material type	age	structural condition	maintenance condition	environmental condition	upstream land use	adjacent flooding potential	ownership	complaints	utility credits	easement	past activity
initial complaint response	X	X	X						X		X	X		X	X	X	X		X	X
maintenance management	X	X	X		X	X	X	X	X	X	X	X	X			X	X		X	X
remedial construction	X	X	X	X		X	X	X	X		X	X		X					X	X
capital construction	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X		X	X
inventory control	X	X				X	X		X	X										
master planning	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X
financial tracking	X		X													X	X	X	X	X
material testing	X	X	X			X		X	X	X	X	X	X			X	X			X
legal support information	X	X	X											X		X	X	X	X	X
regulatory control	X	X	X			X		X					X	X	X	X	X		X	X

Table 9.2-1 Infrastructure Information and Uses

9.2.3 Conducting the Inventory

The following items should be considered before undertaking a stormwater system inventory:

1. Determine who will use the inventory information and what specific types of information and accuracy are required. For example, if the information on street location simply needs a general location of streets then a street centerline file would suffice. But if the actual edges of pavement are required a much greater level of complexity is involved including aerial photography and ground surveys. It is critically important to bring all stakeholders into the discussion of data needs both for cost sharing and to make sure the data is sufficiently accurate for its most stringent use.

2. Determine the types of data and the methods of data collection. It is important to insure accuracy in the collection, storage, and maintenance of the information. In many instances new technology is available for some data and information. Data may already be available from a government agency (such as land use information from other aerial flights or satellite imagery). There is always a tradeoff between the use of new technology and the opportunity for it to either fail or for unknown errors to be introduced due to lack of familiarity with the technology. Inefficient use of GPS has been an example of this where some inventories have ended up being more expensive than conventional surveying when the extra time needed to restore lost satellite lock and for training is factored in.

3. Determine the technology and organizational responsibilities that will be used to store and maintain the data. What types of hardware and software are necessary to collect and manipulate the information? Who will have access to the information and for what purposes? How will it be maintained and by whom?

4. **Collect the data and information.** Quality assurance is paramount. A single simple error repeated consistently over and over can render the whole data effort fruitless. Checks should be made for random errors, systematic errors, blunders, and system assumption errors.

- Random errors occur due to both human error and the inability of equipment to accurately read information. They tend to vary around the correct value both high and low. These can be taken into account in planning for the use of the data, and minimized through repeated readings.
- Systematic errors are consistent ways to doing something, but doing it wrong. Systematic errors always render a reading high or low, and can be very dangerous. Close supervision at the beginning of the inventory should smoke out most of these types of errors.
- Blunders occur when a reading is simply wrong, and wrong to the point that the information is way off the mark. Blunders can usually be caught by error checking software during the input process (i.e. automated out of bounds checking) or during graphical plotting of information to check for outliers.
- System assumption errors are those errors introduced during the planning of the inventory when the planner simply makes a mistake on specifying how equipment is to be used or data read. A simple example of this might be the assumption that a certain datum is correct when it is in error.

5. **Store and test the data.** Make sure it is accessible. Develop the data access software and programming. Concentrate on the procedures for data handling and access. Collect and manipulate trial data first, when possible, to make sure the system works as planned.

6. **Maintain the data.** Make sure that responsibilities for data updates have been assigned and budgeted. Procedures which are triggered by changes in the specific data (such as subdivision approval or use and occupancy permit issuance) should be set up and worked out.

7. **Develop and foster applications of the data.** Data is only as good as the use that is made of it. Therefore it is vitally important that applications are developed for easy use of the inventory data and that a pool of potential users is trained in their use. Those applications envisioned early in the process should be quickly brought on line. The greater amount of time that passes after the inventory the less chance there is that full use of the information is ever made.

9.3 Geographic Information Systems

9.3.1 Introduction

A Geographic Information System (GIS) is a computer-based database system designed to spatially analyze and display data. A GIS stores information about a given area as a collection of thematic layers that can be linked together by geography or geo-referencing. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world stormwater problems from tracking complaints, to master planning applications and infrastructure management.

9.3.2 GIS Components

A functional GIS integrates four key components: hardware, software, data, and trained users:

- Hardware: Desktop computers and digitizing equipment are the primary hardware components of a typical local GIS system.
- Software: GIS software provides the functionality and tools needed to capture or input, store, analyze, display, and output geographic information.

- Data: Generally the most costly part of a GIS is data development. Some geographic data and related tabular data can be collected in-house or purchased from commercial data providers. A GIS can also integrate tabular data or electronic drafting (CAD) data to build information into the GIS database.
- Users: GIS technology is of limited value without trained operators who understand the data, system, organization and how to apply the resources to achieve the desired results.

9.3.3 GIS Functions

General purpose geographic information systems essentially perform six processes or tasks:

Data Input

Before geographic data can be used in a GIS, the data must be converted into a suitable digital format. The process of converting data from paper maps into computer files is called digitizing. Modern GIS technology can sometimes automate this process fully for projects using scanning technology; some jobs may require some manual digitizing using a digitizing table. Today many types of geographic data already exist in GIS-compatible formats. These data can be obtained from a number of different sources including the Georgia GIS Data Clearinghouse at <http://www.gis.state.ga.us/Clearinghouse/clearinghouse.html>

Data Conversion

It is likely that some needed data may not be in the correct format or proper map projection to use with your system. Most GIS software has the ability to do this conversion, but in some cases this is better done by a contractor who specializes in data conversion. Be careful with third party data; it is imperative that you understand the source, quality, age, accuracy and limitations of a dataset. This and other information about a dataset is often provided in (FGDG) metadata that accompanies the dataset.

Query and Analysis

Once there is a functioning GIS containing geographic information, it can be used to answer questions such as:

- Who owns the land parcel being flooded?
- What is the distance between two stream locations?
- Which homes are located in the updated floodplain?
- How will the new development impact downstream properties?
- What types of infrastructure give us the most complaints and where are they located?

