ORDINANCE NO.: 2019-033

Authorizing the City Manager to execute a Twelfth Amendment to Purchase Agreement between the City of Columbia and Bright-Meyers 2001 LLC for the sale of 5.97 +/-acres (Capital City Stadium), Richland County TMS #11204-02-02

BE IT ORDAINED by the Mayor and City Council this 18th day of June, 2019, that the City Manager is authorized to execute the attached Twelfth Amendment to Purchase Agreement, or on a form approved by the City Attorney, between the City of Columbia and Bright-Meyers 2001 LLC for the sale of 5.97 acres +/- (Capital City Stadium), Richland County TMS #11204-02-02.

Requested by:

Assistant City Manager Gentry

Approved by:

City Manager

Mayor

Approved as to form:

City Attorney

ATTEST:

City Clerk

Introduced: 5/7/2019; deferred 6/11/2019
Final Reading: 6/18/2019

Last revised: 4/29/2019
19001276

TWELFTH AMENDMENT TO PURCHASE AGREEMENT

This Twelfth Amendment to Purchase Agreement is made and entered into by and between the City of Columbia, hereinafter referred to as "Seller", and Ballpark, LLC, a South Carolina limited liability company, as assignee of Bright-Meyers Assembly Street, LLC, hereinafter referred to as "Buyer".

WITNESSETH:

WHEREAS, Seller and Bright-Meyers 2001 LLC entered into a Purchase Agreement effective August 27, 2012 (as amended by eleven prior instruments, the "Agreement"), which gives Buyer the exclusive right to purchase the property ("Property") described in the Agreement under the terms and conditions of the Agreement; and,

WHEREAS, pursuant to that certain Assignment of Purchase Agreement dated October 15, 2018 Bright Meyers 2001 LLC assigned its rights and obligations under the Agreement to its affiliate, Bright-Meyers Assembly Street, LLC, a Tennessee limited liability company; and

WHEREAS, pursuant to that certain Assignment of Contract dated January 29, 2019 Bright-Meyers Assembly Street, LLC assigned its rights and obligations under the Agreement to Ballpark, LLC; and

WHEREAS, Seller and Buyer mutually desire to further modify, amend and clarify said Agreement.

NOW, THEREFORE, IT IS HEREBY AGREED, that for and in consideration of the sum of Ten and No/100 ($10.00) Dollars, the receipt and sufficiency of which is hereby acknowledged, the Agreement is amended as follows:

1. Seller hereby acknowledges the assignment of the rights and obligations under the Agreement by Bright-Meyers Assembly Street, LLC to Ballpark, LLC.

2. Paragraph 2 of the Agreement is amended as necessary to state that the Price in increased from One Million Fourt Hundred Twenty-five Thousand and No/100 ($1,425,000.00) to One Million Six Hundred Twenty-five Thousand and No/100 ($1,625,000.00) Dollars.

3. Paragraph 5 is hereby amended to read:

> 5. CONDITIONS AND RESTRICTIONS. The Seller shall convey the property described in Paragraph 1 hereof to the Buyer in fee simple by proper Indenture Limited Warranty Deed with Covenants, in the form of which is attached hereto as Exhibit "A" and incorporated herein by reference, free from all liens and encumbrances except as are herein agreed to. The Buyer agrees to accept the property subject to any governmental statute or ordinance, zoning ordinance and regulation, building restriction and condition, restrictive covenant, and easements of record, including any shown on a recorded plat; also, any state of facts that an accurate survey would show.

4. Paragraph 6 of the Agreement is amended as necessary to add that Seller agrees not cause the buildings and other improvements located on the Property to be demolished or otherwise removed from the Property unless any such improvements are damaged by fire or other casualty which creates an unsafe or unsightly condition.

5. Paragraph 7 of the Agreement is deleted in its entirety.

6. Paragraph 8 of the Agreement is amended as necessary to state that Buyer shall develop and fund a plan ("Security Plan") to provide private security to monitor the Property in an effort to prevent unauthorized persons from entering the Property. Buyer's Security Plan shall be scalable and shall be provided to the City Manager (or designee) of Seller for review and approval. All modifications reasonably requested by the City Manager (or designee) shall be incorporated into the Security Plan. Such Security Plan shall be provided to the City Manager (or designee) no later than ten (10) days after the Amendment Effective Date, implemented within ten (10) days after the City Manager's (or designee's) approval thereof, and shall continue

until the earlier of Closing or termination of this Agreement. Buyer shall indemnify and hold harmless Seller from any and all actual damages and injuries suffered or incurred as a result of the willful acts or gross negligence of Buyer, or its agents, in implementing and executing the Security Plan.

7. Paragraph 12 of the Agreement is hereby amended to read as follows:

If the Buyer shall default under this Agreement, the Seller's sole remedy shall be to terminate this Agreement and retain and/or receive all Earnest Money as full and complete liquidated damages. Buyer shall be in default under this Agreement if Buyer fails to comply with any term, covenant, provision or requirement of this Agreement within twenty (20) days after receipt of written notice ("Seller's Notice") from Seller specifying such default. In the event the default is of a nature that is not reasonably capable of cure within such twenty (20) day period, Buyer shall commence such curative efforts within such period and thereafter diligently pursue such curative efforts to completion no later than forty-five (45) days after Seller's Notice.

8. Paragraph 14 of the Agreement is amended to provide that the Closing shall take place no later than May 1, 2020; provided however, that Buyer shall give Seller written notice of its intent to close at least eight (8) weeks prior to the desired Closing date.

9. Paragraph 24 of the Agreement is hereby amended to delete the following:

"Seller will obligate up to Five Hundred Thousand and No/100 ($500,000.00) Dollars of the proceeds realized from the sale of the property to make improvements to Rocky Branch which will further reduce flooding and further improve water quality. These improvements will be made by the Seller after the Buyer has completed improvements to reduce flooding and further improve water quality in Rocky Branch as required of the Buyer in this Agreement of Sale. The type of improvements to be made by the Seller shall be in the Seller's sole and exclusive discretion."

10. Paragraph 25 of the Agreement is deleted in its entirety.

11. The following provisions are added to the Agreement:

(a) <u>Contributions to Historic Columbia</u>. In addition to the purchase price, Buyer agrees to contribute the sum of Sixty Thousand and No/100 ($60,000.00) Dollars ("HC Funding") to Historic Columbia for the specific purpose of funding a documentary of Capital City Stadium as well as site preparation and event staffing for an on-site "last tour" event to take place prior to the demolition of the structure. Thirty Thousand and No/100 ($30,000.00) Dollars shall be funded by Buyer no later than June 30, 2019 and the balance shall be funded no later than August 30, 2019. The HC Funding is nonrefundable to Buyer once paid.

(b) <u>SSRC Proforma</u>. No later than thirty (30) days after the Amendment Effective Date, Buyer shall provide a project proforma and supporting documentation to identify the anticipated costs associated with the improvements to be supported by the Special Source Revenue Credit ("SSRC") to support the Rocky Branch improvements and construction of the Greenway. Buyer agrees, at Buyer's expense, to make its project team members available to City of Columbia and Richland County staff as needed to ensure there is a complete understanding of the improvements being planned that are intended to be supported by the SSRC. Seller acknowledges that the project proforma shall be subject to modifications as permitting and planning for the planned improvements progresses; provided, however, that no financial assistance other than the SSRC, if approved, will be requested or accepted from the City of Columbia.

(c) <u>SSRC Approval</u>. Buyer agrees to submit its application for the SSRC to Richland County Council for first reading no later than July 9, 2019. Seller acknowledges that the July 9, 2019 meeting of Richland County Council is a special called meeting and may be subject to cancellation. Consequently, Buyer intends to submit its application for the June 18, 2019 meeting of Richland County Council. Upon City Council approval of the second reading of the 12th amendment, the City will provide written notification to Richland County confirming the PSA extension which includes acknowledgement of the Developer's intent to seek a SSRC from Richland County and the City of Columbia for purposes of supporting the off-site storm water improvements required for the project to proceed. This notification will acknowledge upon approval of First Reading by Richland County, City staff will proceed with placing the item on the next available City Council agenda for approval within the guidelines for the agenda submittals.

(d) Purchase of SCE&G Property. Buyer is concurrently pursuing from South Carolina Electric & Gas Company ("SCE&G") consent for the assignment to Buyer and modification of that certain Agreement of Sale and Purchase (1031 Exchange Applicable) dated October 4, 2011, as amended between SCE&G and Bright-Meyers Assembly Street, LLC (the "SCE&G Contract") for the purchase and sale of approximately 11.60 acres of land located adjacent to the Property (the "SCE&G Property"). Buyer shall close on its acquisition of the SCE&G Property simultaneously with its Closing on this Property.

(e) Assignment The Agreement shall not be assigned or transferred in whole or in part without the prior written consent of the Seller which shall not be unreasonably withheld or delayed. Notwithstanding the forgoing restriction, Buyer may assign this Agreement to a new entity created by Buyer's equity investor in connection with the purchase of the Property provided (i) Buyer provides Seller ten (10) days prior written notice of such assignment, and (ii) such assignment is made not sooner than thirty (30) days prior to closing.

(f) Earnest Money. Buyer and Seller acknowledge and agree that the $304,000 Earnest Money paid prior to the Amendment Effective Date is nonrefundable and has been paid to the Seller. The Earnest Money shall be applied as a credit against the Purchase Price at the Closing. Buyer shall pay additional Earnest Money in the amount of One Hundred Fifty Thousand and No/100 ($150,000.00) DOllars to Seller as follows:

(1) The sum of Thirty Thousand and No/100 ($30,000.00) Dollars shall be paid not later than two business days following second reading approval by Columbia City Council of Buyer's application for rezoning.

(2) The sum of Thirty Thousand and No/100 ($30,000.00) Dollars shall be paid not later than two business days following the date Buyer receives written confirmation from South Carolina Department of Health and Environmental Control that the Voluntary Cleanup Contract for the Property (the "VCC") has been approved. Buyer agrees to submit its application for the VCC not later than July 31, 2019.

(3) The sum of Sixty-five Thousand and No/100 ($65,000.00) Dollars shall be paid not later than two business days following third reading approval by Richland County Council of Borrower's request for the SSRC. Buyer agrees to submit its request for the SSRC for the August 1, 2019 meeting of Richland County Council. If Richland County Council does not meet on August 1, 2019, Buyer shall submit its request for the SSRC for the September 10, 2019 meeting.

(4) The sum of Twenty-five Thousand and No/100 ($25,000.00) Dollars shall be paid not later than December 15, 2019.

(g) Rezoning. Buyer shall submit its request to rezone the Property to the City of Columbia no later than July 31, 2019, and diligently pursue such rezoning to completion.

(h) Assurances of Development Capability. Buyer agrees to provide City with monthly updates summarizing all activities undertaken and planned with regard to Buyer's plans to develop the Property as a multifamily development with supporting retail (the "Project"). Such updates shall include, but not be limited to, all meetings with public officials, the status of all permit applications and other entitlements, the status of all architectural plans, engineering plans, flood plain mitigation plans and other design work and studies required for development of the Project. Buyer shall also provide Seller with documents reasonably requested to evidence Buyer's prior experience and success with projects requiring similar entitlements, planning and funding.

(i) Use of Property. Seller may grant third parties the right to utilize all or a portion of the Property from time to time provided all such agreements are terminated prior to Closing. Buyer shall not be liable for any damages or injuries caused by or resulting from such third parties' use of or entry onto the Property, and the Security Plan may be modified with Seller's approval during the pendency of such parties' use and occupancy. Seller will use commercially reasonable efforts to avoid interference with Buyer's due diligence due to any such use of the Property.

(j) Notwithstanding anything to the contrary in the Agreement, the Seller reserves the right to require the Buyer to match Seller's funding of the costs of the greenway to Olympia Park, subject to a maximum funding obligation by Buyer of Two Hundred Fifty Thousand and No/100 ($250,000.00) Dollars.

(k) Seller reserves the right to remove any items from the Property prior to Closing.

12. The Agreement is hereby reinstated and is in full force and effect as of the date of this Amendment.

The "Amendment Effective Date" shall be the date upon which this Amendment is executed by both Seller and Buyer.

Except as modified and amended hereby, all the terms, covenants and conditions of said Purchase Agreement and subsequent Amendments shall continue and remain in full force and effect insofar as they do not conflict with the terms of this Twelfth Amendment. In the event that the language of the Agreement or a prior Amendment is contrary to the language of this Amendment, the language of this Amendment shall control regarding that provision.

IN WITNESS WHEREOF, the parties have caused this Twelfth Amendment to Purchase Agreement to be executed and effective as of the date of the last signature hereinbelow.

WITNESSES:

[signature]

[signature]

SELLER: CITY OF COLUMBIA

BY: [signature]
Teresa B. Wilson
ITS: City Manager
Date: 6/24/2019

[signature]

[signature]

BUYER: BALLPARK, LLC

BY: [signature]
Name: James C. Shine
ITS: Authorized Signer
Date: 6-26-19

APPROVED AS TO FORM
[signature]
Legal Department City of Columbia, SC

1971532v10
2019-033

Exhibit "A"

Limited Warranty Deed with Covenants

This deed was prepared in the law offices of
BURR FORMAN McNAIR
Post Office Box 11390
Columbia, SC 29211
Attn: Judith L. McInnis

STATE OF SOUTH CAROLINA)
)
COUNTY OF RICHLAND)

INDENTURE LIMITED WARRANTY DEED
(With Covenants)

THIS INDENTURE LIMITED WARRANTY DEED ("Deed") made effective as of the day of the last signature hereinbelow, by and between CITY OF COLUMBIA, SOUTH CAROLINA, ("Grantor"), and BALLPARK, LLC, a South Carolina limited liability company ("Grantee"), having an address at ______________________________ ; in this Deed, the singular shall include the plural, and plural shall include the singular, and the gender shall include all genders.

FOR AND IN CONSIDERATION of the covenants and conditions hereinafter contained and the sum of Ten and 00/100 Dollars ($10.00) and other valuable consideration, paid to Grantor at and before the sealing of these presents by the Grantee, in the State aforesaid, the receipt and adequacy whereof is hereby acknowledged, SUBJECT TO easements, restrictions, reservations, agreements, covenants, and conditions set forth below, Grantor has granted, bargained, sold and released and by these presents does grant, bargain, sell and release, unto the said Grantee, the real property described on Exhibit A attached hereto and incorporated herein (hereinafter referred to as the "Property").

The Property is conveyed subject to all matters of record in the Register of Deeds Office for Richland County, South Carolina affecting title, ad valorem property taxes, zoning laws and ordinances, and to all matters that would be revealed by an accurate survey or inspection of the Property.

The Property is conveyed subject to all easements, restrictions, reservations, agreements, covenants and conditions set forth on Exhibit B attached hereto and incorporated herein.

Grantee agrees to observe and perform its obligations as set forth herein.

TOGETHER with all and singular the rights, members, hereditaments and appurtenances to the Property belonging, or in anywise incident or appertaining.

TO HAVE AND TO HOLD all and singular the Property, unto the Grantee, its successors and assigns forever; subject, however, to the easements, restrictions, reservations, agreements, covenants and conditions that constitute covenants running with the land, all as set forth herein above.

Subject to the matters set forth above, Grantor does hereby bind itself to warrant and forever defend all and singular the Property unto Grantee, its successors assigns, from and against Grantor and its successors and assigns, but no others.

IN WITNESS WHEREOF, the Grantor and Grantee have caused this Deed to be executed in their respective names by their duly authorized officers and under seal to be hereto affixed, this ______ day of ______________, 2019.

SIGNED, SEALED AND DELIVERED
IN THE PRESENCE OF:

Tasha Watson
Signature of 1st Witness

Erika D. Moore
Signature of 2nd Witness/Notary Public

CITY OF COLUMBIA, SOUTH CAROLINA

By: Teresa Wilson
Teresa B. Wilson
City Manager

STATE OF SOUTH CAROLINA)
)
COUNTY OF RICHLAND)

ACKNOWLEDGEMENT

I, the undersigned Notary Public, do hereby certify that Teresa B. Wilson, as City Manager of City of Columbia, South Carolina, by and on behalf of City of Columbia, South Carolina, personally appeared before me this day and acknowledged the due execution of the foregoing instrument.

Witness my hand and official seal this the 24th day of June, 2019.

Erika D. Moore
Notary Public for South Carolina
Print Name: Erika D. Moore
My Commission Expires: 04/16/2022

(NOTARIAL SEAL)

ERIKA D. MOORE
NOTARY PUBLIC
Exp. April 16, 2022
SOUTH CAROLINA

1958906v6

SIGNED, SEALED AND DELIVERED
IN THE PRESENCE OF:

____
Signature of 1st Witness

____
Signature of 2nd Witness/Notary Public

BALLPARK, LLC, a South Carolina limited liability company

By:______________________________
Name:____________________________
Title:____________________________

STATE OF SOUTH CAROLINA)
)
COUNTY OF RICHLAND)

ACKNOWLEDGEMENT

I, the undersigned Notary Public, do hereby certify that ______________________________, as ______________________________ of BALLPARK, LLC, a South Carolina limited liability company, by and on behalf of company, personally appeared before me this day and acknowledged the due execution of the foregoing instrument.

Witness my hand and official seal this the _____ day of _______________, 2019.