GIS provides both simple point-and-click query capabilities and sophisticated spatial analysis tools to provide timely information to stormwater managers and analysts alike. GIS technology can also be used to analyze geographic data to look for patterns and trends and to undertake "what if" scenarios. Most modern GISs have many powerful analytical tools including:

- Size Analysis – Provides specific information about a feature (e.g. What is the area and perimeter of a parcel?)
- Proximity Analysis – Determines relationships between objects and areas (e.g. Who is located within 100 feet of the streambank?)
- Overlay Analysis – Performs integration of different data layers (e.g. What is the SCS curve number for this sub-watershed considering soils, and land use?) Figure 9.3-1 illustrates the overlay concept.
- Network Analysis – Analyzes the connectivity of linear features and establishes routes or direction of flow (e.g. Which pipes feed into this junction box?)
- Raster Analysis – Utilizes a raster model to address a number of hydrologic issues (e.g. What does the 3-D model of this watershed look like? Where does the water flow?)

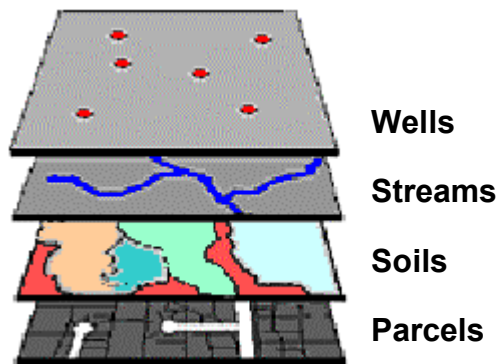


Figure 9.3-1 Example of Overlay Analysis
Source: ESRI

Data Display, Output and Visualization

Geographic information systems excel at being able to create rich and detailed maps, graphs and other types of output which allow local staff, elected officials and the general public to be able to visualize and understand complex problems and large amounts of information. These maps and charts can be integrated with reports, three-dimensional views, photographic images, and multimedia presentations.

9.3.4 Use of GIS in Stormwater Management

Types of Uses

GIS can be useful to a community in a wide variety of stormwater-related applications:

- GIS can be used for the mapping of surface features, land uses, soils, rainfall amounts, watershed boundaries, slopes, land cover, etc.
- A GIS can manage a stormwater system inventory and information about facility conditions, storm sewer networks, maintenance scheduling, and problem areas.
- GIS can be used to automate certain tasks such as measuring the areas of subwatersheds, plotting floodplain boundaries, or assessing stormwater utility fees. Figure 9.3-2 shows an example of automated hydrologic mapping.
- A GIS can be used to evaluate water quality impacts and answer cause and effect questions, such as the relationship between various land uses and in-stream pollution monitoring results.
- “What if” analyses can be undertaken with GIS. For example, various land use scenarios and their impacts on pollution or flooding can be tried in various combinations to determine the best management solutions or to determine the outcome of current decisions. When tied to hydrology, hydraulics and/or water quality models this type of analysis becomes a powerful tool to assess the impacts of new development on downstream properties. For example, Figure 9.3-3 shows the flooding impacts on a small tributary for a proposed new development approved during a rezoning.
- GIS databases can provide staff, elected officials, and citizens with immediate answers and ready information. For example, inventory, complaints and other information about stormwater infrastructure (including pictures) can be placed in a database tied to geographic location.
- Complex problems or changes over time, such as water quality improvements, can be easily visualized in maps and graphs generated by GIS systems.
- GIS maps can be used to educate or convince citizens and political leadership concerning a course of action or a project's viability.

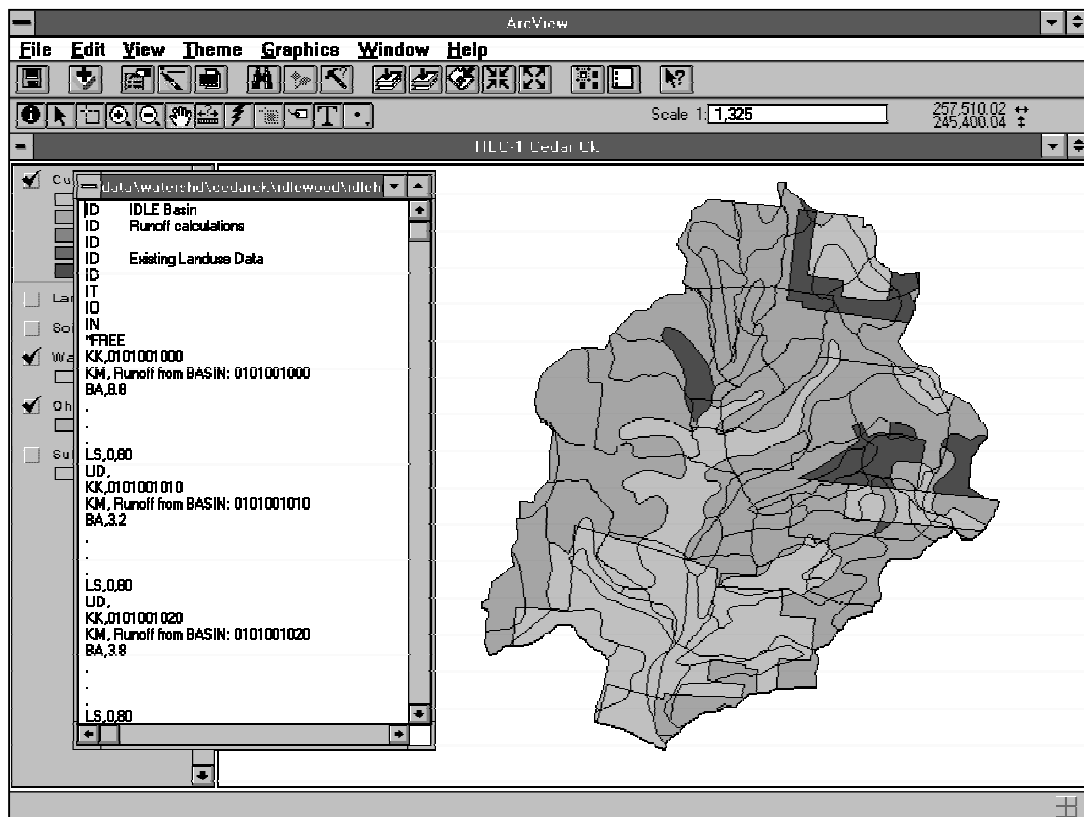


Figure 9.3-2 Automated Hydrologic Modeling

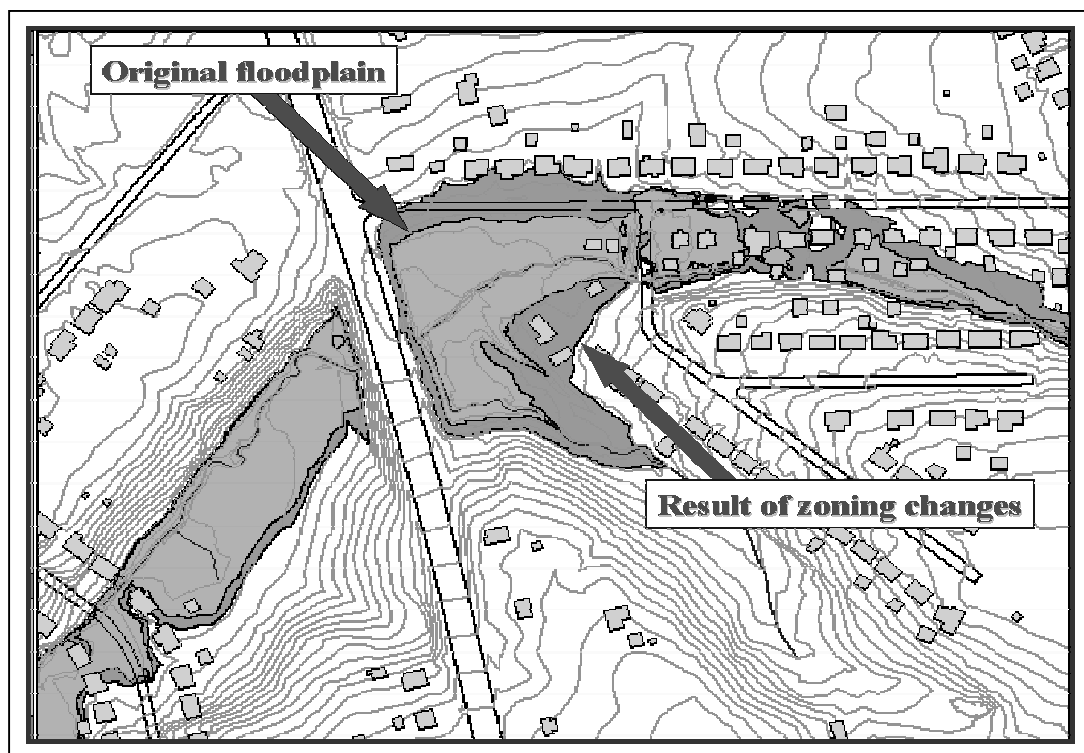


Figure 9.3-3 Use of a GIS to Map Current and Potential Floodplains & Flood Prone Homes

Implementation Issues

Communities often make the mistake of making enormous expenditures on data, hardware and software and databases but little on planning, staff familiarization, training and graphical user interface (GUI) and applications development. The end result is often an unusable system accessible by only a few who have the resources both to learn the system, hire competent staff, and develop applications. It is often better to target the GIS implementation to certain needs and quickly roll-out applications that work for these needs even prior to the complete development of the database and overall system.

Proper implementation of GIS applications for stormwater management involves planning for both stormwater only applications and to integrate these applications with other potential users within the municipality.

9.3.5 Other Related Technologies

GIS is closely related to several other types of information systems, and can be used with these other information tools, including:

CAD

Computer-Assisted Design (CAD) systems evolved to create designs and plans of buildings and infrastructure. The systems are designed to do very detailed drafting and drawing but have only limited capability to attach data fields to the electronic drawing. As a result these systems do not have the capability to perform spatial analysis. Fortunately these drawing can be input to a GIS saving significant digitizing efforts. Once in a GIS, attribute data can then be added to the graphic features.

DBMS

Database management systems (DBMS) specialize in the storage and management of all types of data including geographic data. DBMSs are optimized to store and retrieve data and many GISs rely on them for this purpose. They do not typically have the analytic and visualization tools common to GIS.

SCADA

SCADA stands for supervisory control and data acquisition system. These systems combine the ability to monitor information (e.g. rainfall, stream flow, flood level, etc.) remotely through telemetry. SCADA systems can also execute commands to do such things as open gates or close valves from a distance. Examples of the use of SCADA include automating stormwater pump station operation, automated alarms for flood warning and automated lowering of traffic control barrier arms during high water periods. SCADA systems can be combined with GIS to create comprehensive tracking systems.

9.4 Global Positioning Systems

9.4.1 Introduction

The Global Positioning System (GPS) is a space satellite based radio positioning system for obtaining accurate positional information for mapping or navigational purposes. GPS is made up of three distinct parts:

- Satellites – A constellation of 24 satellites orbiting the earth continuously emit a timing signal, provided by an on-board atomic clock, which is used to calculate the distance from each satellite to the receiver.
- Receiver – A GPS receiver located on the ground converts satellite signals into position, velocity, and time estimates.

- **Ground Control** – The U.S. Department of Defense (DOD) developed and currently manages the maintenance of the satellite system. The DOD uses tracking antennas to constantly monitor the precise position of the NAVSTAR satellites. These positions can be used to correct for errors in the calculated positions of the roving receivers.

The GPS was built and is maintained by the U.S. government. The satellites orbit at an altitude of approximately 12,000 miles in a 12-hour pattern that provides coverage to the entire earth. The system is capable of serving an unlimited number of users free of charge.