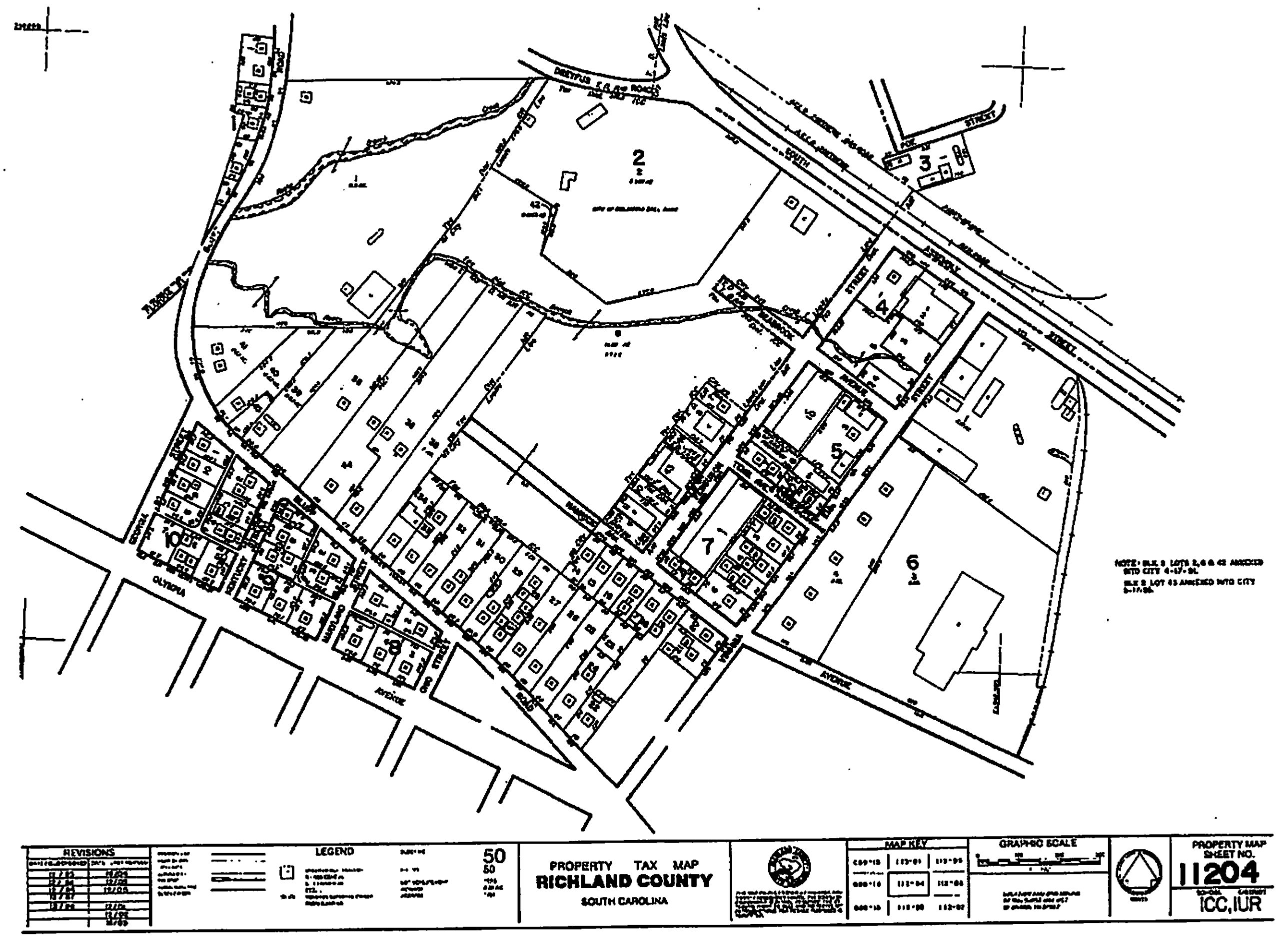
____
Notary Public for South Carolina
Print Name:______________________

My Commission Expires: ____________

(NOTARIAL SEAL)

EXHIBIT A

TMS No.: 11204-02-02



1958906v6

EXHIBIT B

A. The Property is conveyed subject to the following easements, restrictions, reservations, agreements, covenants and conditions (collectively the "Covenants"):

1. The Property shall be held, developed and operated subject to and as provided in the Commercial Development Guidelines attached hereto and incorporated herein as Exhibit B-1.

2. The Property shall be held, developed and operated subject to and as provided in the City of Columbia Best Management Practice Design Manual attached hereto and incorporated herein as Exhibit B-2.

3. The Property shall be held, developed and operated subject to and as provided in the Rocky Branch and Rocky Branch Watershed Improvements attached hereto and incorporated herein as Exhibit B-3.

4. Grantee shall cause the Property to be cleared of all structures and all debris removed, in accordance with all applicable laws, at the Grantee's expense, within ninety (90) days of the date of this Indenture Deed.

5. For and during the period commencing on the date of recording of this Indenture Limited Warranty Deed and ending on that date five (5) years thereafter (the "Restricted Period"), the Property shall at all times, be owned by the individual or entity that owns the property described on Exhibit C attached hereto and incorporated herein (the "Adjacent Property", and, together with the Property, the "Combined Property"). During the Restricted Period the Combined Property shall not be subdivided, and shall not be sold, conveyed, mortgaged, pledged, or assigned except as one entire parcel.

6. The Grantee shall commence vertical construction of improvements on the Property no later than June 1, 2020. Vertical construction shall commence with the pouring of footings for such improvements.

7. Not later than August 20, 2021, the improvements developed and occupied or ready for occupancy on the Property shall contain a minimum of 20,000 SF of street front commercial and retail space.

B. If the Grantee or its successors and assigns, or any developer, operator, tenant or person/entity in possession of all or any part of the Property (collectively the "Owner/Operator") fails to comply with all of the Covenants with regard to the portion of the Property owned, leased or otherwise controlled by the Owner/Operator, the Grantor shall provide written notice to the Owner/Operator of such non-compliance and the Owner/Operator shall have thirty (30) days from the date of such notice to take such actions that may be required to cause to the Property to comply with the covenants (or if such corrective actions would reasonably be expected to take longer than thirty (30) days, the

Owner/Operator shall promptly commence such efforts and then diligently pursue such corrective actions to completion). In the event the Owner/Operator fails to undertake such corrective actions in the manner stated above, the Grantor, its successors and assigns, shall, at its option, have the right to

1. Compel compliance with the Covenants by pursuing any action available to the Grantor at law or in equity; and

2. Assess and collect damages from the Owner/Operator in the amount of $500 per day during the time such violation of the Covenants or failure to comply with the Request continues.

C. The Covenants set forth herein and the rights of Grantor to enforce such Covenants are separate and distinct from the laws, regulations, ordinances and requirements of the City of Columbia. Approval, disapproval, waiver or other action pursuant to the Deed by Grantor shall be separate and distinct from, and shall have no bearing on, the laws, regulations, ordinances and requirements of the City of Columbia.

D. The Covenants may be amended from time to time by recorded instrument executed by Grantor and Grantee.

E. If any legal action or proceeding is brought by Grantor to enforce any of the Covenants, all reasonable attorneys' fees and costs related thereto incurred by Grantor shall be paid by the Grantee if the Grantor prevails in such action or proceeding.

F. The provisions in this Deed are intended to be independent. In the event any provisions of this Deed should be declared by a court of competent jurisdiction to be invalid, illegal or unenforceable for any reason whatsoever, such illegality, unenforceability or invalidity shall not affect other provisions of this Deed.

G. Failure of the Grantor to insist upon compliance with any provision hereof shall not constitute a waiver of the rights of the Grantor to subsequently insist upon compliance with this Deed nor in any way affect the validity of all or any part of this Deed. No waiver of any breach of this Deed shall constitute a waiver of any other or subsequent breach.

Exhibit B-1
Design and Development Guidelines
April ##, 2019

The Property shall be designed and developed in conformance with the Innovista Design Guidelines as amended June 5, 2018 and attached as reference with the following additions and clarifications.

1. **Review.** Review of site, building and overall design of the project shall occur by a committee of city staff consisting of the Director of Planning and Development Services, Planning Administrator, Land Development Administrator, Urban Design Planner, and the City Storm Water Manager. Review and approval shall occur prior to submitting the project to the City of Columbia for development approval.

2. **Architectural Style.** The context, form, layout and design features of the development shall consider urban forms as well as mill structures, and mill villages. Consideration of context shall be considered in relationship to architectural detailing, and materials. Standard suburban and/or marketing/branding Architecture and site design is not acceptable. The entire development shall be designed as unified whole.

3. **Site Design and Relationship to Surrounding Community**
   a. The Buyer will work with USC and Comet to facilitate the location of a bus stop at the development.
   b. The entire site shall be designed for pedestrian connectivity.
   c. A minimum of one pedestrian connection to the site from each public right of way shall be provided for each vehicular access point.
   d. Pedestrian connections that are adjacent to a vehicular access points or parking areas shall be separated by an average of six (6) feet of green space to be planted with trees.
   e. Internal pedestrian connections shall interconnect with one another, and shall provide continental painted crosswalks at each point of crossing of vehicular areas.
   f. Pedestrian areas to rear support functions and other non semi-public areas are not required.
   g. Pedestrian connections to Bluff Road shall be provided.
   h. Bicycle facilities shall be provided at a rate of one connection for each vehicular access point provided. Facilities shall be limited to interior circulation routes and not the general parking areas for vehicles.
   i. Bike facilities shall be provided along Assembly Street per section 5. below.
   j. Bike facilities and pavement markings shall be analyzed for the intersection of Assembly and Main Entry and shall be based upon final circulation layout and overall design.
   k. Bike parking layout and racks shall comply with the Association of Pedestrian and Bicycle Professionals Bicycle Parking Guidelines 2nd Edition or later.

l. All bike facilities on public and private streets and on access roads adjacent to or within the development shall comply with the National Association of City Transportation Officials Urban Street Design Guide and Urban Bikeway Design Guidelines

4. **Lighting.**
    a. All lighting shall be full cut off style fixtures to reduce light pollution.
    b. No pole mounted light within the main tenant parking field shall be higher than 35 feet from its mount. The developer shall provide lower poles within smaller parking fields and access drives.
    c. Pedestrian style lighting shall be provided along the entry facades of each structure as well as multi-use paths and sidewalk areas that are not illuminated by parking lot lighting. Pedestrian lighting within the site shall coordinate with the City of Columbia Standard for the downtown area and be full cut off when appropriate.

5. **Improvements to the Public Right of way**
    a. One standard pedestrian/ road street light, shall be provided parallel to Assembly Street and Dreyfus rights of way per 80 feet of right of way, or as determined by the City Traffic Engineering Department. Lighting style, color, installation and all other specifications shall comply with all City Requirements and coordinate with downtown acorn fixture design or other approved design.
    b. Curb and Gutter shall be provided along Assembly Street and Dreyfus Road and turn the corner at the Ferguson Street intersection.
    c. The Buyer will provide signalization of Ferguson Street and Assembly Street contingent on DOT approval/permitting.
    d. All sidewalks shall comply with all ADA regulations. Crosswalks shall be provided at all intersections meeting requirements by the City Engineer.
    e. A pedestrian sidewalk shall be provided along the rights of way of Assembly Street and Dreyfus Road adjacent to the parcel. Walkways shall have a minimum width of 8 feet
    f. Shade trees shall be provided as single row of trees within a 5 foot-7 foot (7ft max. 5-foot min.) tree lawn. Shade trees shall be provided as a single row of trees between the separated bike facility and the pedestrian sidewalk. Trees alternating pattern. Flexibility as to location do to entries and site conditions may require wider or tighter spacing.
    g. Sidewalk pavement shall consist of a combination of scored concrete paving, and concrete pavers.
    h. Sidewalk areas located near development entrances and intersections shall be paved with concrete pavers and have detailing substantially similar to detailing located at the southwest corner of Assembly Street and Whaley Street.
    i. 8. Tree species shall be of a type that will at maturity canopy approximately 75% of the sidewalk area as shade during summer months.

j. 9. A separated dedicated bike lane shall be provided parallel to Assembly Street and Dreyfus and shall be designed to allow future north south connections. The separated dedicated bike lane shall have clearly identifiable crossings at intersections or transitions to on road lanes or sharrow. Alternatively, a series of bike lanes, Cycle Tracks, or other bike amenities may be considered by the review committee and the developer at the time of construction or as indicated in the City of Columbia Pedestrian and Bicycle Master Plan draft or adopted document. All bike facilities within the right of way shall comply with NACTO Urban Bikeway Design Guide.

6. Environmental

a. Stream buffers. The development shall exceed the BMP manual to utilize state of the are techniques to insure water quality is improved, while also complying with the City's Low Impact Development BMP Manual and Stream Buffer language when proposing site design with respect to quality and quantity.
b. Relocations of streams shall create a naturalized effect through the use of topography, plant life, bank stabilization, and a path that meanders, etc.

EXHIBIT B-2

City of Columbia Best Management Practice Design Manual

EXHIBIT B-2

City of Columbia
Best Management Practice (BMP)
Design Manual

Prepared for:

The City of Columbia, Utilities and Engineering Department
Columbia, South Carolina

Prepared by:

AMEC Environment and Infrastructure, Inc.
720 Gracern Road
Columbia, SC 29210

Date Revised:
January 10 2014

CoC BMP Design Manual: Table of Contents

Chapter 1 – Stormwater Design Requirements

This chapter provides engineers, designers, developers, and others with the necessary information to assist with the development of systems that will control the rate, volume, and pollutants released from a new or re-development project. The City of Columbia Utilities and Engineering Department's Stormwater Division (SWD) has been authorized by law or agreement to enforce these design requirements. These design requirements are based on Best Management Practices and reference State and Federal regulations, engineering publications, and other municipal and academic guidance.

It is an overall goal of this Manual to provide a set of design standards that will result in effective stormwater management. The goal is to mitigate the impact of land development on existing/natural hydrologic and hydraulic processes, as well as attempt to prevent further degradation of the water resources in the City of Columbia through proper planning and design. The design professional is encouraged to use all means necessary to develop land in a manner consistent with City Ordinances, Engineering Regulations, and this Manual and to ensure the safety of the general public. Specific methods and applications not covered in this section must be discussed with the SWD for applicability.

NOTE: In addition to the content included in this manual, the Georgia Stormwater Management Manual (GSMM) will also be utilized, which uses the same methodology – specific GSMM sections to be used are cited with links to those specific sections throughout the document.

The following process (Figure 1.1) will be described in detail throughout this Manual, and will be the basis for compliance with the City of Columbia stormwater requirements:

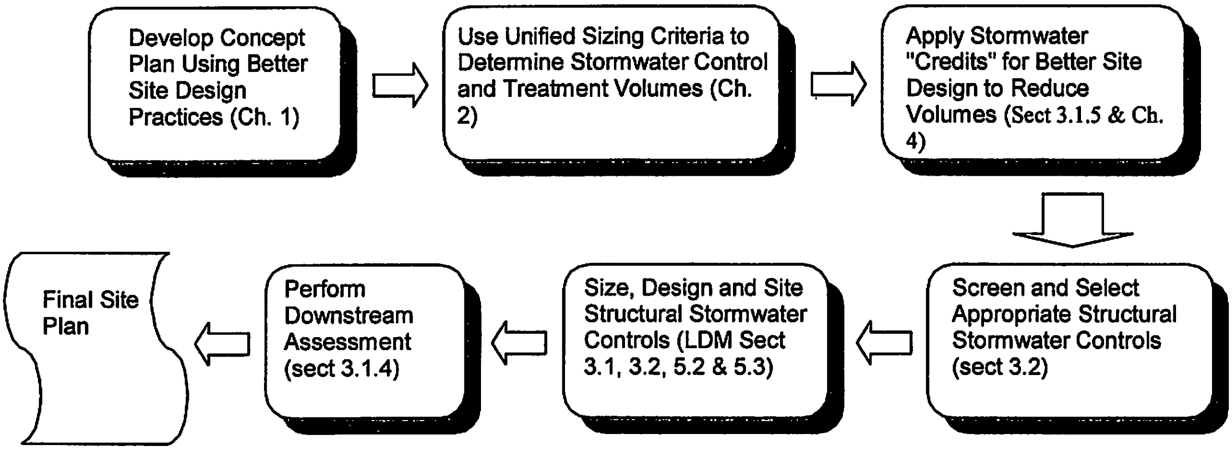


Figure 1.1 – Stormwater Compliance Process

1.1 General Requirements

General requirements for all stormwater systems will include, but not limited to the following:

1. The Uniform Sizing Criteria (USC) will be used as described in this Manual to address:
   a. The Water Quality Volume (WQv)
   b. The Channel Protection Volume (CPv)
   c. Impacts from overbank and extreme flooding events (2- through 100-year)
   d. Avoiding downstream water quality or quantity impacts
   e. Applying proper volume "credits" to a site design
   f. The specific design and performance requirements for each allowable BMP

2. All privately owned stormwater facilities shall have a maintenance agreement. This notarized covenant is to be recorded with the Register of Deeds in the City of Columbia.

3. Re-development is typically governed by the same design criteria as new developments, however the SWD reserves the right to alter (increase or decrease) the requirements for redevelopment to address specific conditions of the site or the receiving watershed.

4. All post-development BMPs must be protected from erosion and sedimentation during the construction phases; a final inspection by the City will be required to determine if additional action is needed to remove sediment deposits from post-construction BMPs. See Section 21-44 of the Stormwater Quantity and Quality Control Ordinance for further maintenance, construction, inspection and Notice of Termination (NOT) requirements for activities under a land disturbance permit. In cases where other City or SCDHEC sediment prevention and erosion control regulations are applicable, the most restrictive requirements will be adhered to.