A GPS receiver uses information from at least 4 of the 24 satellites to precisely triangulate its position on the earth with about one meter accuracy. If a receiver cannot "see" four satellites, it can calculate a less-accurate estimate based on three satellites. Virtually all GPS receivers display basic positional information including latitude, longitude, elevation and speed (if moving). Most receivers also display time, heading, the number of satellites in view, where those satellites are positioned in the sky, and signal quality. GPS receivers for data collection can collect both the location (coordinates) and the attribute data of a given geographical feature.

9.4.2 GPS Applications to Stormwater

Stormwater infrastructure inventories can be conducted more easily and in far less time using GPS. In the past, traditional geodetic surveying was used to locate and map stormwater system components. A transit survey requires traversing between a known point to the point of interest, which may take half to one day per point. GPS surveying is much more efficient, possibly taking as little as a few seconds to map each point. Using bicycle or car-mounted equipment, a community may be able to survey up to 500 points per day.

GPS inventory work can be integrated with GIS application software. For example, a GIS layer of structural control locations can be created using GPS data and linked to a maintenance database. GPS data can also be used in computer modeling activities for stormwater management. For instance, GPS data can be used to create a ground surface for automated stream floodplain modeling and mapping.

9.5 Remote Sensing

9.5.1 Introduction

Remote Sensing is a technique for collecting observations of the earth using airborne platforms (airplanes and satellites) which have on-board instruments, or sensors. These sensors record physical images based on light, temperature or other reflected electromagnetic energy. This sensor data may be recorded as either analog data, such as photos or digital image data. Figure 9.5-1 gives an example of low (25-meter), medium (5-meter) and high (1-meter) resolution satellite imagery.

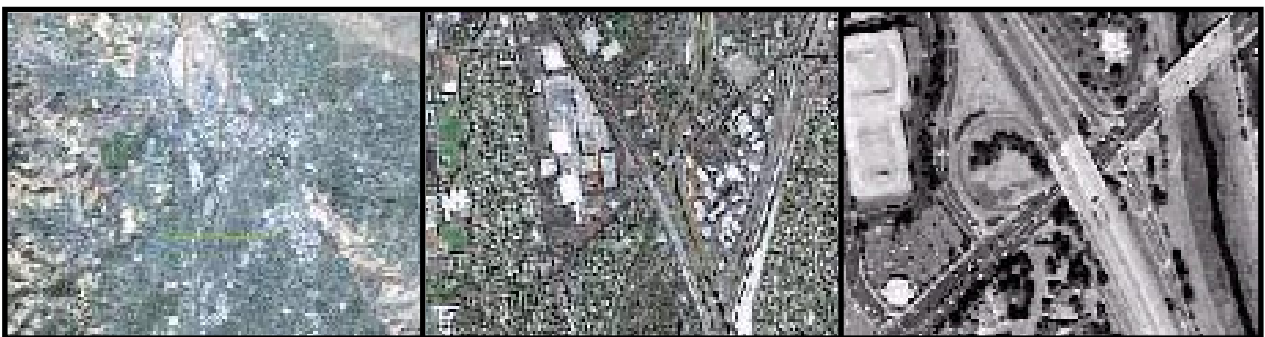


Figure 9.5-1 Low, Medium and High Resolution Satellite Imagery

Source: Space Imaging, Inc.

Ground reference data is then applied to aid in the analysis and interpretation of the sensor data, to calibrate the sensor, and to verify the information extracted from the sensor data. Remotely sensed images have a number of advantages to on-the-ground observation, including:

- Remote sensing can provide a regional view.
- Remote sensing can provide repetitive looks at the same area over time.
- Remote sensors "see" over a broader portion of the electromagnetic spectrum than the human eye.
- Sensors can focus on specific bandwidths in an image and can also look at a number of bandwidths simultaneously.
- Remote sensors often record signals electronically and provide geographically referenced data in digital format.
- Remote sensors operate in all seasons, at night, and in bad weather.

The airborne platforms that carry remote sensing instruments can be any kind of aircraft or satellite observing the Earth at altitudes anywhere from a few thousand feet to orbits of hundreds of kilometers. Satellites may employ a variety of sensors for numerous of applications. Currently, no single sensor is sensitive to all wavelengths. All sensors have fixed limits of spectral sensitivity and spatial sensitivity, the limit on how small an object on the earth's surface can be seen. The common type of sensors aboard satellites include:

- Multispectral Scanner (MSS) Sensors – Data are sensed in four spectral bands simultaneously: green, red, and two in near-infrared. (Steve – these can sense as many as six bands including UV, visible, near-IR, mid-IR and thermal)
- Thematic Mapper (TM) Sensors – Data are sensed in seven spectral bands simultaneously: blue, green, red, near-infrared, and two in mid-infrared. The seventh band detects only the thermal portion of the spectrum.
- Radio Detection and Ranging (RADAR) – Examples are Doppler radar systems used in weather and cloud cover predictions.

The appropriate band or combination of MSS bands should be selected for each interpretive use. For example bands 4 (green) and 5 (red) are usually best for detecting cultural features such as urban areas, roads, new subdivisions, gravel pits, and quarries. The TM bands are more finely tuned for vegetation discrimination than those of the MSS due in part to the narrower width of the green and red bands.

Examples of the growing number of remote sensing satellites include the U.S. Landsat satellites, the Indian Remote Sensing (IRS) satellites, Canada's RADARSAT, and the European Space Agency's Radar Satellite. Images from these satellites have spatial resolutions ranging from approximately 100 meters to 15 meters or better. The first commercial satellite capable of resolving objects on the ground as small as one meter in diameter was recently launched. Several competing companies have similar offerings. For example, the IKONOS-2 features high spatial resolutions of 1-meter panchromatic (black and white) and 4-meter multispectral (color). Panchromatic data has a higher resolution, while multispectral data provides better interpretation. Additionally, the 1-meter panchromatic spatial content can be combined with the spectral content of the 4-meter multispectral data. This 1-meter accuracy allows for a wide range of applications in stormwater management at a price typically less than \$500 per square mile (with some minimum order restrictions).