5. An assessment of the presence/absence of wetlands/Waters of the State shall be performed on all sites by a qualified professional. If wetlands/Waters of the State are suspected to exist on a property, they shall be investigated and delineated by a qualified professional. If wetlands are to be impacted, the City will not issue a Land Disturbance Permit without a confirmation or denial letter from the US Army Corps of Engineers (USACE).

6. All stormwater management and sediment control practices shall be designed, constructed, and maintained with consideration for the proper control of mosquitoes and other vectors.

7. The entire watershed that drains to a particular design point shall be included in determining the appropriate design storm. <u>All drainage systems regardless of size or classification (see sections 1.1.7 a-d below and the City of Columbia's Utilities and Engineering Regulations for their Drainage Ordinance) shall be analyzed and designed as necessary to safely pass the 100-year storm event to avoid the likelihood of dwelling flooding, property damage or public access and/or utility interruption.</u>

   Example 1: a residential stormwater drainage system is required to collect and convey flows from a 10-year event. However, the designer estimated the depth of flow across roadways and other surfaces during a 100-year event, which were in excess of those that catch basins and inlets could collect and convey, but would ultimately be directed to the receiving stormwater pond (or waterway). Those depths of flow, for the entire site, were determined to be below those that would cause flooding (or other damages) to neighboring/adjacent properties or cause an impediment to public access and/or utility interruption. Therefore, this system safely passes the 100-year storm event.

All computations shall be based on the contributing watershed, not just the project area or disturbed area. Classification of stormwater systems are as follows according to Part 4 of the City's Utilities and Engineering Regulations' Drainage Ordinance (Sec. 6-5004), and will be addressed in addition to satisfying the Unified Stormwater Sizing Criteria:

a. Minor Drainage Systems: 0 - <40 Acres

All drainage systems, excluding ponds that carry less than 40 acres of stormwater runoff shall be designed to carry flows resulting from a ten (10) - year storm event. Ditches and channels shall be provided to carry the runoff from a rain of fifty (50) year frequency with protection against channel erosion.

b. Collector Systems: 40 - <500 Acres

All drainage systems, excluding ponds, that carry at least 40 acres but less than 500 acres shall be designed to carry flows resulting from a twenty-five (25) - year storm event.

c. Major Drainage Systems: 500 and more Acres

All drainage systems, excluding ponds, that carry at least 500 and more acres shall be designed to carry a flow resulting from a fifty (50)-year storm event. Encroachment upon Major Drainage Channels and the adjacent overflow land shall be avoided to the maximum extent possible.

d. City or FEMA Floodplains: 640 and more Acres

Bridges and culverts being constructed in natural channels, creeks, or rivers draining more than 640 acres, shall be designed to carry a flow resulting from a one-hundred (100)-year storm event. Bridges and culverts shall be sized to accommodate a 50-year frequency rain fall, without increasing the depth of flow in the channel. Design of bridges and culverts shall conform to the current South Carolina State Highway Department construction specifications. Encroachment upon these channels shall be avoided to the maximum extent practicable, and new encroachments into an established floodway (excluding bridge piers) shall be avoided.

The Floodplain provisions in Part 22 of the City Utility and Engineering Regulations Manual shall apply, where applicable, to drainage systems which drain 640 or more acres.

1.2 Special Protection Areas

In an effort to address some of the most critical water resource problems that exist in the City, Special Protection Areas can be established. Those wishing to develop or redevelop lands within these protected areas will be required to comply with the minimum standards listed in the preceding sections (i.e. The Unified Stormwater Sizing Criteria) as well as a more stringent set of design criteria detailed below. These generally focus on either a water quantity or a water quality problem. For more information on areas to be considered as Special Protection Areas, contact Richland County.

1.2.1 Flooding Problem Areas

Flooding problem areas exist in locations around the City where development densities have increased to the point that stormwater controls have become overwhelmed, or where controls were never adequately designed or installed to control runoff (see map located at in Appendix C). In an effort to relieve existing flooding problems, the following list of design criteria will be required in designated areas. These areas are expected to change with time. The requirement in conjunction with the enforcement of other design criteria listed in the sections above, are expected to assist in reducing these problem areas.

1. The post-development, peak discharge rates is restricted to ½ the pre-development rates for the 2, 5, 10 and 25-year storm events or to the downstream system capacity, whichever is less.

2. When deemed appropriate, the City's SWD can require that the limits of flooding under a 100-year event be established on the site, regardless of drainage area. If such a requirement is enacted by the SWD, a hydraulic modeling methodology consistent with FEMA studies will be used.

3. When deemed appropriate, the City's SWD can require that a downstream hydrologic (and/or hydraulic) analysis be performed to assess potential impacts to receiving properties and stormwater systems under a 100-year event, due to altered timing of released stormwater discharges (See Section 3.1.4). If such a requirement is enacted by the SWD, a hydrologic (and/or hydraulic) modeling methodology consistent with FEMA studies will be used. A more detailed discussion of this analysis is provided in Section 2.1.9 of the GSMM.

Additional criteria may be established on a case by case basis.

1.2.2 Areas Associated with TMDLs and Impaired Waterbodies

In conjunction with the NPDES permitting program, SCDHEC, through delegated responsibility from EPA, must identify and mitigate impaired waterbodies. Impaired waterbodies are identified through a monitoring program, the results of which are compared against water quality standards developed to protect designated uses of individual waterbodies. Waterbodies that are not meeting water quality standards cannot be designated as fishing, swimming, recreation, and/or aquatic life areas. In accordance with Section 303 of the Clean Water Act states must release a bi-annual report of impaired waterbodies. Waters listed on the 303(d) list will eventually have a TMDL developed, which represents the daily amount of a particular pollutant that a waterbody can receive and still meet the water quality standard for its designated use(s).

City of Columbia's 303(d) listed waters can be found at:
http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_10-303d.pdf

For projects discharging to a 303(d) listed water the pollutant load reduction required along with the structural and non-structural BMPs that will be utilized to achieve that load reduction will be required to prevent further degradation. Water quality calculations must be provided to show that discharges from the site will not further degrade water quality. Procedures can be found in Section 2.4.3.

If a waterbody has an established TMDL the SWD will require that a plan be implemented that uses structural and nonstructural BMPs to reduce the current loading to either a certain total load or by a percentage. The plans to address the TMDLs will contain provisions for both existing and future land uses. TMDL waters in City of Columbia can be found at: http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_10-303d.pdf.

Those areas affected will change as additional TMDLs are adopted, and it is the designer's responsibility to check for updated information from SCHDEC.

TMDL and 303(d) requirements listed in Section 2.4.3 only apply if the development project discharges a pollutant of concern based on the land use. For residential properties the applicable pollutants of concern include bacteria, sediment, dissolved oxygen and nutrients. For commercial properties the applicable pollutants of concern include, heavy metals, bacteria, dissolved oxygen and sediment.

Note: while dissolved oxygen (DO) is not considered a "pollutant", it is a measure of stream health/impairment. If a stream is impaired for low DO, the specific pollutants that can lead to low DO levels will be addressed.

1.2.3 Critical Water Bodies

Rocky Branch Creek, Smith Branch, Gills Creek, and Pen Branch are vital water resources for the City of Columbia, providing a vast habitat for aquatic life. Criteria listed below, in addition to the requirements detailed in this Manual, will be enforced for all new development and re-development projects near these water bodies. These design requirements shall specifically apply to stormwater runoff from all new development and re-development projects that is discharged to these water bodies.

The specific design requirements are as follows:

1. Water Quality:

    a. All sites which disturb greater than one acre shall have a permanent water quality BMP in place to treat at least the runoff from the entire site for a 1.2-inch rainfall event. The Unified Stormwater Sizing Criteria method shall be used to determine the water quality volume (WQv), as described in Chapter 2. This volume shall be released for a minimum period of 24-hours when a detention pond is used. For other BMPs that address water quality, the design criteria provided in Sections 3.2-3.4 of the GSMM will be followed.

b. All sites which disturb greater than one acre shall have a permanent water quality BMP in place to treat the Channel Protection Volume, which is associated with the 1-year storm event. The Unified Stormwater Sizing Criteria method shall be used to determine the channel protection volume CPv), as described in Chapter 2. This volume shall be released for a minimum period of 24-hours when a detention pond is used. For other BMPs which have the ability to address the channel protection volume, the design criteria provided in Sections 3.2-3.4 of the GSMM will be followed.

c. Due to lake boundary topography, it may be impractical to route all impervious areas to a water quality BMP. In such cases, exemptions for roof area and sidewalks may be allowed with documentation that every effort was made to route impervious areas to water quality BMPs to the maximum extent technically feasible. However, the water quality volume in the BMP must reflect that from the disturbed portion of the site (i.e. runoff from a 1.2-inch rainfall event). In no cases are roads and parking areas exempt. Area-weighting will be used to determine the net treatment for the water quality and channel protection volumes. Specific examples on how to qualify for credits that reduce the WQv and CPv requirements are provided in Chapter 4 of this document.

d. A pretreatment device such as a forebay, micro-pool, filter strips or vault, to remove debris and large sediments shall be constructed either as part of the water quality BMP or as a separate device. Specific sizing requirements, as provided in the GSMM, shall be followed.

e. Developments with a commercial land use or a parking lot which exceeds 2,000 ft^2 must include the ability to capture hydrocarbons either in pretreatment or in the main BMP(s).

2. Erosion Prevention:

All discharge points shall include energy dissipation features which reduce velocity to a non-erosive state of 5 fps for clay and 2.5 fps for sand unless site conditions warrant further evaluation The use of level spreaders to dissipate energy and create a sheet flow discharge pattern is preferred over a single, large discharge pipe/channel. All energy dissipation measures shall be installed above the 360-foot elevation contour.

1.3 Better Site Planning

Through stormwater better site design practices and techniques, it is possible to reduce the amount of runoff and pollutants generated. 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. The site design approach can better mimic the natural hydrologic conditions of the site, have a lower maintenance burden and provide for more sustainability. Better site design includes:

- Conserving natural features and resources
- Using lower impact site design techniques
- Reducing impervious cover
- Utilizing natural features for stormwater management

For each of the above categories, there are a number of practices and techniques that aim to reduce the impact of urban development and stormwater runoff from the site. These better site design practices are described in detail in Section 1.3.

For several of the better site design practices, there is a direct economic benefit to their implementation for both stormwater quality and quantity through the application of site design "credits." In terms of the unified stormwater sizing criteria, Table 1.1 shows how the use of nonstructural site design practices can provide a reduction in the amount of stormwater runoff required to be treated and/or controlled through the application of site design credits.

Table 1.1 Reductions or "Credits" to the Unified Stormwater Sizing Criteria through the Use of Better Site Design Practices

Sizing Criteria	Potential Benefits of the Use of Better Site Design Practices
Water Quality (WQ_V)	• Better site design practices that reduce the total amount of runoff will also reduce WQ_V by a proportional amount. • Certain site design practices will allow for a further reduction to the Water Quality Volume. The site design credits are discussed in Section 3.8.
Channel Protection, Overbank Flood Protection, and Extreme Flood Protection (CP_V, Q_{FP}, Q_{100})	• The use of better site design practices that reduce the total amount of runoff will also reduce CP_V, Q_{FP}, and Q_{100} by a proportional amount. • Floodplain preservation may allow waiving of overbank flood and/or extreme flood protection requirements.

1.3.1 Stormwater Better Site Design

The first step in addressing stormwater management begins with the site planning and design process. By implementing a combination of these nonstructural approaches (aka: better site design practices), it is possible to reduce the amount of runoff and pollutants a site generates from a 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

The aim of better site design 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 size and cost of necessary drainage infrastructure and structural stormwater controls while maintaining or even increasing the value of the property.

Several of the site design practices described in this section provide a calculable reduction or site design "credit" which can be applied to the unified stormwater sizing criteria requirements. The use of stormwater better site design can also have a number of other ancillary benefits including:

- Reduced construction costs
- Increased property values
- More open space for recreation
- More pedestrian friendly neighborhoods
- Protection of sensitive forests, wetlands and habitats
- More aesthetically pleasing and naturally attractive landscape
- Easier compliance with wetland and other resource protection regulations

1.3.2 List of Stormwater Better Site Design Practices and Techniques

The stormwater better site design practices and techniques allowed for in this Manual are grouped into four categories and are listed below:

- Conservation of Natural Features and Resources
  - Preserve Undisturbed Natural Areas
  - Preserve Riparian Buffers
  - Avoid Floodplains

- Avoid Steep Slopes
- Minimize Siting on Porous or Erodible Soils

- Lower Impact Site Design Techniques
  - Fit Design to the Terrain
  - Locate Development in Less Sensitive Areas
  - Reduce Limits of Clearing and Grading
  - Utilize Open Space Development
  - Consider Creative Development Design

- Reduction of Impervious Cover
  - Reduce Roadway Lengths and Widths
  - Reduce Building Footprints
  - Reduce the Parking Footprint
  - Reduce Setbacks and Frontages
  - Use Fewer or Alternative Cul-de-Sacs
  - Create Parking Lot Stormwater "Islands"

- Utilization of Natural Features for Stormwater Management
  - Use Buffers and Undisturbed Areas
  - Use Natural Drainage ways Instead of Storm Sewers
  - Use Vegetated Swale Instead of Curb and Gutter
  - Drain Rooftop Runoff to Pervious Areas

More detail on each site design practice is provided in the Stormwater Better Site Design Practice Summary Sheets in subsection 1.4.2 of the GSMM. These summaries provide the key benefits of each practice, examples and details on how to apply them in site design. Site design should be done in unison with the design and layout of stormwater infrastructure in attaining stormwater management goals. Figure 1.2 illustrates the stormwater better site design process that utilizes the four better site design categories.

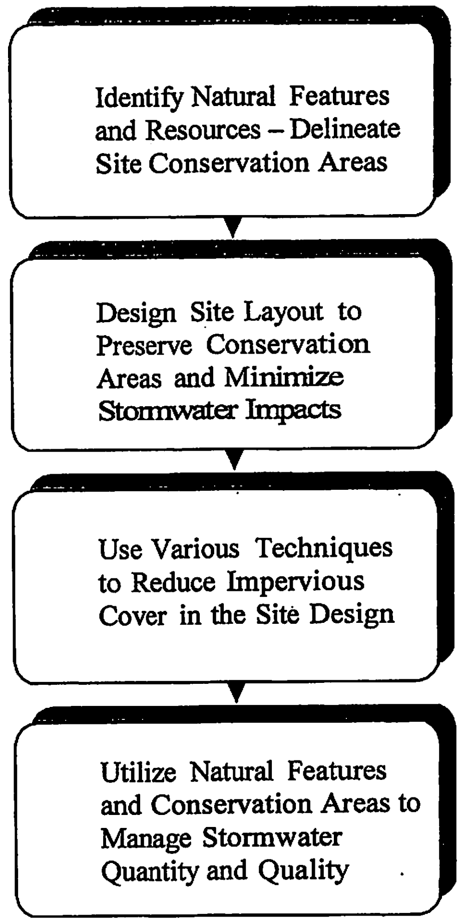


Figure 1.2 - Stormwater Better Site Design Process

1.4 *Water Quality Control Requirements*

Water quality control is an integral and required component of overall stormwater management systems to preserve the water resources of City of Columbia. New development and re-development projects must include controls that treat or otherwise limit the discharge of pollutants. These requirements are due to State and Federal requirements. Because this is a requirement of stormwater design, this section provides background information, references, and design standards addressing water quality. This section will utilize the better site design methods described in Section 1.3, as well as the credits described in Chapter 4, to reduce the volumes that must be treated.

Note: The designer must also comply with the buffer requirements described in Section 21-46. - Watercourse Protection of the City's Stormwater Ordinance where the City buffer requirements may differ from those required by SCDHEC in the NPDES Construction General Permit (CGP), the more restrictive buffer requirements (i.e. larger) will be required.

1.4.1 Design Requirements

The following design criteria are established for water quality control and shall be incorporated by the use of BMPs for a given project area unless a specific water quality waiver is granted by the City's SWD. Incorporation of these requirements shall constitute adequate control of the discharge of the pollutants of concern.

1. All projects requiring a land disturbance permit, as defined in the City Stormwater Ordinance (Section 21-40/43), shall have permanent water quality BMPs installed according to the criteria listed in Chapter 2. Stormwater discharges to special protection areas with sensitive resources are subject to additional performance criteria (See Section 1.2).

2. Permanent water quality ponds and water quality structures having a permanent pool elevation shall be designed to store the runoff from the contributing area of the site from a 0.6-inch rainfall event, and release the accumulated water quality volume (WQv) over a minimum period of 24-hours.

3. Permanent water quality structures not having a permanent pool elevation shall be designed to store the runoff from the contributing area of the site from a 1.2-inch rainfall event, and release the accumulated WQv over a minimum period of 24-hours.

4. Engineered devices that are designed to treat the runoff volume from a project area may be substituted for a permanent water quality pond, if appropriate.

5. BMPs used for water quality shall have a pretreatment device as part of the BMP or treatment system. Options include forebays, vaults, or other devices that remove debris and coarser sediments from the drainage system.

    a. Forebays shall be placed inside the main pond area or upstream of the main storage pond area.

b. Unless a separate vault is to be used for the forebay, the forebay shall be separated from the larger detention area by barriers or baffles that may be constructed of earth, stones, riprap, gabions, or geotextiles. The barrier and/or baffles act as a trap for coarse sediments and minimize their movement into the main pond.

c. Maintenance of forebays will be needed more frequently than the main storage area and all designs, maintenance schedules must consider this need.

d. Forebays shall be sized to provide a volume for 0.1-inches of runoff from impervious surfaces,

6. Projects that discharge either directly or indirectly into an impaired waterbody as determined by the existence of an adopted TMDL by SCDHEC or through SCDHEC's listing of the waterbody on the latest 303(d) list shall be required to reduce pollutant loads so as to meet applicable water quality standards or other criteria listed in an adopted TMDL, such as percent reductions. More background information is covered in Section 1.2.2. This will require the installation and implementation of measures which are expected to adequately reduce pollutant loads to levels required by the TMDL or prevent future impairments as required by the current 303(d) list.

   a. If the site disturbs less than 25 acres, an evaluation of the BMPs chosen to control the release of pollutants must be provided. Such evaluations may reference published values on BMP effectiveness or provided in Appendix A.

   b. If greater than 25 acres, a comprehensive quantitative and qualitative analysis shall be provided, and include at a minimum calculations that show:

      - A site's pollutant load for all pollutants of concern (see Table 1.2),
      - The trapping effectiveness of the chosen BMPs based on City rainfall statistics and soil types, and
      - The runoff discharged through the last water quality BMP shall have a water quality level equal to or better than the in-stream standard. Standards are listed in the table below. If an adopted TMDL is in place for the receiving water, calculations must show pre- and post-BMP loads and percent reduction achieved.

7. All BMPs must have a maintenance plan. Example maintenance agreements are included in the appendix.

8. A credit system is available from the SWD that offers alternatives on how a site meets these water quality requirements (Chapter 4). However, S.C. DHEC minimum stormwater criteria must be met.

9. The SWD reserves the right to require specific effluent limits for any pollutant from a site if necessary to ensure the water quality standards and other local, State, and Federal water quality regulations are met. The SWD also reserves the right to not allow credits at certain sites.

10. Annual groundwater recharge rates must be maintained to the maximum extent practical by promoting infiltration through the use of structural and non-structural methods.

11. Literature, signage, or other documentation shall be provided to owners and HOAs to educate and train themselves on the impact they can have on water quality and the activities necessary to maintain structural controls, as appropriate. These efforts are particularly critical in LID designs.

Table 1.2: SCDHEC/USEPA Water Quality Standards

Pollutant	Standard
*Bacteria	200 CFU/100-mL
Total Nitrogen	1.5 mg/L
Total Phosphorus	0.06 mg/L
TSS	80% reduction or 0.5 mg/L
Metals	See SCDHEC Reg. 61-68

*Impairment is based on 10%-exceedances of 400 CFU/100-mL

1.4.2 General Design Procedures

If the proposed project does **not** discharge to a receiving water that is either impaired (303(d) listed) or has an adopted TMDL, stormwater treatment is achieved through addressing the USC. Use Table 1.2 to determine the pollutants of concern based on the proposed land use or disturbing activity. Then use Appendix A to help select BMPs to treat the pollutants of concern. The design of all BMPs must follow the process described below:

1. Calculate the water quality volumes using the USC equations in Chapter 2
2. Look for opportunities to reduce runoff through better site design (See Section 1.3)
3. Identify crediting opportunities for reduced volumes identified in Step 2 (See Chapter 4)
4. Review BMP suitability (See Section 3.2.7)
5. Perform BMP sizing calculations (See GSMM Section 3.2-3.4)
6. Compute stage-storage and stage-discharge relationships of the outlet control structure(s).
7. Repeat Steps 2-6 until initial design criteria is met
8. Check for treatment train (i.e. a series of BMPs) efficiency as needed (See Section 3.2.8)
9. Check for downstream impacts (See Section 3.1.4), revise the design as needed
10. Check for opportunities to reduce peak discharges due to WQv (See Section 3.1.5)
11. Repeat Steps 5-10, as needed, until final criteria is met
12. Design off-line diversions as needed (See Section 3.2.9)

Note: For engineered devices, alternative calculations other than detailed here must be provided. SCDHEC has accepted some such devices as providing adequate treatment.

1.4.3 Design Procedures for Impaired Waters and TMDLs

If the receiving water of the project is impaired (303(d) listed) or has an adopted TMDL, in addition to the design procedures in Section 1.4.2, the applicant must show some additional calculations of the BMPs to treat stormwater runoff. For 303(d) listed impaired waters, water quality calculations must be provided that show that discharges from the site will not further degrade water quality. This analysis must be quantitative and qualitative. The most up to date information in impaired water and adopted TMDLs is available from SCDHEC's website. The appropriate steps include:

Determine if the site discharges to a receiving water that is impaired (303(d) list) or has an adopted TMDL(s). A list of the City's 303(d) listed waters and TMDLs can be found at: http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_10-303d.pdf

- A waterbody may be listed on the 303(d) list and have an approved TMDL. It is important that both the 303d list and TMDL listing are both checked to determine if there is more than one impairment

- Determine all the pollutants causing the impairments or listed in the TMDL(s). The percent reduction provided in the TMDL is the default level of treatment needed from the permanent BMPs on the site. City of Columbia SWD may reduce this requirement to a lower percentage on a case by case basis.

- If the receiving water is on the 303(d) list, calculate the post construction load for the pollutant(s) of concern. A possible equation is the Schuler Simple Method (Schueler 1987). This method is based on an extensive database obtained in Washington, D.C. for the National Urban Runoff Program (NURP). The Simple Method estimates pollutant loads from urban development by the following equation:

$$L = 0.227(Q\ P_j\ R_v\ C\ A) \qquad \text{Equation 1}$$

Where:
L =Pollutant load in pounds per desired time interval,
Q =Rainfall depth,
0.6-inch for wet ponds, some wetlands,
1.2-inch for all other BMPs,
P_j =Fraction of rainfall events over the time interval that produce runoff
$P_j = 1$ for a single event
$P_j = 0.9$ for larger time intervals (months, years),
R_v =Volumetric runoff coefficient expressing the fraction of rainfall converted to runoff (See Equation 2),
C = Event mean pollutant concentration in mg/l (See Table 3.3),
A = Total area of site in acres (areas < 640 acres are recommended for this method).

$$R_v = 0.05 + 0.09(I) \qquad \text{Equation 2}$$

Where: **I** = <u>percent</u> impervious cover (i.e. I = 30 for 30% impervious cover)

- If the receiving water is on the 303(d) list only (no TMDL), calculate the allowed load to meet water quality standards using equation 1. Replace variable C with the concentration of the water quality standard for the pollutant of concern listed in Table 1.2. Then compute the percent needed to reduce the post construction pollutant load from the allowed load.

- Use Appendix A to help select BMPs to treat the pollutants of concern. The last table in Appendix A provides an estimate of how effective a given BMP will be. The BMPs chosen must be able to achieve the required percent reductions in the TMDL or the required load reduction calculated for 303(d) listed waters computed in the previous step.

- If the receiving water is listed on the 303(d) list and has an approved TMDL calculate the load reduction for the pollutant of concern for the water way on the 303(d) list. Compare the percent reduction required to the percent reduction listed in the TMDL. Select BMPs for the pollutant that has the highest percent reduction requirement (i.e. TMDL or 303(d) reduction requirement whichever is highest).

- Revise chosen BMPs until required percent reductions are achieved.

- Provide all calculations in submittal package in a cohesive, easy to follow organization.

Table 1.3 Event Mean Concentration (EMC) Pollutant Loading for Various Land Uses (mg/l)												
	EMC Pollutant Loading (mg/l)											
Land Use	**BOD**	**COD**	**TSS**	**TDS**	**TP**	**DP**	**TKN**	**NO2 / NO3**	**Pb**	**Cu**	**Zn**	**Cd**
Forest Rural Open	3	27	51	415	0.11	0.03	0.94	0.80	0.000	0.000	0.000	0.000
Urban	3	27	51	415	0.11	0.03	0.94	0.80	0.014	0.000	0.040	0.001
Agricultural/ Pasture	3	53	145	415	0.37	0.09	1.92	4.06	0.000	0.000	0.000	0.000
Low Density Residential	38	124	70	144	0.52	0.27	3.32	1.83	0.057	0.026	0.161	0.004
Medium Density Residential	38	124	70	144	0.52	0.27	3.32	1.83	0.180	0.047	0.176	0.004
High Density Residential	14	79	97	189	0.24	0.08	1.17	2.12	0.041	0.033	0.218	0.003
Commercial	21	80	77	294	0.33	0.17	1.74	1.23	0.049	0.037	0.156	0.003
Industrial	24	85	149	202	0.32	0.11	2.08	1.89	0.072	0.058	0.671	0.005
Highways	24	103	141	294	0.43	0.22	1.82	0.83	0.049	0.037	0.156	0.003
Water/ Wetlands	4	6	6	12	0.08	0.04	0.79	0.59	0.011	0.007	0.003	0.001

Adapted from NURP (1983), Horner et. al (1994), and Cave et. Al. (1994)

BOD	=	Biochemical Oxygen Demand
COD	=	Chemical Oxygen Demand
TSS	=	Total Suspended Solids
TDS	=	Total Dissolved Solids
TP	=	Total Phosphorus
DP	=	Dissolved Phosphorus
BIO	=	Macroinvertebrates
TKN	=	Total Kjeldahl Nitrogen
NO_2/NO_3	=	Nitrates / Nitrites
Pb	=	Lead
Cu	=	Copper
Zn	=	Zinc
Cd	=	Cadmium

Fecal coliform (FC) concentrations were not provided in the table above due to the large variability. Guidance from SCHDEC, Beaufort County (2010, Manual for Stormwater Best Management Practices) and Harper (2007, Evaluation of Current Stormwater Design Criteria Within the State of Florida) should be sought when estimating existing and post-development bacteria loads and the reduction requirements.

Chapter 2 – Unified Sizing Criteria

This section presents an integrated approach for meeting the stormwater runoff quality and quantity management requirements by addressing the key adverse stormwater runoff impacts from site development and redevelopment. The purpose is to provide a design framework, which will be required for all sites, to:

- Remove stormwater runoff pollutants and improve water quality
- Prevent downstream streambank and channel erosion
- Reduce downstream overbank flooding
- Safely pass or reduce the runoff from extreme storm events

For these objectives, an integrated set of engineering criteria, known as the Unified Stormwater Sizing Criteria, have been developed to size and design structural stormwater controls. More detailed discussions on the Unified Sizing Criteria can be found in Section 1.3 of the GSMM. Table 2.1 below briefly summarizes the criteria. An example problem, with detailed solution, is provided in Appendix B. Calculation tools can be found in Appendix C.

Table 2.1 Summary of the Unified Sizing Stormwater Sizing Criteria for Stormwater Control and Mitigation

Sizing Criteria	Description
Water Quality	Treat the runoff from the vast majority of the storms that occur in an average year. For the City, this equates to providing water quality treatment for the runoff (from an entire site) from 1.2 inches of rainfall.
Channel Protection	Provide extended detention of the 1-year storm event released over a period of 24 hours to reduce bank-full 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 (2-, 5-, 10- and 50-yr events are also detained/retained to meet pre-development rates.)
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, for the entire range of critical hydrologic events. Figure 2.1 graphically illustrates that the criteria are "stacked" upon one another. For example, the extreme flood protection volume requirement also contains the channel protection volume and the water quality treatment volume. Figures 2.2a and 2.2b show how these volumes would be stacked in a typical stormwater wet or dry pond designed to handle all four criteria. Figure 2.2c provides additional details on a typical outlet structure configuration.

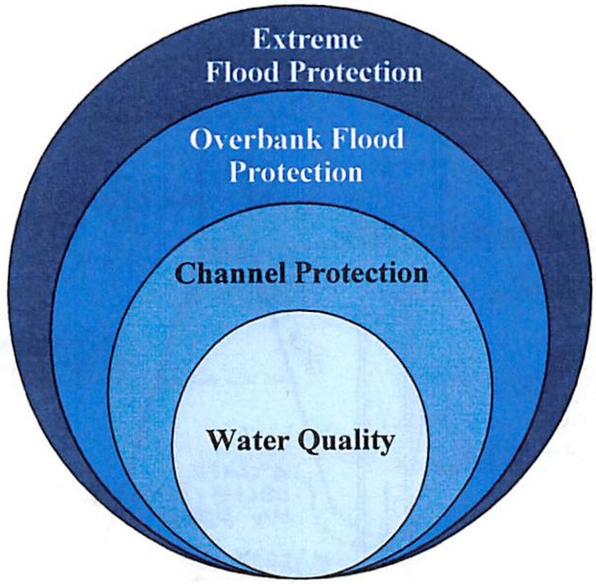


Figure 2.1: Representation of the Unified Stormwater Sizing Criteria

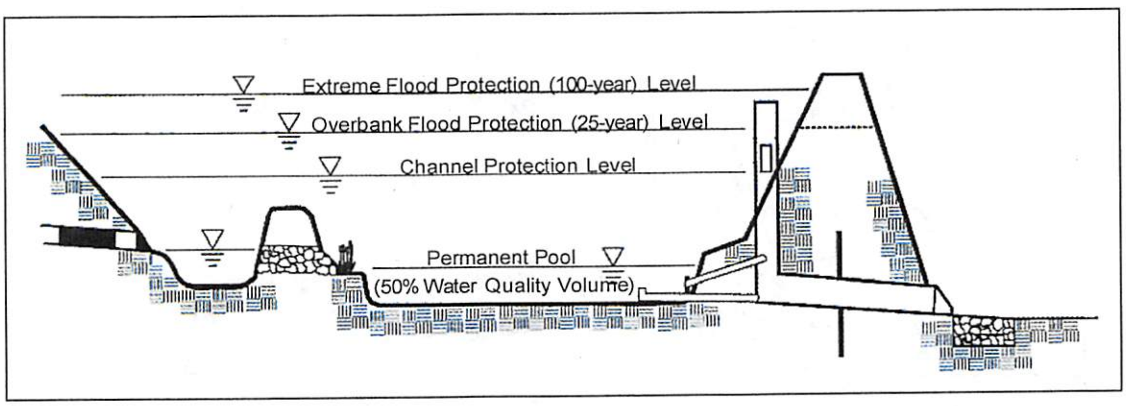


Figure 2.2a: Unified Sizing Criteria Water Surface Elevations in a Wet Pond

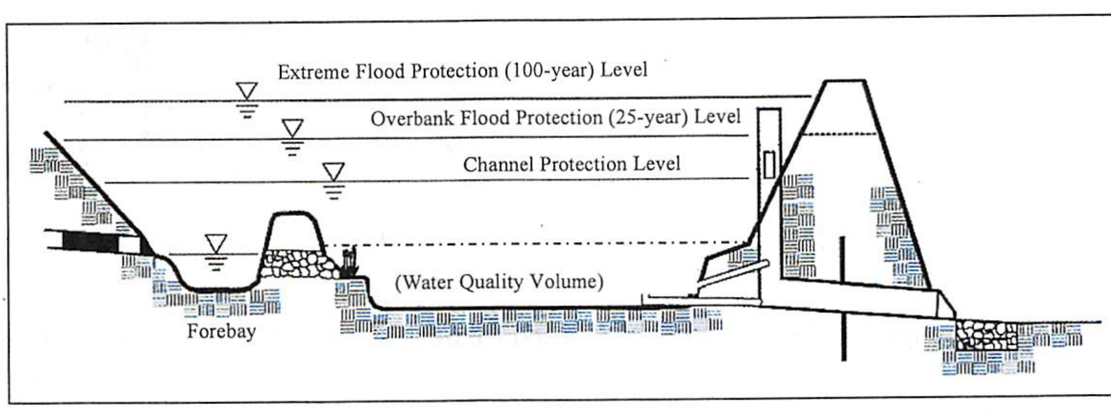


Figure 2.2b: Unified Sizing Criteria Water Surface Elevations in a Dry Pond

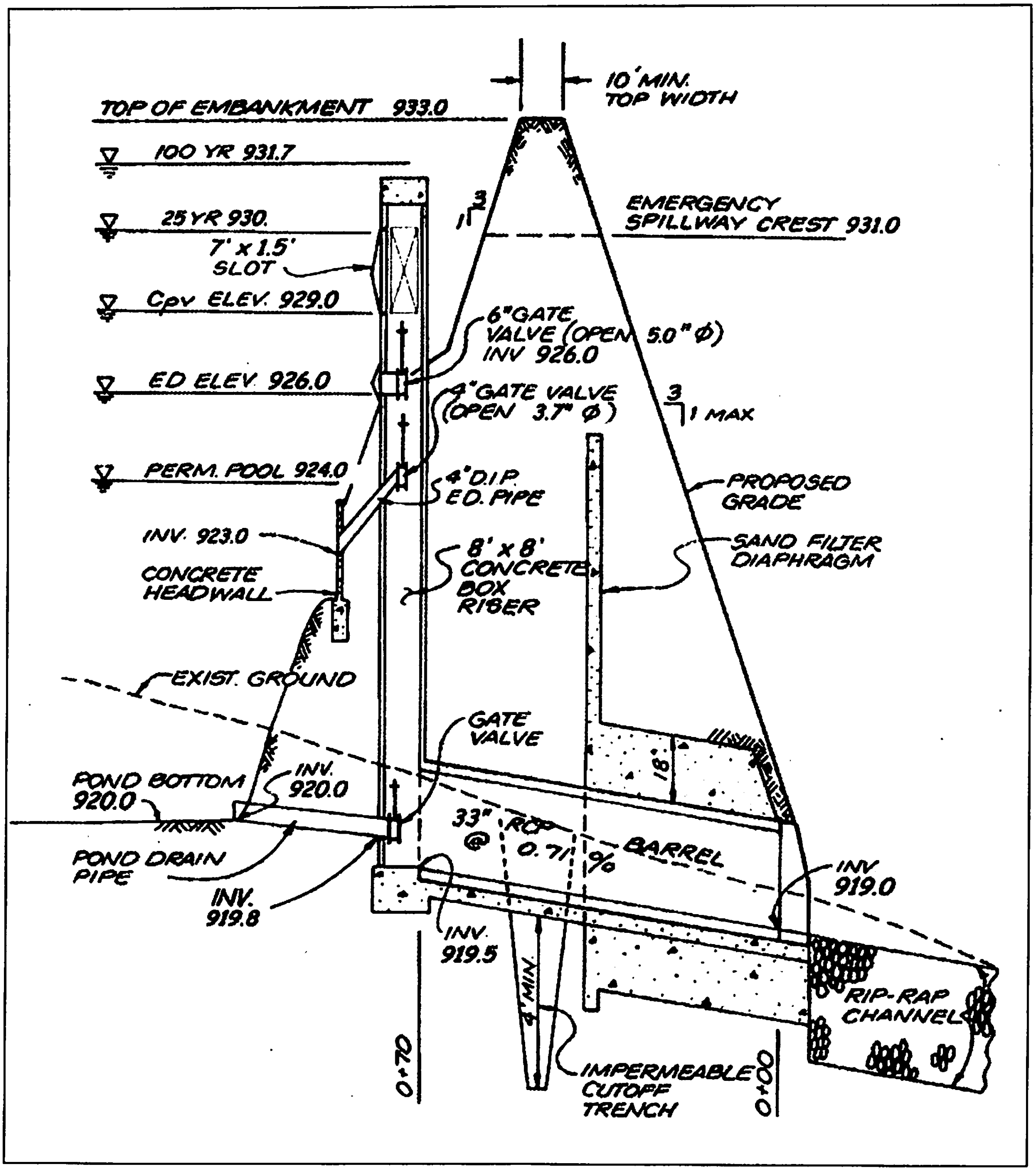


Figure 2.2c: Example of Unified Sizing Criteria Outfall Structure Details

The following pages describe the four sizing criteria in detail and present guidance on how to properly compute and apply the required storage volumes.