9.5.2 Digital Orthophoto Quarter Quadrangles (DOQQs)

Orthophotos combine the image characteristics of a photograph with the geometric qualities of a map. Unlike standard aerial photography, relief displacement in orthophotos has been removed displaying ground features in their true ground position, thus allowing for direct measurement of distance, area, angles, and positions.

The National Aerial Photography Program (NAPP) is the primary source of aerial photography used in the production of 1-meter digital orthophotos. The State of Georgia maintains a database of digital aerial photography known as digital orthophoto quarter quadrangles (DOQQs).

Figure 9.5-2 illustrates a section of a DOQQ from Columbus, Georgia. Local government organizations that do not have access to their own digital aerial photography can acquire this data. The details concerning DOQQs are:

- A standard DOQQ image covers an area of 3.75' x 3.75', or ¼ of a USGS quadrangle with some overlap
- 1-meter pixel resolution (1-meter resolution provides the minimum resolution needed for capturing smaller impervious features within the 200 sq. ft. to 100 sq. ft. range)
- Projected in Universal Transverse Mercator (UTM) with units in meters
- Available in TIFF format
- Coverage for the entire state of Georgia
- Images were captured between 1993 and 1999
- DOQQ images for all of Georgia can be obtained at the Georgia GIS Data Clearinghouse (<http://www.gis.state.ga.us/Clearinghouse/clearinghouse.html>)



Figure 9.5-2 Example DOQQ

9.5.3 Remote Sensing Applications for Stormwater

Satellite imagery offers a diverse set of mapping products for projects ranging from land use/land cover evaluation to urban and regional planning, tax assessment and collection, and growth monitoring. In the case of stormwater runoff, multispectral imagery can be used to measure impervious surfaces, such as rooftops, streets, and parking lots. Pervious surfaces, such as tree- and grass-covered areas can also be measured or delineated. Applying runoff coefficients to the area of each surface type can provide the best available estimates for nonpoint source water pollution. By adding parcel boundaries, it is possible to provide estimates of runoff per parcel in order to calculate stormwater user fees. Similarly, designated land use categories can be applied to the area of each surface type and in combination with the known soil coverage can be used to calculate hydrologic curve numbers. Flood boundaries can be measured within a few meters accuracy in areas without tree cover using submeter multispectral fused imagery. Individual buildings and parcel boundaries can also be identified in order to assess flood vulnerability.

9.6 Computer Models

9.6.1 Introduction

There is a great deal of computer software that has been developed based on the intensive research effort in urban hydrology, hydraulics and stormwater quality. Computer models use the computational power of computers to automate the tedious and time-consuming manual calculations. Most models also include extensive routines for data management, including input and output procedures, and possibly including graphics and statistical capabilities.

Computer modeling became an integral part of storm drainage planning and design in the mid-1970s. Several agencies undertook major software developments and these were soon supplemented by a plethora of proprietary models, many of which were simply variants on the originals. The proliferation of personal computers in the 1990s has made it possible for virtually every engineer to use state-of-the-art analytical technology for purposes ranging from analysis of individual pipes to comprehensive stormwater management plans for entire cities.

In addition to the simulation of hydrologic and hydraulic processes, computer models can have other uses. They can provide a quantitative means to test alternatives and controls before implementation of expensive measures in the field. If a model has been calibrated and verified at a minimum of one site, it may be used to simulate non-monitored conditions and to extrapolate results to similar ungauged sites. Models may be used to extend time series of flows, stages and quality parameters beyond the duration of measurements, from which statistical performance measures then may be derived. They may also be used for design optimization and real-time control.

A local staff or design engineer will typically use one or more of these pieces of software in stormwater facility design and review, according to the design objectives and available resources. However, it should be kept in mind that proper use of computer modeling packages requires a good knowledge of the operations of the software model and any assumptions that the model makes. The engineer should have knowledge of the hydrological, hydraulic and water quality processes simulated and knowledge of the algorithms employed by the model to perform the simulation.

9.6.2 Types of Models

In urban stormwater management there are typically three types of computer models that are commonly used: *hydrologic*, *hydraulic* and *water quality* models.

Hydrologic Models – Hydrologic models attempt to simulate the rainfall-runoff process to tell us “how much water, how often.” They use rainfall information or models to provide runoff characteristics including peak flow, flood hydrograph, and flow frequencies.

Hydraulic Models – Hydraulic models take a known flow amount (typically the output of a hydrologic model) and provide information about flow height, location, velocity, direction and pressure.

Water Quality Models – The goal in water quality modeling is to adequately simulate the various processes and interactions of stormwater pollution. Water quality models have been developed with an ability to predict loadings of various types of stormwater pollutants.

There are also a number of other specialty models to simulate any number of ancillary topics (some of which are sub-sets of the three main categories) including sediment transport, scour, lake quality, dissolved oxygen, channel stability, evapotranspiration, etc.

9.6.3 Model Applications

Stormwater computer models can also be categorized by their use or application:

Screening level models are typically equations or spreadsheet models that give a first estimate of the magnitude of urban runoff quality or quantity. At times this is the only level that is necessary to provide answers. This is true either because the answer needs to be only approximate or because there is no data to justify a more refined procedure.

Planning level models are used to perform “what if” analysis comparing in a general way design alternatives or control options. They are used to establish flow frequencies, floodplain boundaries, and general pollution loading values.

Design level models are oriented toward the detailed simulation of a single storm event for the purposes of urban stormwater design. They provide a more complete description of flow or pollution values anywhere in the system of concern and allow for adjustment of various input and output variables in some detail. They can be more exact in the impact of control options, and tend to have a better ability to be calibrated to fit observed data.

Operational models are used to produce actual control decisions during a storm event. They are often linked with SCADA systems described earlier. They are often developed from modified or strongly calibrated design models, or can be developed on a site specific basis to appropriately link with the system of concern and accurately model the important physical phenomena.