2.1 Water Quality (WQv)

The Water Quality sizing criterion, denoted WQv, specifies a treatment volume required to remove a significant percentage of the total pollution load inherent in stormwater runoff. This is done by intercepting and treating the runoff from approximately 85% of the storms that are expected to occur during the course of a "typical" year. It is also expected that a portion of the runoff from all storms greater than 1.2 inches can also be treated. WQv is a runoff volume that is directly related to the amount of impervious cover at a site.

The volumetric runoff coefficient (Rv) and the site area are the key factors used in this calculation, as shown in the formula below:

$$WQ_V = \frac{1.2 R_V A}{12} \quad \text{where:}$$

WQ_V = water quality volume 1.2-inch rainfall (in acre-feet)

A = site area in acres

R_V = 0.05 + 0.009(I) where:

I is entered as <u>percent</u> impervious cover (i.e. I = 30 for 30% impervious cover)

<u>Pollutant Reduction Goal</u>

This Unified Sizing Criteria, and other supporting elements of the BMP Manual, follows the philosophy of removing pollutants to the "maximum extent practicable" (MEP) or the "maximum extent technically feasible" (METF) through the use of a percentage removal performance goal. The approach taken by the City is to require treatment of the WQv 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. EPA guidance and has been adopted nationwide by many local and statewide agencies. This method has also been shown to address other pollutants of concern to the MEP/METF, as both runoff volume reduction and sediment loads, which pollutants can be bound to, are addressed. Furthermore, when coupled with the Channel Protection sizing criterion, which detains and treats even greater flows, the goals of SCDHEC Regulation 72-300 will be met.

<u>Determining the Water Quality Volume (WQv)</u>

- Measuring Impervious Area: The area of impervious cover can be taken directly off a set of plans or appropriate mapping. Where this is impractical, NRCS TR-55 land use/impervious cover relationships can be used to estimate impervious cover. **I is expressed as a percent value not a fraction (e.g., I = 30 for 30% impervious cover)**
- Multiple Drainage Areas: When a development project contains or is divided into multiple drainage areas, WQv must be calculated and addressed separately for each drainage area.
- Off-site Drainage Areas: Off-site existing impervious areas may be excluded from the calculation of the WQv volume.
- Credits for Site Design Practices: The use of certain better site design practices may allow the WQv volume to be reduced through the subtraction of a site design "credit." These site design credits are described in Chapter 4.

- Determining the Peak Discharge for the Water Quality Storm: When designing off-line structural control facilities, the peak discharge of the water quality storm (Qwq) can be determined using the method provided later in this Chapter.
- Extended Detention of the Water Quality Volume: The water quality treatment requirement can be met by providing a 24-hour drawdown of a portion of WQv in a stormwater pond or wetland system. Referred to as water quality ED (extended detention), it is different than providing extended detention of the 1-year storm for the channel protection volume (CPv). The ED portion of the WQv may be included when routing the CPv.
- WQv can be expressed in cubic feet by multiplying by 43,560.
- WQv can also be expressed in watershed-inches by removing the area (A) and the "12" in the denominator.

2.2 Channel Protection (CPv)

The Channel Protection sizing criterion specifies that <u>24 hours of extended detention be provided for runoff generated by the 1-year, 24-hour rainfall event</u> to protect downstream channels.

- CPv control is not required for sites with minimal areas or imperviousness which result in post-development discharges less than 2.0 cfs.
- The use of nonstructural site design practices that reduce the total amount of runoff will also reduce the channel protection volume by a proportional amount.
- The channel protection criteria may be waived by a local jurisdiction for sites that discharge directly into larger streams, rivers, wetlands, or lakes where the reduction in the smaller flows will not have an impact on streambank or channel integrity.

  The increase in the frequency and duration of bank-full flow conditions in stream channels due to urban development is the primary cause of streambank erosion and the widening and down-cutting 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 correspond approximately to the 1-year storm event) in a gradual manner to ensure that critical erosive velocities and flow volumes are not exceeded.

<u>Determining the Channel Protection Volume (CPv)</u>

- Rainfall Depths: The rainfall depth of the 1-year, 24-hour storm is 3.1 inches.
- Multiple Drainage Areas: When a development project contains or is divided into multiple drainage areas, CPv may be distributed proportionally to each drainage area.
- Off-site Drainage Areas: Off-site drainage areas must be modeled as "present condition" for the 1-year storm event. If there are adequate upstream channel protection controls, then the
- Off-site area can be modeled as "forested" or "natural" condition. A structural stormwater control located "on-line" will need to safely bypass any off-site flows.
- Routing/Storage Requirements: The required storage volume for the CPv may be provided above the WQv storage in stormwater ponds and wetlands with appropriate hydraulic control structures for each storage requirement.
- Control Orifices: Orifice diameters for CPv control of less than 3 inches are not recommended without adequate clogging protection.

Specific Methodology:

1. Compute Initial Abstraction divided by rainfall, (I_a/P) for given hydrologic parameters:

   - $P = 3.1$ inches
   - $Ia = 0.2*(1000/CN-10)$
   - T_c = as per TR-55

2. From Chart 2.1, read Unit Peak Discharge (q_u) for given post developed time of concentration (t_c) and computed I_a/P (in csm/inch).
3. From attached Chart 2.2, read ratio of Outflow to Inflow (q_o/q_i) for 24-hr detention or from the equation:

   $qo/qi = 12.03\ qu^{-0.9406}$
4. Compute the ratio of the volume of storage divided by the volume of runoff (v_s/v_r) from Chart 3.3 or by equation where:

   $v_s/v_r = 0.683 - 1.43(q_o/q_i) + 1.64\ (q_o/q_i)^2 - 0.804(q_o/q_i)^3$
5. Estimate Channel Protection Volume (Cp_v);

   $Cp_v = v_r(v_s/v_r)(A)/12$ in acre-feet.

   Where: v_r = the post-developed volume of runoff <u>depth</u> for the 1-yr 24-hr storm in <u>inches</u>

   A = the drainage area in acres, and

   12 = a conversion factor.

Or

$Cp_v = v_r(v_s/v_r)$ in acre-feet.

Where: v_r = the post-developed volume of runoff <u>volume</u> for the 1-yr 24-hr storm in <u>acre-feet</u>

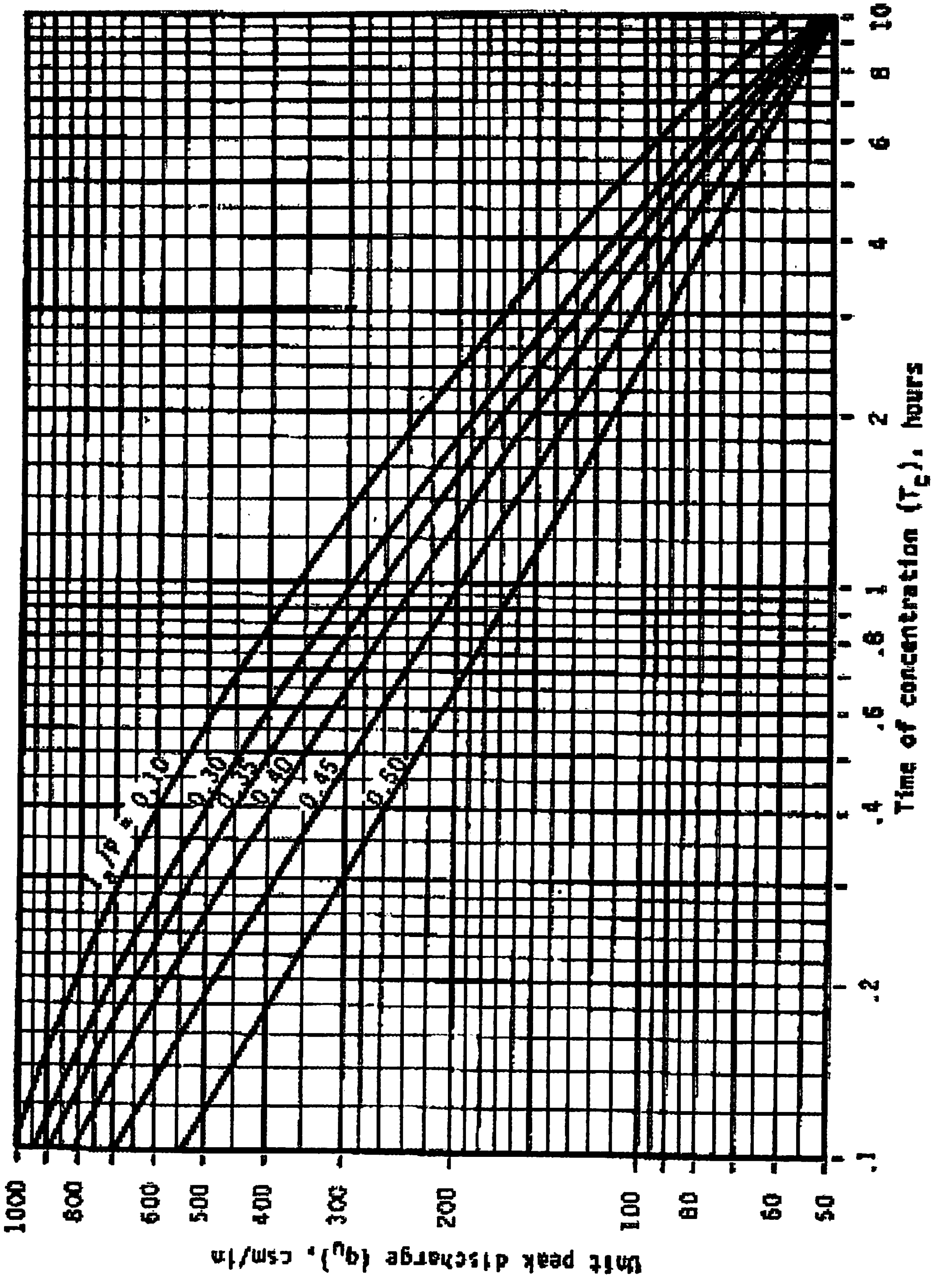


Figure 2.1.5-6
SCS Type II Unit Peak Discharge Graph
(Source: SCS TR-55, Second Edition, June 1986)

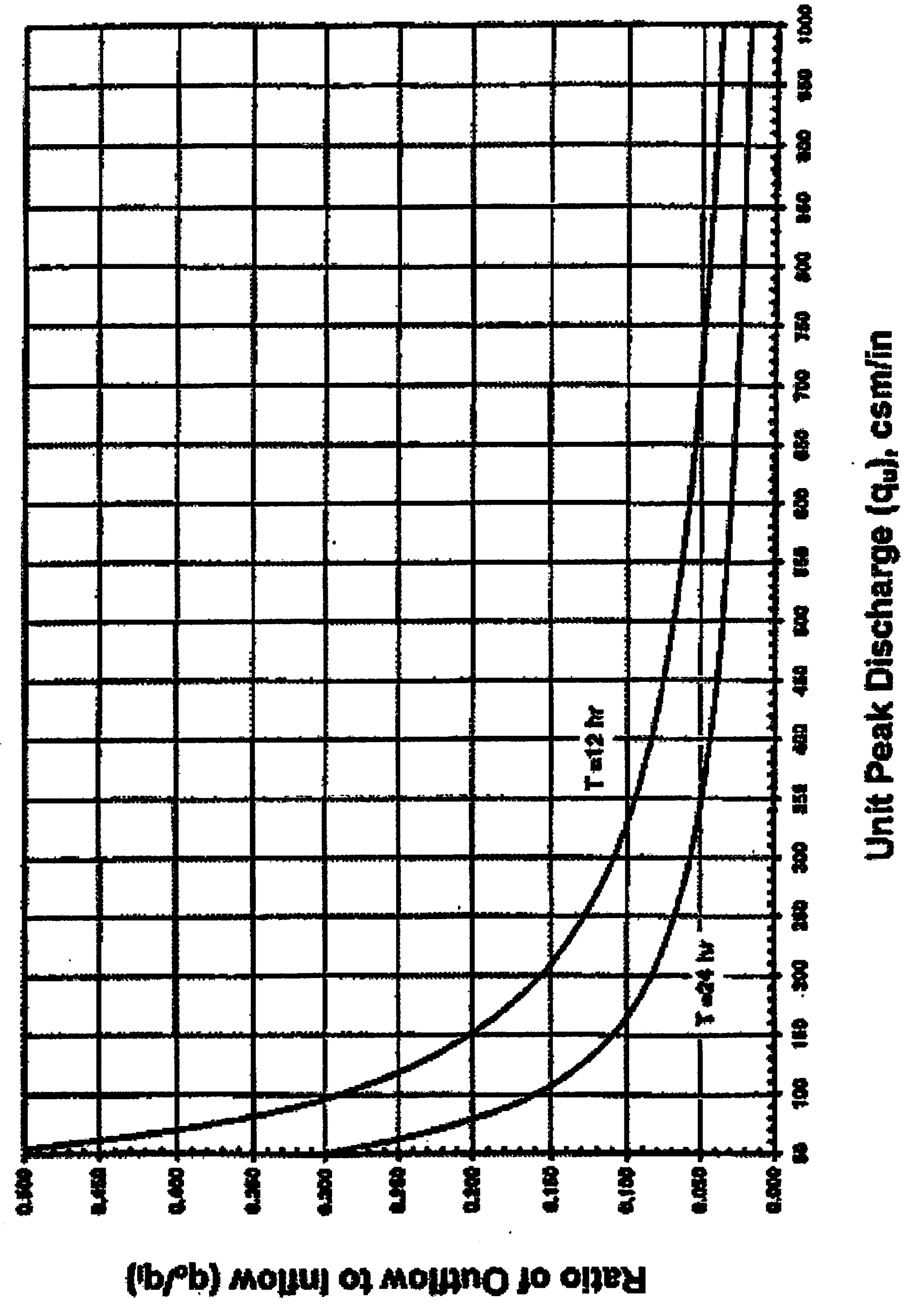


Chart 2.1
SCS Type II Unit Discharge Graph
(Source: SCS, TR-55, Second edition, June 1986)

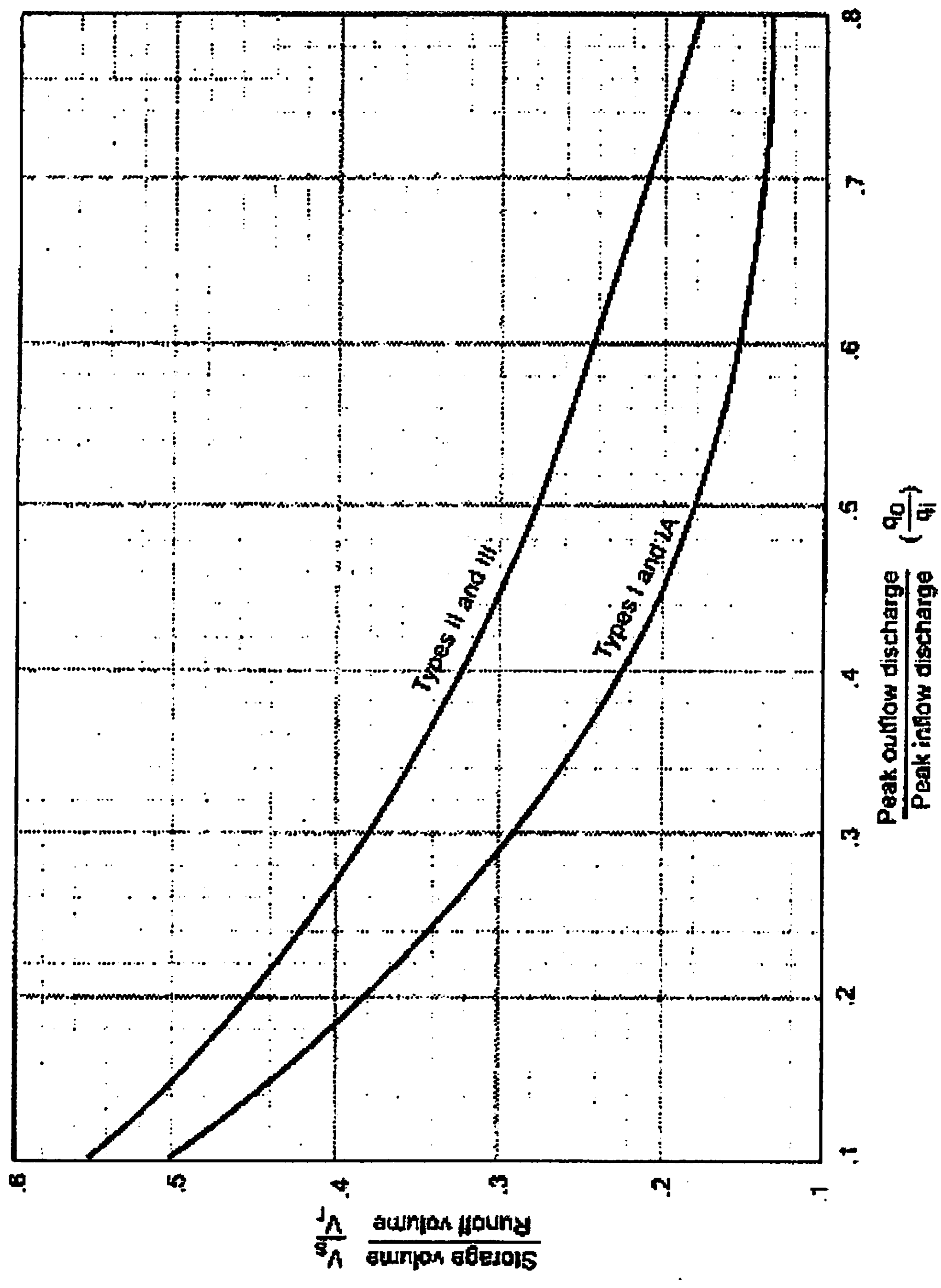


Chart 2.3
Approximate Detention Basin Routing for Rainfall Types I, IA, II and III
(Source: TR-55, 1986)

2.3 Overbank Flood Protection (Q_{FP})

The Overbank Flood Protection criterion specifies that the post-development 2-year and 10-year (also 25-year for site 40 acres and larger), 24-hour storm peak discharge rates not exceed the pre-development (or undisturbed natural conditions) discharge rate. This is achieved through detention of runoff from these events.

- The use of nonstructural site design practices that reduce the total amount of runoff will also reduce Q_{FP} by a proportional amount.
- When the City has designated a watershed to have existing flooding problems that require increased detention and flood control requirements (See Section 1.2.1), the Q_2, Q_{10}, and Q_{FP} flows must be reduced to less than the existing flows as determined by the City.

Note: This portion of the Unified Sizing Criteria is required in ADDITION to all other hydrologic and hydraulic analyses required by the City (i.e. 2-, 5-, 10- and 50-year events).

Determining the Overbank Flood Protection Volume (Q_{FP})

- Peak-Discharge and Hydrograph Generation: The SCS TR-55 hydrograph method will be used to compute the peak discharge rates and runoff volumes for the all analyzed storm events. Apply the methodology for estimating the required storage volume provided below.
- Rainfall Depths: The rainfall depth of the 2-year, 24-hour storm will be 3.6 inches. The rainfall depth of the 10-year 24-hour storm will be 5.3 inches. The rainfall depth of the 25-year, 24-hour storm will be 6.4 inches.
- Off-site Drainage Areas: Off-site drainage areas must be modeled as "present condition" for the design storm events and do not need to be included in Q_{FP} estimates, but can be routed through a structural stormwater control.
- Downstream Analysis: Downstream areas must be checked to ensure there is no peak flow increase above pre-development conditions to the point where the site area is 10% of the total drainage to that point. See Section 3.1.4 for the full details on this method.

Estimated Volume Requirement Methodology:

1. Run typical site hydrology
2. Compute the ratio of the post-developed design storm discharge to the pre-developed discharge (q_o/q_i).
3. Read the volume of storage divided by the volume of runoff (v_s/v_r) from Chart 2.3
4. Estimate the volume of storage required for the overbank flood (V_s).
   $V_s = v_r(v_s/v_r)$ in acre-feet,

   Where: v_r = the post-developed volume of runoff for the selected overbank storm converted to acre-feet
5. Experience shows that multi-outlet volumes are at least 15% low so actual Q_{25} storage estimate is

   $VS = V_s * 1.15$

2.4 Extreme Flood Protection (Q_{100})

The Extreme Flood Protection criterion specifies that all stormwater management facilities and associated grading plans and site layouts be designed to protect buildings, ponds, roads, and other permanent structures from the 100-year, 24-hour return frequency storm event, denoted Q_{100}. This is accomplished either by:

1. Controlling Q_{100} 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. By designing the on-site conveyance system, site grading, and building layout to safely pass Q_{100} without impacting buildings, ponds, roads, or other permanent structures and allowing it to discharge into a receiving water.

   Note: Flows can be conveyed without retention or detention to a receiving floodplain if it can be shown that the floodplain is sufficiently sized to account for extreme flow increases from the site without causing damage; or

3. When the City has designated a watershed to have existing flooding problems that require increased detention and flood control requirements (See Section 3.2.1), the Q_{100} must be reduced to less than the existing 100-year flows as determined by the City.

Local flood protection (levees, floodwalls, flood proofing, etc.) and/or channel enlargements may be offered as a substitution as appropriate, as long as adequate conveyance and structural safety is ensured through the measure used, and stream environmental integrity is adequately maintained. The City reserves the right to reject such substitutions.

Determining the Extreme Flood Protection Criteria (Q_{100})

- Peak-Discharge and Hydrograph Generation: The SCS TR-55 hydrograph method will be used to compute the peak discharge rate and runoff for the 100-year, 24-hour storm. Apply the methodology for estimating the required storage volume provided below
- Rainfall Depths: The rainfall depth of the 100-year, 24-hour storm will be 8.3 inches.
- Off-site Drainage Areas: Off-site drainage areas must be modeled as "full build-out condition" for the 100-year storm event to ensure safe passage of future flows.
- Downstream Analysis: If Q_{100} is being detained, downstream areas must be checked to ensure there is no peak flow increase above pre-development conditions to the point where the site area is 10% of the total drainage to that point. See Section 3.1.4 for more details on how to properly perform a Downstream Analysis.

Estimated Volume Requirement Methodology:

1. Run typical site hydrology
2. Compute the ratio of the post-developed 100-year discharge to the pre-developed discharge (q_o/q_i).
3. Read the volume of storage divided by the volume of runoff (v_s/v_r) from Chart 2.3
4. Estimate the volume of storage required for the overbank flood (V_s).

   $V_s = v_r(v_s/v_r)$ in acre-feet,

Where: v_r = the post-developed volume of runoff for the selected overbank storm converted to acre-feet

5. Experience shows that multi-outlet volumes are at least 15% low so actual Q_{100} storage estimate is

$VS = V_s * 1.15$

2.5 Water Quality Volume Peak Flow Calculation

The peak rate of discharge for the water quality design storm (Qwq) is needed for the sizing of off-line diversion structures, such as for sand filters, bioretention, grass filter strips, grassed swales, and infiltration trenches.

The following procedure can be used to estimate peak discharges for small storm events. It relies on the Water Quality Volume and the simplified peak flow estimating method above. A brief description of the calculation procedure is presented below.

1. Using WQv, a corresponding Curve Number (CN) is computed utilizing the following equation:

   $$CN = 1000/[10 + 5P + 10Qwv - 10(Qwv^2 + 1.25\,QwvP)^{1/2}]$$

   Where, P = rainfall, in inches (use 1.2 inches for the Water Quality Storm)

   Qwv = Depth of Water Quality Volume is expressed in inches (1.2Rv)

   $R_V = 0.05 + 0.009(I)$ where:

   I is entered as percent impervious cover (i.e. I = 30 for 30% impervious cover)

2. Once a CN is computed, the time of concentration (tc) is computed (based on SCS methodology).

3. Using the computed CN, time of concentration (Tc) and drainage area (A), in acres; the peak discharge (Qwq) for the water quality storm event is computed using a slight modification of the Simplified SCS Peak Runoff Rate Estimation technique, using Type II rainfall distribution:

- Read initial abstraction (Ia), compute Ia/P
- Read the unit peak discharge (qu) for appropriate Tc
- Using WQv, compute the peak discharge (Qwq)

$$Qwq = qu * A * Qwv$$

where Qwq = the water quality peak discharge (cfs)
qu = the unit peak discharge (cfs/mi^2/inch)
A = drainage area (mi^2)
Qwv = Depth of Water Quality Volume, in inches (1.2Rv)

Chapter 3 – Best Management Practices (BMPs)

3.1 Water Quantity Control Requirements

3.1.1 General Requirements

Water quantity control is an integral component of overall stormwater management. Its purpose is to negate the effects of stormwater runoff associate with land use changes due to development during storm events. The following design criteria are established for water quantity control, and when applied properly will meet or exceed the requirements of SCDHEC Regulation 72-300.

1. Post-development peak discharge rates shall not exceed pre-development peak discharge rates for the 2, and 10-year frequency 24-hour duration storm events. For developments 40 acres and larger, post-development peak discharge rates shall not exceed pre-development peak discharge rates for the 25-year frequency 24-hour duration storm event. The same hydrologic procedures shall be used in determining both the pre-development and post-development peak flow rates.

2. Post-development discharge velocities shall be reduced to provide non-erosive flow velocities from structures, channels or other control measures, or equal the pre-development 10-year 24-hour storm event flow velocities, whichever is less.

3. For post construction, the detention volume from all controls shall be drained from the structure within 72 hours. During construction, detention volumes can be temporarily stored to allow settling of particles. Upon project finalization pond elevations must be per the approved plans.

5. In addition to being allowed for water quality purposes, infiltration devices shall be required on those sites which do not currently discharge stormwater runoff or have no existing outlet. In such cases, in the post-development condition, devices shall be designed to infiltrate the runoff volume equivalent to the 5-year storm event. For evaluating storm events with a return interval greater than 5 years, the discharge rate from the site shall be limited to (not exceed) that of a site of equivalent size and slope with a SCS Curve Number equal to 39. See Section 5.2.6.L.v for more information, as well as Section 3.2.5 of the GSMM, for detailed selection, design, performance and operation & maintenance details on infiltration basins.

   Note: An alternative design for infiltration basins can be found in Appendix O.

6. Watersheds with documented water quantity problems may have more stringent or modified design criteria determined by the SWD or as dictated by State and Federal Regulations. Some examples of variable criteria include but are not limited to:

   a. Post-development discharge volumes from the entire development area not exceeding pre-development discharge volumes for storm frequencies smaller than the 2-year storm event,

   b. Reduction of peak flow rates below pre-development levels,

   c. Downstream channel, culvert, or property improvements.

7. Water quantity/volume waivers may be granted on a case-by-case basis. Final approval of a waiver request will be given at the discretion of the SWD. A water quantity/volume

waiver does not excuse water quality considerations. A project may be eligible for a waiver from the stormwater management requirements for water quantity/volume control if the applicant can justly verify the following items;

a. The proposed project's peak flow rate or volume control for stormwater management would not create, aggravate, or accelerate downstream flooding or cause a detrimental impact to the downstream ecosystem, the receiving storm water system, or downstream property.

b. The design engineer shall sign the following statement, "The increased flows will not have a significant adverse impact on the downstream and adjacent properties".

c. Calculations shall be provided that demonstrate the site has addressed the Unified Stormwater Sizing Criteria, including the Water Quality (WQv) and Channel Protection (CPv) volumes, to the maximum extent practical, or to the level specific by the SWD.

- It is recommended that a designer consult with the SWD at the earlier conceptual stages of a project to discuss water quality performance requirements for sites that may be more challenging.

8. An analysis shall be required for all development sites disturbing more than 2 acres to determine the impacts on downstream areas based on the 10-and 100-year 24-hour storm events unless a waiver or variance is granted. Downstream analysis shall determine whether the design storm events of interest cause or increase flooding, pollution, or erosion impacts to downstream properties, road crossings, and others areas as directed by the SWD. Applications for permit coverage must discuss this impact, the degree of the impact, and potential solutions. Analysis criteria shall include, but not be limited to:

a. Existing land use curve numbers shall be used for developed areas outside of the project area.

b. The weighted curve number for the developed portion of the site shall be used for all undeveloped upstream areas.

c. Flows must be routed using an accepted hydrologic and hydraulic method.

d. Hydraulic step-backwater calculations (Corps of Engineer's HEC-2 or HEC-RAS models or equivalent) may be required by the SWD based on several factors, such as the severity of potential impact and location of project.

e. The discussions must include the severity of impact on any upstream and proposed storm water quantity or quality structure.

- If the downstream analysis determines that the development of a particular site does contribute to flooding, pollution, or erosion problems, then appropriate controls shall be implemented:

9. All quantity controls that are also used for water quality control shall have a forebay, mirco-pool, screening vault, or skimmer/debris deflector for removal of debris and coarse sediments. The benefit of the forebay is that it inhibits the main pond from filling up with large particles, therefore allowing the main pond to maintain its original design volume.

10. Documentation on the design, installation, and maintenance of stormwater quantity facilities can be found in Sections 3.2-3.4 of the GSMM.

3.1.2 Accepted Quantity Controls

Detention structural controls are used for providing water quantity control and are typically used downstream of other minor structural controls. These structures are designed to provide channel protection, overbank flood protection, and protection against adverse downstream impacts that are related to the increase in peak flow rates and flow volumes from land disturbing activities. Detention structural stormwater controls accepted by SWD are shown in Table 3.1.

Table 3.1: Accepted quantity controls

General Structural Control	Description
Dry Detention/Dry Extended Basins	Dry detention basins and dry extended detention basins are surface storage facilities intended to provide temporary storage of stormwater runoff and releasing it at a designed flow rate to reduce downstream water quantity impacts. These structures are designed to completely drain to a dry condition within 72 hours.
Wet Storm Water Detention Basins • Wet Pond • Wet Extended Detention Pond • Micropool Extended Detention Pond • Multiple Pond System	Wet detention basins are constructed stormwater basins that have a permanent pool or micropool of water. Runoff from each rain event is detained above the permanent pool and released at a designed flow rate to reduce downstream water quantity impacts. Permanent pool depths must be $\geq$ 4 feet to reduce mosquito breeding.
Multi-purpose Detention Areas	Multi-purpose detention areas are used for one or more specific activities such as parking areas and rooftops. These areas are used to provide temporary storage of runoff. Some of the multi-purpose area such as infiltration trenches or bio-retention areas may also be used for water quality purposes.
Underground Detention	Underground detention is used as an alternative to surface dry-detention basins. They are used in areas that are space-limited where there is not enough adequate land to provide the required detention volume. The underground storage utilizes tanks, vaults, and buried pipes to supply the required storage volume.
Infiltration Basins	Infiltration basins are used to remove runoff from the flow path into the ground. They are used in areas that currently do not discharge stormwater or create runoff only during large storm events.

3.1.3 Design Procedures

This section provides the general procedures for the design of stormwater quantity structures. The following items shall be required for the design of these structures and routing flows through them:

1. Compute the inflow hydrograph for the structure for the 2, 10, 25, 50 and 100-year 24-hour storm events for both the existing and proposed conditions. From this, determine peak flow rates for each storm.

2. Compute a stage-storage relationship for the proposed structure. A stage storage-curve defines the relationship between the depth of water and storage volume within the detention facility. Stage-storage and stage-discharge calculations must be included in the engineering calculations.

3. Compute stage-discharge relationship of the outlet control structure(s). A stage-discharge curve defines the flow capacity of a structure at a given stage or elevation. Also compute outlet barrel capacity and discharge velocity for energy dissipation design.

4. Perform routing calculations for the 2, 10, 25, 50 and 100-year storm events.

5. The peak discharge rate from the pond must be less than or equal to the peak discharge rate for the pre-development conditions for the 2 and 10-year storm events (also 25-year storm event for developments 40 acres and larger), unless the SWD allows a tolerance for peak flow matching. Finally, check to make sure the discharge hydrograph from the 100-year storm event provides a minimum of 1-foot of freeboard with the banks of the facility.

6. Evaluate the control structure outlet flow velocity and provide velocity control and channel stabilization. Drawings and details must be provided for outlet structures and basin.

7. Concentrated flow from any discharge point shall be returned to the overland flow condition.

3.1.4 Downstream Hydrologic Assessment

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. 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 the required procedure, as part of a developer's stormwater management site plan, which is detailed in Section 2.1.9 of the GSMM.

The Ten-Percent Rule: Based on studies and results for a large number of sites, a site's zone of influence is considered to be the point where the drainage area controlled by the detention or storage facility comprises 10% of the total drainage area. For example, if the structural control drains 10 acres, the zone of influence ends at the point where the total drainage area is 100 acres or greater. However, some sites may require that the "zone of influence" be extended further downstream.