9.6.4 Basic Computer Modeling Principles

The following basic principles apply to all forms of computer modeling:

- (1) All computer models require site-specific information to be supplied by the user. Inputs are the measured or estimated parameters the model needs to make calculations. For example, for basic hydrologic models it might include: area, slope, land use, channel forms and roughness, connectivity, and rainfall. A basic hydraulic model would include: channel slope, discharge, roughness, shape, obstructions or constrictions, and connectivity. Water quality models may add pollution loading or build-up-washoff factors, and fate and transport information. All models, for planning and design, allow the modeler to try different combinations of variables to see what happens (called a “what if” analysis).
- (2) While modeling generally yields more information, simpler methods may provide sufficient information for design or solving management issues. In general, the simplest method that provides the desired analysis should be used. The risk of using a more complex (and presumably “better”) model is that it requires more expertise, data, support, etc. to use and understand, with a consequent higher probability of misapplication.
- (3) If water quality problems are being considered, it still may not be necessary to simulate quality processes since most control strategies are based on hydrologic or hydraulic considerations. Quality processes are very difficult to simulate accurately. If abatement strategies can be developed without the simulation of water quality parameters, the overall modeling program will be greatly simplified.

Models sometimes may be used to extrapolate beyond the measured data record. It is important to recognize, however, that models do not extend data, but rather generate simulated numbers that should never be assumed to be the same as data collected in the field. Careful consideration should be given when using models to provide input to receiving water quality analyses. The quality response of most receiving waters is relatively insensitive to such short-term variations. In many instances, the total storm load will suffice to determine the receiving water response. Simulation of short time increment changes in concentrations and loads is generally necessary only for analysis of control options, such as storage or high-rate treatment, whose efficiency may depend on the transient behavior of the quality constituents.

9.6.5 Selecting the Appropriate Computer Model

Models can be simple, representing only a very few measured or estimated input parameters or can be very complex involving twenty times the number of input parameters. The “right” model is the one that: (1) the user thoroughly understands, (2) gives adequately accurate and clearly displayed answers to the key questions, (3) minimizes time and cost, and (4) uses readily available or collected information. Complex models used to answer simple questions are not an advantage. However, simple models that do not model key necessary physical processes are useless.

Volume 2 of this Manual provides additional information and guidance for local governments and engineers on computer models for stormwater management modeling and design.

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Schueler T., and Holland, H., 2000. The Practice of Watershed Protection. Center for Watershed Protection (CWP).

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CONTACT AGENCIES FOR STORMWATER MANAGEMENT REGULATIONS AND PROGRAMS

National Flood Insurance Act / Flood Disaster Protection Act

Contact Agency	Phone	Address
Federal Emergency Management Agency (FEMA)	770-220-5200	3003 Chamblee Tucker Road Atlanta, GA 30341

Website: www.fema.gov/reg-iv/index.htm

Contact Agency	Phone	Address
Georgia EPD – Floodplain Management Office	404-656-6382	7 Martin Luther King, Jr. Dr. Atlanta, GA 30334

Website: www.dnr.state.ga.us/dnr/envIRON

Georgia Safe Dams Act

Contact Agency	Phone	Address
Georgia EPD – Safe Dams Program	404-362-2678	4220 International Parkway, Suite 101 Atlanta, GA 30354

Website: www.dnr.state.ga.us/dnr/envIRON

Municipal NPDES Stormwater Permit Program (Phase I and II)

Contact Agency	Phone	Address
Georgia EPD – Nonpoint Source Program	404-675-6240	4220 International Parkway, Suite 101 Atlanta, GA 30354

Website: www.dnr.state.ga.us/dnr/envIRON

Industrial NPDES Stormwater Permit Program

Contact Agency	Phone	Address
Georgia EPD – Nonpoint Source Program	404-675-6240	4220 International Parkway, Suite 101 Atlanta, GA 30354

Website: www.dnr.state.ga.us/dnr/envIRON

NPDES Stormwater Permits for Construction Areas

Contact Agency	Phone	Address
Georgia EPD – Nonpoint Source Program	404-675-6240	4220 International Parkway, Suite 101 Atlanta, GA 30354

Website: www.dnr.state.ga.us/dnr/environ

NPDES Municipal Wastewater Discharge

Contact Agency	Phone	Address
Georgia EPD – Permitting Compliance & Enforcement Program	404-362-2680	4220 International Parkway, Suite 101 Atlanta, GA 30354

Website: www.dnr.state.ga.us/dnr/environ

Erosion and Sedimentation Act

Contact Agency	Phone	Address
1) Georgia Soil and Water Conservation Commission	706-542-9233	P.O. Box 8024 Athens, GA 30603

Website: <http://www.gaswcc.org/>

2) State Soil and Water Conservation Districts	(contact above for your district)
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3) Georgia EPD – Erosion and Sedimentation Unit	404-675-6240	4220 International Parkway, Suite 101 Atlanta, GA 30354
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Website: www.dnr.state.ga.us/dnr/environ

Total Maximum Daily Load (TMDL) Program

Contact Agency	Phone	Address
US EPA – Region 4	404-562-9900	Atlanta Federal Center 61 Forsyth Street, SW Atlanta, GA 30303-3104

Website: www.epa.gov/region4/water/tmdl

Georgia EPD – Total Maximum Daily Load Unit	404-675-6232	4220 International Parkway, Suite 101 Atlanta, GA 30354
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Website: www.dnr.state.ga.us/dnr/environ

River Corridor Protection

Contact Agency	Phone	Address
Georgia DCA – Office of Coordinated Planning	404-679-3107	60 Executive Park, South, NE Atlanta, GA 30329

Website: www.dca.state.ga.us/planning/

Metropolitan River Protection Act

Contact Agency	Phone	Address
Atlanta Regional Commission (ARC)	404-463-3100	40 Courtland Street, NE Atlanta, GA 30303

Website: www.atlantaregional.com

Georgia Planning Act (Water Supply Watersheds, Groundwater Recharge Areas)