Typical steps in the application of the ten-percent rule are:

1. Determine the target peak flow for the site for predevelopment conditions.
2. Using a topographic map determine the lower limit of the zone of influence (aka "10% point").
3. Using a hydrologic model determine the pre-development peak flows and timing of those peaks at each tributary junction beginning at the pond outlet and ending at the next tributary junction beyond the 10% point.

4. Change the land use on the site to post-development and rerun the model.

- If the undetained post-development peak flow rates are unchanged at the "10% point", when compared the pre-development model, the lower limit of the zone of influence has been affirmed.
- If the undetained post-development peak flow rates have increased at the "10% point" when compared the pre-development model, the lower limit of the zone of influence must be extended further downstream until there is no change in flow.

5. Design the structural control facility such that the overbank flood protection (25-year) post-development flow does not increase the peak flows at the outlet and the determined tributary junctions.

Even if the overbank flood protection requirement is eliminated, the water quality treatment (WQv), channel protection (CPv), and extreme flood protection (Q_{100}) criteria will still need to be addressed.

For a detailed example, see Section 2.1.9 of the GSMM.

3.1.5 Routing with WQv Removed

When off-line structural controls such as bioretention areas, sand filters and infiltration trenches capture and remove the water quality volume (WQv), downstream structural controls do not have to account for this volume during design. That is, the WQv may be subtracted from the total volume that would otherwise need to be routed through the downstream structural controls.

From a calculation standpoint this would amount to removing the initial WQv from the beginning of the runoff hydrograph – thus creating a "notch" in the runoff hydrograph. Since most commercially available hydrologic modeling packages cannot handle this type of action, the following method has been created to facilitate removal from the runoff hydrograph of approximately the WQv:

- Enter the horizontal axis on Chart 3.1 with the impervious percentage of the watershed and read upward to the predominant soil type (interpolation between curves is permitted)
- Read left to the factor
- Multiply the curve number for the sub-watershed that includes the water quality basin by this factor – this provides a smaller curve number

The difference in curve number will generate a runoff hydrograph that has a volume less than the original volume by an amount approximately equal to the WQv.

Notes:

1. This method should be used only for bioretention areas, filter facilities and infiltration trenches where the drawdown time is ≥ 24 hours.
2. This method can only be applied to catchments with a homogenous soil class (i.e. A, B, C, D), or are dominated significantly by a single soil class.
3. This method also assumed that 100% of the required WQv for the catchment area being analyzed is stored in upland BMPs

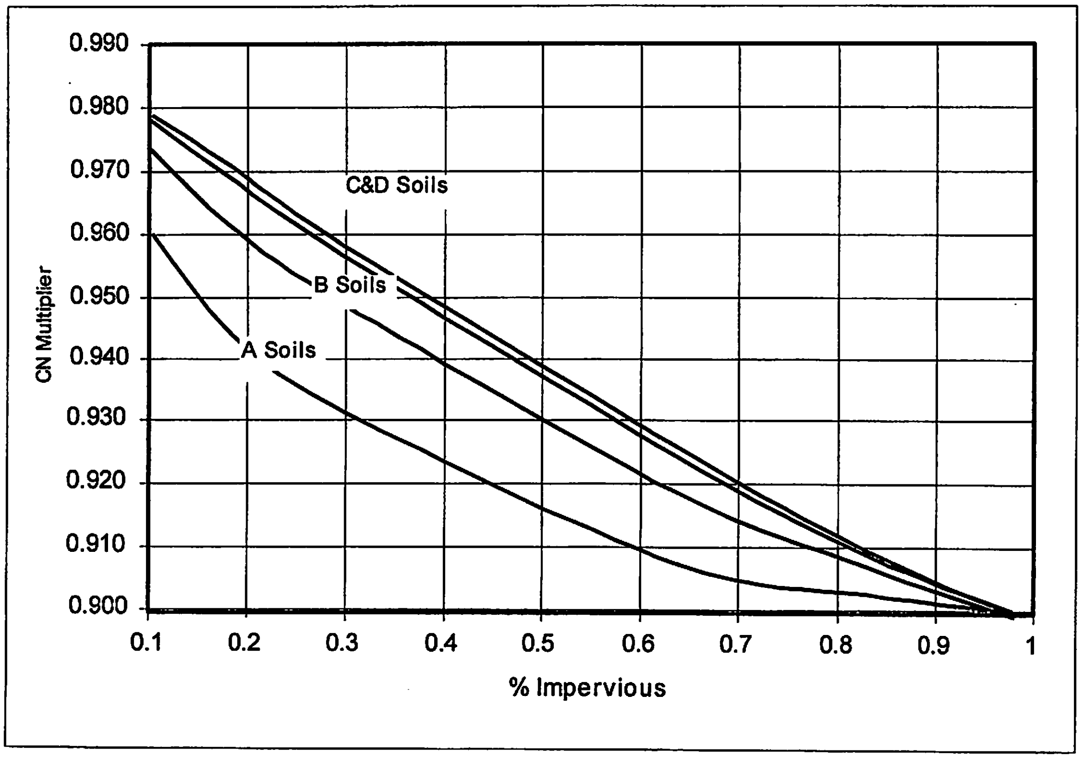


Chart 3.1 - Curve Number Adjustment Factor

<u>Example</u>

A site design employs an infiltration trench for the WQv and has a curve number of 72, is B type soil, and has an impervious percentage of 60%, the factor from Chart 3.1 is 0.92. The curve number to be used in calculation of a runoff hydrograph for the quantity controls would be:

(72*0.92) = 66

3.2 Accepted Water Quality BMPs

In selecting a BMP(s), it is most important to know what pollutants need to be treated to meet water quality goals. With proper planning, installation, and maintenance, BMPs are expected to reduce pollutant loads to receiving waters, reduce erosion, and provide health and safety benefits. Structural stormwater controls (aka 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.

This Manual allows for a number of structural stormwater controls for meeting unified stormwater sizing criteria. The recommended controls are divided into three categories: general application, limited application, and detention structural controls. These categories of BMPs have varying abilities to address downstream channel protection (CPv), overbank flood protection (Q_{25}) and/or extreme flood protection (Q_{100}).

3.2.1 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 (WQv) 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.

The allowable types of general application controls are summarized below. Detailed descriptions of each structural control along with design criteria and procedures are provided in Section 3.2 of the GSMM.

Table 3.2 lists and briefly describes the general application structural stormwater control practices. These structural controls are recommended for use in a wide variety of applications. A detailed discussion of each of the general application controls, as well as design criteria and procedures can be found in Section 3.2 of the GSMM.

Table 3.2 General Application Structural Controls

Structural Control	Description
Stormwater Ponds • Wet • Wet Extended Detention • Micropool Extended Detention • Multiple Pond Systems	Wet detention basins are constructed stormwater basins that have a permanent pool or micropool of water. Runoff from each rain event is detained above the permanent pool and released at a designed flow rate to reduce downstream water quantity impacts. Permanent pool depths must be ≥ 4 feet to reduce mosquito breeding.
Bioretention Areas	Bioretention areas are shallow stormwater basins or landscaped areas which utilize engineered soils and vegetation to capture and treat stormwater runoff. Runoff may be returned to the conveyance system, via underdrain, or allowed to partially infiltrate into the soil.
Infiltration Trench/Basin	An infiltration trench is an excavated trench filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils through the bottom and sides of the trench. An infiltration basin allows infiltration of stormwater runoff into the surrounding soils through the bottom and sides of the trench.

Table 3.2 General Application Structural Controls	
Structural Control	**Description**
Enhanced Swales • Dry Swale • Wet Swale/Wetland Channel	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.

3.2.2 Limited Application Controls

Table 3.3 lists the limited application structural stormwater control practices, along with the rationale for limited use. These structural controls are recommended for use with particular land uses and densities, to meet certain water quality requirements, for limited usage on larger projects, or as part of a stormwater treatment train. A detailed discussion of each of the limited application controls, as well as design criteria and procedures can be found in Section 3.3 of the GSMM.

Table 3.3 Limited Application Structural Controls	
Structural Control	**Description and Rationale for Limited Use**
Biofilters • Filter Strip • Grass Channel	Both filter strips and grass channels provide "biofiltering" of stormwater runoff as it flows across the grass surface. However, by themselves these controls cannot meet the performance goal. Consequently, both filter strips and grass channels should only be used as pretreatment measure or as part of a treatment train approach. They are also acceptable for use as a site design credit (see Chapter 4).
Hydrodynamic Devices • Gravity (Oil-Grit) Separator	Hydrodynamic controls use the movement of stormwater runoff through a specially designed structure to remove target pollutants. They are typically used on smaller impervious commercial sites and urban hotspots. These controls typically do not meet the 80% TSS removal performance goal and therefore should only be used as a pretreatment measure and as part of a treatment train approach.
Porous Surfaces • Porous Concrete • Porous Asphalt • Modular Porous Paver Systems	Porous surfaces are permeable pavement surfaces with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. Porous concrete is the term for a mixture of course aggregate, portland cement and water that allows for rapid infiltration of water. Modular porous paver systems consist of open void paver units laid on a gravel subgrade. Both porous concrete and porous paver systems provide water quality and quantity benefits, but have high workmanship and maintenance requirements, as well as high failure rates. Note: Porous asphalt surfaces have a higher tendency to be clogged by clays, silts and oils resulting in a potentially high maintenance burden to maintain the effectiveness of this structural control. Further, summer heat in South Carolina can cause the asphalt to melt, destroying the porous properties of the surface. Therefore, the specific application of this BMP must be reviewed for both sediment and heat issues, as well as the traffic load that it is intended to carry, before allowing the application of this BMP.

Table 3.3 Limited Application Structural Controls (Cont.)	
Structural Control	**Description and Rationale for Limited Use**
• Media Filter Inserts	Media filter inserts, such as catch basin inserts and filter systems, are easily clogged and require a high degree of regular maintenance and replacement to achieve the intended water quality treatment performance and should not be used for areas of new development or redevelopment. These structural controls may serve a potential use in stormwater retrofitting. Before using this BMP, the designer must justify the anticipated performance for the constituent of concern, and receive approval from the City before included this BMP in any designs or construction activities.
Proprietary Systems • Commercial Stormwater Controls	Proprietary controls are manufactured structural control systems available from commercial vendors designed to treat stormwater runoff and/or provide water quantity control. Proprietary systems often can be used on small sites and in space-limited areas, as well as in pretreatment applications. However, proprietary systems are often more costly than other alternatives, may have high maintenance requirements, and often lack adequate independent performance data, particularly for use in Georgia conditions.

3.2.3 Detention Structural Controls

Table 3.4 lists the detention structural stormwater control practices. These structural controls are recommended only for providing water quantity control, i.e. channel protection, overbank flood protection and/or extreme flood protection in a stormwater treatment train. A detailed discussion of each of the detention controls, as well as design criteria and procedures can be found in Section 3.4 of the GSMM.

Due to the potential for pollutant resuspension and outlet clogging, detention structural controls are not intended to treat stormwater runoff and should be used downstream of other water quality structural control in a treatment train (forebay, micro-pool, filter strip, etc.)

Table 3.4 Detention Structural Controls	
Structural Control	**Description**
Dry Detention / Dry Extended Detention Basins	Dry detention basins and dry extended detention (ED) basins are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts.
Multi-Purpose Detention Areas	Multi-purpose detention areas are site areas used for one or more specific activities, such as parking lots and rooftops, which are also designed for the temporary storage of runoff.
Underground Detention	Underground detention tanks and vaults are an alternative to surface dry detention for space-limited areas where there is not adequate land for a dry detention basin or multi-purpose detention area.

3.2.4 Not Recommended Structural Controls

The following structural controls in Table 3.5 are not recommended for use in the City of Columbia to meet stormwater management objectives, as they fail to demonstrate an ability to meet the majority of the water quality treatment goals and/or present difficulties in operation and maintenance.

Table 3.5 Not Recommended Structural Controls	
Structural Control	**Rationale for Lack of Recommendation**
Stormwater Wetlands • Shallow Wetland • Extended Detention Shallow Wetland	Stormwater wetlands consist of a combination of shallow marsh areas, open water and semi-wet areas above the permanent water surface. In order to keep them alive and functioning, proper hydroperiods must be maintained. Creating a wetland near development is likely to have difficulty in maintaining the hydrperiod due to the lack of baseflow and distance from the water table.

3.2.5 Using Other or New Structural Stormwater Controls

Innovative technologies may be allowed, providing there is sufficient documentation as to their effectiveness and reliability. The City will not allow any such technologies without independently derived information concerning performance, maintenance, application requirements and limitations.

More specifically, new structural stormwater control designs will not be accepted for inclusion in the Manual until independent pollutant removal performance monitoring data determine that the practice can meet the TSS and other selected pollutant concentration removal targets, and that the structural control conforms with local and/or State criteria for treatment, maintenance, and environmental impact.

3.2.6 Structural Stormwater Control Pollutant Removal Capabilities

General and limited application structural stormwater controls are intended to provide water quality treatment for stormwater runoff. Though each of these structural controls provides pollutant removal capabilities, the relative capabilities vary between structural control practices and for different pollutant types.

Pollutant removal capabilities for a given structural stormwater control practice are based on a number of factors including the physical, chemical and/or biological processes that take place in the structural control and the design and sizing of the facility. In addition, pollutant removal efficiencies for the same structural control type and facility design can vary widely depending on the tributary land use and area, incoming pollutant concentration, rainfall pattern, time of year, maintenance frequency and numerous other factors.

To assist the designer in evaluating the relative pollutant removal performance of the various structural control options, Appendix J provides design removal efficiencies for each of the general and limited application control practices. It should be noted that these values are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. A structural control design may be capable of exceeding these performances, however the values in the table are minimum reasonable values that can be assumed to be achieved when the structural control is sized, designed, constructed and maintained in accordance with recommended specifications in this Manual.

Where the pollutant removal capabilities of an individual structural stormwater control are not deemed sufficient for a given site application, additional controls may be used in series in a "treatment train" approach. More detail on using structural stormwater controls in series is provided in Section 3.2.8.

For additional information and data on the range of pollutant removal capabilities for various structural stormwater controls, the reader is referred to the National Pollutant Removal Performance Database (2nd Edition) available at:
www.cwp.org
www.bmpdatabase.org

3.2.7 Structural Stormwater Control Selection

General Application Control Screening Process

Outlined below is a screening process for General Application structural stormwater controls. This process is intended to assist the site designer and design engineer in the selection of the most appropriate structural controls for a development site, and provides guidance on factors to consider in their location.

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

- Stormwater Treatment Suitability
- Water Quality Performance
- Site Applicability
- Implementation Considerations

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

- Physiographic Factors
- Soils
- Special Watershed or Stream Considerations

Finally, environmental regulations that may influence the location of a structural control on site, or may require a permit, need to be considered.

Section 3.1.3 of the GSMM provides a detailed selection process for comparing and evaluating various general application structural stormwater controls using two screening matrices and a list of location and permitting factors. Those tools can assist the design engineer in selecting the subset of structural controls that will meet the stormwater management and design objectives for a development site or project.

3.2.8 Using Structural Stormwater Controls in Series

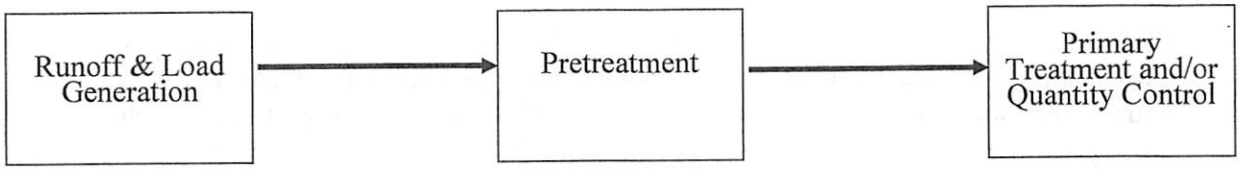
The following subsections provide a general description of how BMPs in series can be used to meet water quality goals, and the appropriate manner in which to calculate their cumulative effect on removing pollutants.

3.2.8.1 General Methodology

Stormwater Treatment Trains

The minimum stormwater management standards are an integrated planning and design approach, sometimes called a stormwater "treatment train". A treatment train consists of all the design concepts and nonstructural and structural controls that work to attain water quality and quantity goals. This is illustrated in Figure 3.1.

Figure 3.1: Generalized Stormwater Treatment Train



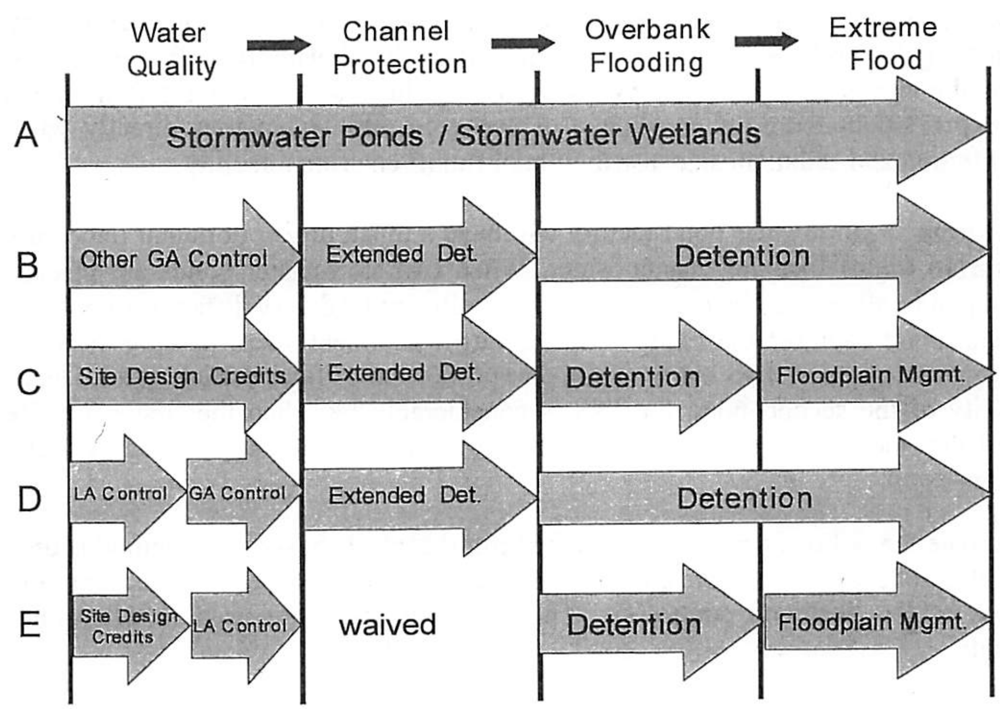
Runoff and Load Generation – The initial part of the "train" is located at the source of runoff and pollutant load generation, and consists of better site design and pollution prevention practices that reduce runoff and stormwater pollutants.