Contact Agency	Phone	Address
Georgia EPD – Watershed Planning and Monitoring Program	404-675-6236	4220 International Parkway, Suite 101 Atlanta, GA 30354

Website: www.dnr.state.ga.us/dnr/environ

Groundwater Management / Wellhead Protection Program

Contact Agency	Phone	Address
Georgia Geologic Survey – Groundwater Management and Wellhead Protection	404-656-3214	19 Martin Luther King Dr, SW, Room 400 Atlanta, GA 30334

Website: www.dnr.state.ga.us/dnr/environ

Source Water Assessment Program

Contact Agency	Phone	Address
Georgia EPD – Drinking Water Compliance Program	404-656-4807	SWAP Unit Floyd Tower East, Suite 1362 205 Butler Street, SE Atlanta, GA 30334

Website: www.dnr.state.ga.us/environ

Coastal Management Program and Coastal Marshlands Protection Act

Contact Agency	Phone	Address
Georgia DNR – Coastal Resources Division	912-264-7218	1 Conservation Way, Suite 300 Brunswick, GA 31520

Website: www.dnr.state.ga.us/dnr/coastal/

Section 404 of Clean Water Act and Section 10 Rivers and Harbors Act

Contact Agency	Phone	Address
For Section 404 CWA:		
US Army Corps of Engineers, Savannah District (for Central and Coastal Areas of State)	800-448-2402	P.O. Box 889 Savannah, GA 31402
US Army Corps of Engineers, Atlanta Office (for North Area of State – top half of state)	678-422-2720	1590 Adamson Parkway, Suite 130 Morrow, GA 30260

Website: www.sas.usace.army.mil/permit.htm

Georgia Greenspace Program

Contact Agency	Phone	Address
Georgia Greenspace Commission	404-656-5165	7 Martin Luther King, Jr. Drive, Room 146 Atlanta, GA 30334

Website: www.state.ga.us/dnr/greenspace/

STORMWATER MANAGEMENT SITE PLAN REVIEW CHECKLISTS

- ❑ **Example Checklist for Preliminary Stormwater Management Site Plan Preparation and Review**

- ❑ **Example Checklist for Final Stormwater Management Site Plan Preparation and Review**

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Example Checklist for **Preliminary** Stormwater Management Site Plan Preparation and Review

1. Applicant information

- ☐ Name, legal address, and telephone number

2. Common address and legal description of site

3. Vicinity map

4. Existing and proposed mapping and plans (recommended scale of 1" = 50' or greater detail) which illustrate at a minimum:

- ☐ Existing and proposed topography (minimum of 2-foot contours recommended)
- ☐ Perennial and intermittent streams
- ☐ Mapping of predominant soils from USDA soil surveys
- ☐ Boundaries of existing predominant vegetation and proposed limits of clearing and grading
- ☐ 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.)
- ☐ Location of existing and proposed roads, buildings, parking lots and other impervious areas
- ☐ Location of existing and proposed utilities (e.g., water, sewer, gas, electric) and easements
- ☐ Preliminary estimates of unified stormwater sizing criteria requirements
- ☐ Preliminary identification and calculation of stormwater site design credits
- ☐ Preliminary selection and location of structural stormwater controls
- ☐ Location of existing and proposed conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow
- ☐ Flow paths
- ☐ Location of floodplain/floodway limits and relationship of site to upstream and downstream properties and drainages
- ☐ Preliminary location and dimensions of proposed channel modifications, such as bridge or culvert crossings

5. Hydrologic and hydraulic analysis including:

- ☐ Existing conditions hydrologic analysis for runoff rates, volumes, and velocities showing methodologies used and supporting calculations
- ☐ Proposed (post-development) conditions hydrologic analysis for runoff rates, volumes, and velocities showing the methodologies used and supporting calculations

-
- ❑ Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms
 - ❑ Preliminary sizing calculations for structural stormwater controls including contributing drainage area, storage, and outlet configuration
 - ❑ Preliminary analysis of potential downstream impact/effects of project, where necessary
- 6. Preliminary erosion and sediment control plan that at a minimum meets the requirements outlined in the Manual for Erosion and Sediment Control in Georgia**
 - 7. Preliminary landscaping plans for structural stormwater controls and any site reforestation or revegetation**
 - 8. Preliminary identification of waiver requests**

Example Checklist for **Final** Stormwater Management Site Plan Preparation and Review

1. Applicant information

- ☐ Name, legal address, and telephone number

2. Common address and legal description of site

3. Signature and stamp of registered engineer/landscape architect and designer/owner certification

4. Vicinity map

5. Existing and proposed mapping and plans (recommended scale of 1" = 50' or greater detail) which illustrate at a minimum:

- ☐ Existing and proposed topography (minimum of 2-foot contours recommended)
- ☐ Perennial and intermittent streams
- ☐ Mapping of predominant soils from USDA soil surveys as well as the location of any site-specific borehole investigations that may have been performed
- ☐ Boundaries of existing predominant vegetation and proposed limits of clearing and grading
- ☐ 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.)
- ☐ Location of existing and proposed roads, buildings, parking lots and other impervious areas
- ☐ Location of existing and proposed utilities (e.g., water, sewer, gas, electric) and easements
- ☐ Estimates of unified stormwater sizing criteria requirements
- ☐ Identification and calculation of stormwater site design credits
- ☐ Selection and location of structural stormwater controls
- ☐ Location of existing and proposed conveyance systems such as storm drains, inlets, catch basins, channels, swales, and areas of overland flow
- ☐ Flow paths
- ☐ Location of floodplain/floodway limits and relationship of site to upstream and downstream properties and drainages
- ☐ Location and dimensions of proposed channel modifications, such as bridge or culvert crossings

6. Hydrologic and hydraulic analysis including:

- ☐ Existing conditions hydrologic analysis for runoff rates, volumes, and velocities showing methodologies used and supporting calculations
- ☐ Proposed (post-development) conditions hydrologic analysis for runoff rates, volumes, and velocities showing the methodologies used and supporting calculations

-
- ❑ Hydrologic and hydraulic analysis of the stormwater management system for all applicable design storms
 - ❑ Final sizing calculations for structural stormwater controls including contributing drainage area, storage, and outlet configuration
 - ❑ Stage-discharge or outlet rating curves and inflow and outflow hydrographs for storage facilities
 - ❑ Final analysis of potential downstream impact/effects of project, where necessary
 - ❑ Dam safety and breach analysis, where necessary

7. Representative cross-section and profile drawings and details of structural stormwater controls and conveyances which include:

- ❑ Existing and proposed structural elevations (e.g., invert of pipes, manholes, etc.)
- ❑ Design water surface elevations
- ❑ Structural details of structural control designs, outlet structures, embankments, spillways, grade control structures, conveyance channels, etc.

8. Applicable construction specifications

9. Erosion and sediment control plan that at a minimum meets the requirements outlined in the Manual for Erosion and Sediment Control in Georgia

10. Landscaping plans for structural stormwater controls and any site reforestation or revegetation

11. Operations and maintenance plan that includes:

- ❑ Name, legal address and phone number of responsible parties for maintenance activities
- ❑ Description and schedule of maintenance tasks
- ❑ Description of applicable easements
- ❑ Description of funding source
- ❑ Access and safety issues
- ❑ Procedures for testing and disposal of sediments, if required

12. Evidence of acquisition of all applicable local and non-local permits

13. Waiver requests

14. Evidence of acquisition of all necessary legal agreements (e.g., easements, covenants, land trusts, etc.)

EXAMPLE STORMWATER FACILITY MAINTENANCE AGREEMENT

THIS AGREEMENT, made and entered into this ____ day of _____, 20____, by and between (Insert Full Name of Owner) _____ hereinafter called the "Landowner", and the [Local Jurisdiction], hereinafter called the "[City/County]". WITNESSETH, that WHEREAS, the Landowner is the owner of certain real property described as (Tax Map/Parcel Identification Number) _____ as recorded by deed in the land records of [Local Jurisdiction], Georgia, Deed Book _____ Page _____, hereinafter called the "Property".

WHEREAS, the Landowner is proceeding to build on and develop the property; and WHEREAS, the Site Plan/Subdivision Plan known as _____, (Name of Plan/Development) hereinafter called the "Plan", which is expressly made a part hereof, as approved or to be approved by the County, provides for detention of stormwater within the confines of the property; and

WHEREAS, the [City/County] and the Landowner, its successors and assigns, including any homeowners association, agree that the health, safety, and welfare of the residents of [Local Jurisdiction], Georgia, require that on-site stormwater management facilities be constructed and maintained on the Property; and

WHEREAS, the County requires that on-site stormwater management facilities as shown on the Plan be constructed and adequately maintained by the Landowner, its successors and assigns, including any homeowners association.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site stormwater management facilities shall be constructed by the Landowner, its successors and assigns, in accordance with the plans and specifications identified in the Plan.
2. The Landowner, its successors and assigns, including any homeowners association, shall adequately maintain the stormwater management facilities. This includes all pipes, channels or other conveyances built to convey stormwater to the facility, as well as all structures, improvements, and vegetation provided to control the quantity and quality of the stormwater. Adequate maintenance is herein defined as good working condition so that these facilities are performing their design functions. The Stormwater Structural Control Maintenance Checklists are to be used to establish what good working condition is acceptable to the [City/County].
3. The Landowner, its successors and assigns, shall inspect the stormwater management facility and submit an inspection report annually. The purpose of the inspection is to assure safe and proper functioning of the facilities. The inspection shall cover the entire facilities, berms, outlet structure, pond areas, access roads, etc. Deficiencies shall be noted in the inspection report.
4. The Landowner, its successors and assigns, hereby grant permission to the [City/County], its authorized agents and employees, to enter upon the Property and to inspect the stormwater management facilities whenever the [City/County] deems necessary. The purpose of inspection is to follow-up on reported deficiencies and/or to respond to citizen complaints. The [City/County] shall provide the Landowner, its successors and assigns, copies of the inspection findings and a directive to commence with the repairs if necessary.

5. In the event the Landowner, its successors and assigns, fails to maintain the stormwater management facilities in good working condition acceptable to the [City/County], the [City/County] may enter upon the Property and take whatever steps necessary to correct deficiencies identified in the inspection report and to charge the costs of such repairs to the Landowner, its successors and assigns. This provision shall not be construed to allow the [City/County] to erect any structure of permanent nature on the land of the Landowner outside of the easement for the stormwater management facilities. It is expressly understood and agreed that the [City/County] is under no obligation to routinely maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the [City/County].

6. The Landowner, its successors and assigns, will perform the work necessary to keep these facilities in good working order as appropriate. In the event a maintenance schedule for the stormwater management facilities (including sediment removal) is outlined on the approved plans, the schedule will be followed.

7. In the event the [City/County] pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner, its successors and assigns, shall reimburse the [City/County] upon demand, within thirty (30) days of receipt thereof for all actual costs incurred by the [City/County] hereunder.

8. This Agreement imposes no liability of any kind whatsoever on the [City/County] and the Landowner agrees to hold the [City/County] harmless from any liability in the event the stormwater management facilities fail to operate properly.

9. This Agreement shall be recorded among the land records of [Local Jurisdiction], Georgia, and shall constitute a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interests, including any homeowners association.

WITNESS the following signatures and seals:

Company/Corporation/Partnership Name (Seal)

By: _____

(Type Name and Title)

The foregoing Agreement was acknowledged before me this ____ day of _____, 20____, by _____.

NOTARY PUBLIC

My Commission Expires: _____

COUNTY OF _____, GEORGIA

By: _____

(Type Name and Title)

The foregoing Agreement was acknowledged before me this ____ day of _____, 20____, by _____.

NOTARY PUBLIC

My Commission Expires: _____

Approved as to Form:

[City/County] Attorney Date