Pretreatment – The next step in the treatment train consists of pretreatment measures. These measures typically do not provide sufficient pollutant removal to meet the 80% TSS reduction goal, but do provide calculable water quality benefits that may be applied towards meeting the WQv treatment requirement.

Primary Treatment and/or Quantity Control – The last step is primary water quality treatment and/or quantity (channel protection, overbank flood protection, and/or extreme flood protection) control.

Many combinations of structural controls in series may exist for a site. Figure 3.2 provides a number of hypothetical examples of how the unified stormwater sizing criteria may be addressed by using structural stormwater controls.

Figure 3.2 Examples of Structural Controls Used in Series



Referring to Figure 3.2 by line letter:

A. Two general application (GA) structural controls, stormwater ponds and stormwater wetlands, can be used to meet all of the unified stormwater sizing criteria in a single facility.

B. The other general application structural controls (bioretention, sand filters, infiltration trench and enhanced swale) are typically used in combination with detention controls to meet the unified stormwater sizing criteria. The detention facilities are located downstream from the water quality controls either on-site or combined into a regional or neighborhood facility.

C. Line C indicates the condition where an environmentally sensitive large lot subdivision has been developed that can be designed so as to waive the water quality treatment requirement altogether. However, detention controls may still be required for downstream channel protection, overbank flood protection and extreme flood protection.

D. Where a limited application (LA) structural control does not meet the 80% TSS removal criteria, another downstream structural control must be added. For example, urban hotspot land may be fit or retrofit with devices adjacent to parking or service areas designed to remove petroleum hydrocarbons. These devices may also serve as pre-treatment devices removing the coarser fraction of sediment. One or more downstream structural controls is then used to meet the full 80% TSS removal goal, and well as water quantity control.

E. In line E site design credits have been employed to partially reduce the water quality volume requirement. In this case, for a smaller site, a well designed and tested Limited Application structural control provides adequate TSS removal while a dry detention pond handles the overbank flooding criteria. For this location, direct discharge to a large stream and local downstream floodplain management practices have eliminated the need for channel protection volume and extreme flood protection structural controls on site.

3.2.8.2 Calculation of Pollutant Removal for Structural Controls in Series

For two or more structural stormwater controls used in combination, it is often important to have an estimate of the pollutant removal efficiency of the treatment train. Pollutant removal rates for structural controls in series are not additive. For pollutants in particulate form, the actual removal rate (expressed in terms of percentage of pollution removed) varies directly with the pollution concentration and sediment size distribution of runoff entering a facility.

For example, a stormwater pond facility will have a much higher pollutant removal percentage for very turbid runoff than for clearer water. When two stormwater ponds are placed in series, the second pond will treat an incoming particulate pollutant load very different from the first pond. The upstream pond captures the easily removed larger sediment sizes, passing on an outflow with a lower concentration of TSS but with a higher proportion of finer particle sizes. Hence, the removal capability of the second pond for TSS is considerably less than the first pond. Recent findings suggest that the second pond in series can provide as little as half the removal efficiency of the upstream pond.

To estimate the pollutant removal rate of structural controls in series, a method is used in which the removal efficiency of a downstream structural control is reduced to account for the pollutant removal of the upstream control(s). The following steps are used to determine the pollutant removal:

- For each drainage area list the structural controls in order, upstream to downstream, along with their expected average pollutant removal rates from Appendix J for the pollutants of concern.

- For cases where a limited application control is sited upstream from a general application control in the treatment train, the downstream general application structural control is given full credit for removal of pollutants.
- For any general application structural control located downstream from another general application control or a limited application structural control that has TSS removal rates equivalent to 80%, the designer should use half (i.e. 40% removal rate) of the normal pollutant removal rate for the second control in series. The reason for reducing the downstream BMP removal rate to half of its normal rate is that:
  - The larger particles, which are easier to trap, were removed by the upstream BMP
  - The remaining particles, which are smaller and harder to trap, remain for the downstream BMP and thereby reduce its effective removal rate
- For a general application structural control located downstream from a limited application structural control that cannot achieve the 80% TSS reduction goal the designer should use 75% of the normal pollutant removal rate for the second control in series.

  Example:

  TSS is the pollutant of concern and a stormwater pond is designed at the site outlet. A second stormwater pond is located downstream from the first one in series. If each pond has a normal removal rate of 80%, what is the total TSS removal rate? The following information is given:

  - Control 1 (Stormwater Pond 1) = 80% TSS removal (use 1.0 x design removal rate)
  - Control 2 (Stormwater Pond 2) = 40% TSS removal (use 0.5 x design removal rate)

  Then applying the controls in order and working in terms of "units" of TSS starting at 100 units:

  For Control 1: 100 units of TSS * 80% removal rate
  - 80 units removed; 20 units remaining

  For Control 2: 20 units of TSS * 40% removal rate
  - 8 units removed; 12 units remaining

  For the treatment train in total:
  - We started with 100 units; 12 units remain
  - 88 units were removed = 88% removal rate

3.2.9 On-Line Versus Off-Line Structural Controls

Structural stormwater controls are designed to be either "on-line" or "off-line." On-line facilities are designed to receive, but not necessarily control or treat, the entire runoff volume up to the Q_{25} or Q_{100} event. On-line structural controls must be able to handle the entire range of storm flows.

Off-line facilities on the other hand are designed to receive only a specified flow rate through the use of a flow regulator (i.e. diversion structure, flow splitter, etc). Flow regulators are typically used to divert the water quality volume (WQv) to an off-line structural control sized and designed to treat and control the WQv. After the design runoff flow has been treated and/or controlled it is returned to the conveyance system. Figure 3.3 provides an example of an off-line sand filter and an off-line enhanced dry swale.

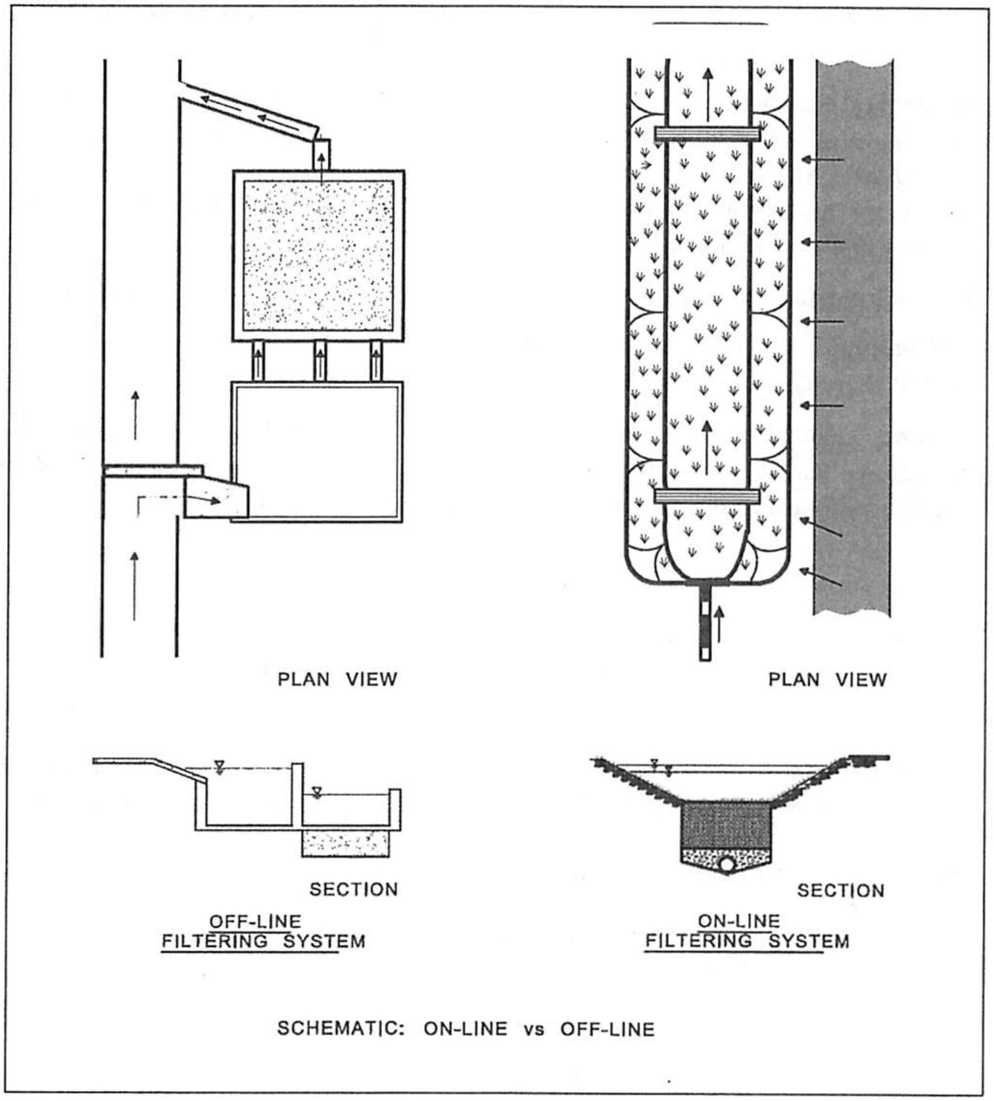


Figure 3.3 Example of On-Line versus Off-Line Structural Controls
(Source: CWP, 1996)

Flow regulation to off-line structural stormwater controls can be achieved by either:

- Diverting the water quality volume or other specific maximum flow rate to an off-line structural stormwater control, or
- Bypassing flows in excess of the design flow rate

The peak water quality flow rate (Qwq) can be calculated using the procedure found in Chapter 2.

Flow regulators can be flow splitter devices, diversion structures, or overflow structures (See Figures 3.4-3.6).

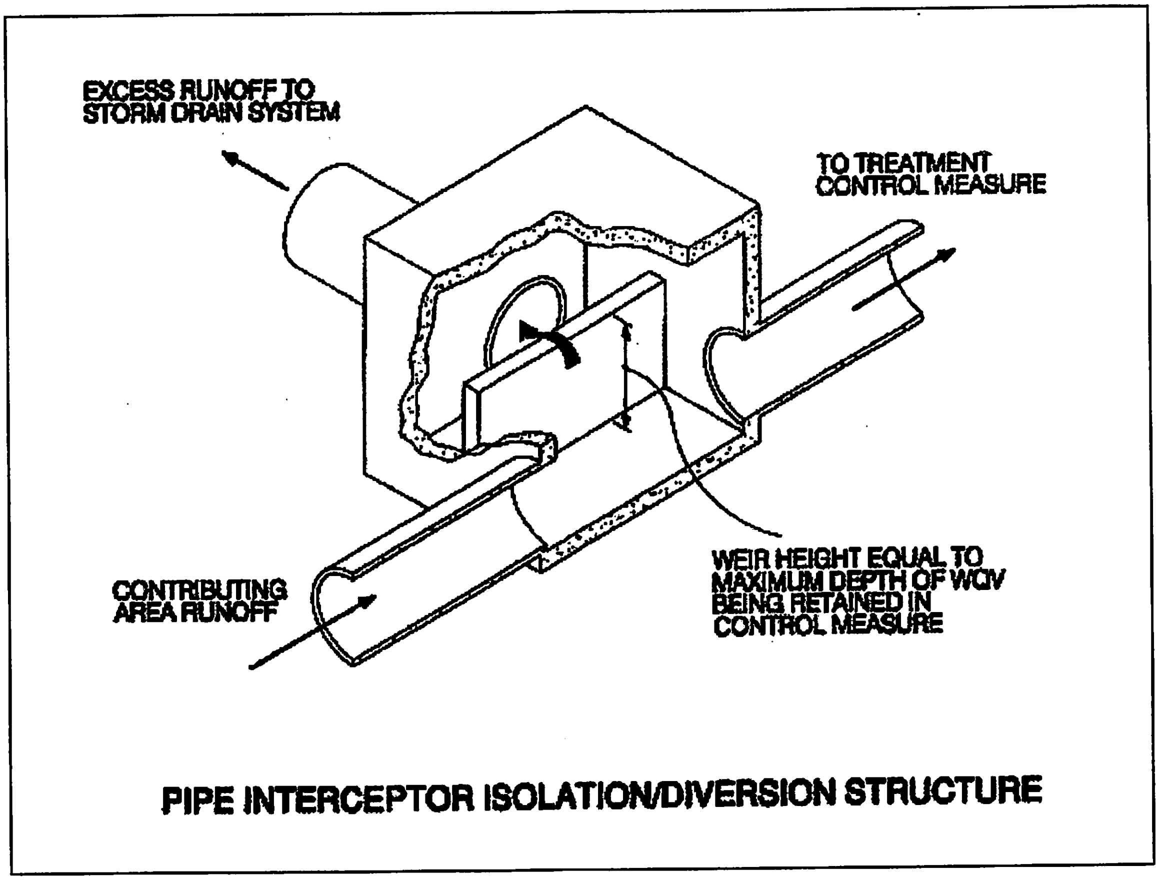


Figure 3.4 Pipe Interceptor Diversion Structure
(Source: City of Sacramento, 2000)

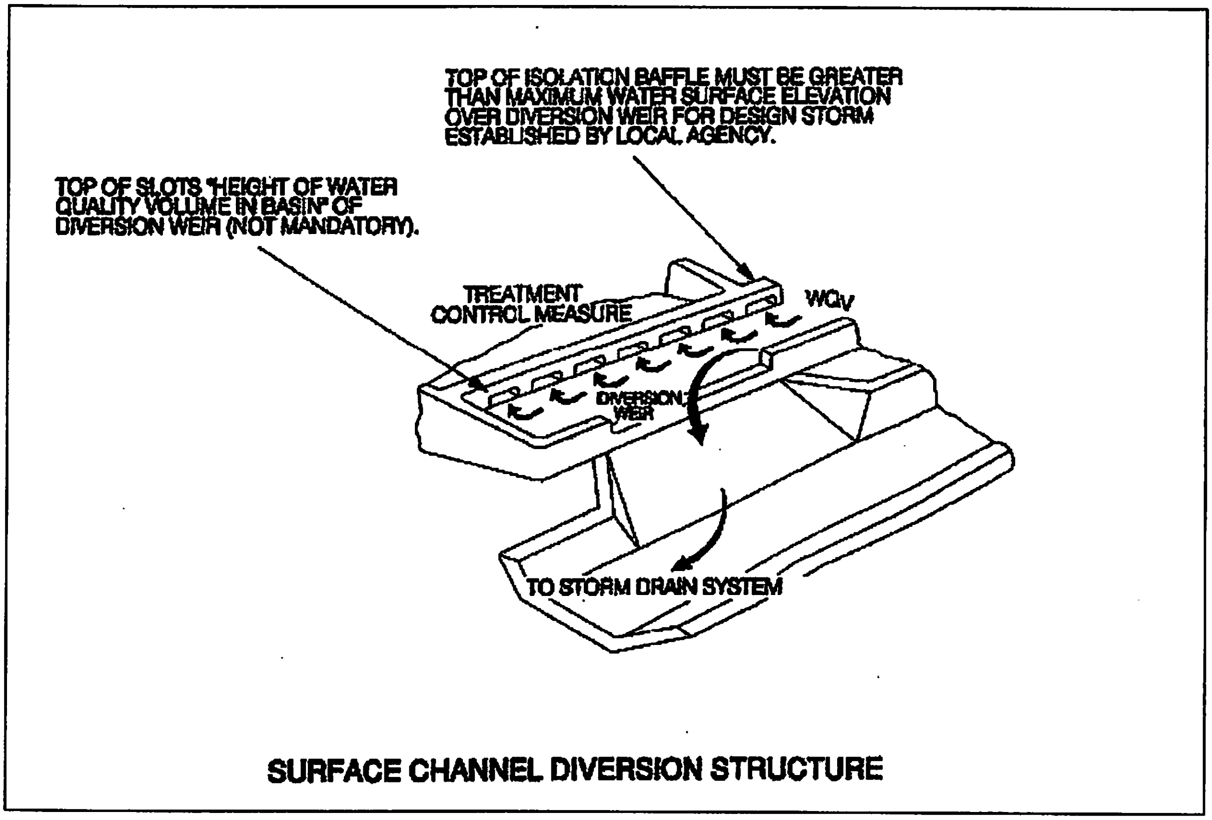


Figure 3.5 Surface Channel Diversion Structure
(Source: City of Sacramento, 2000)

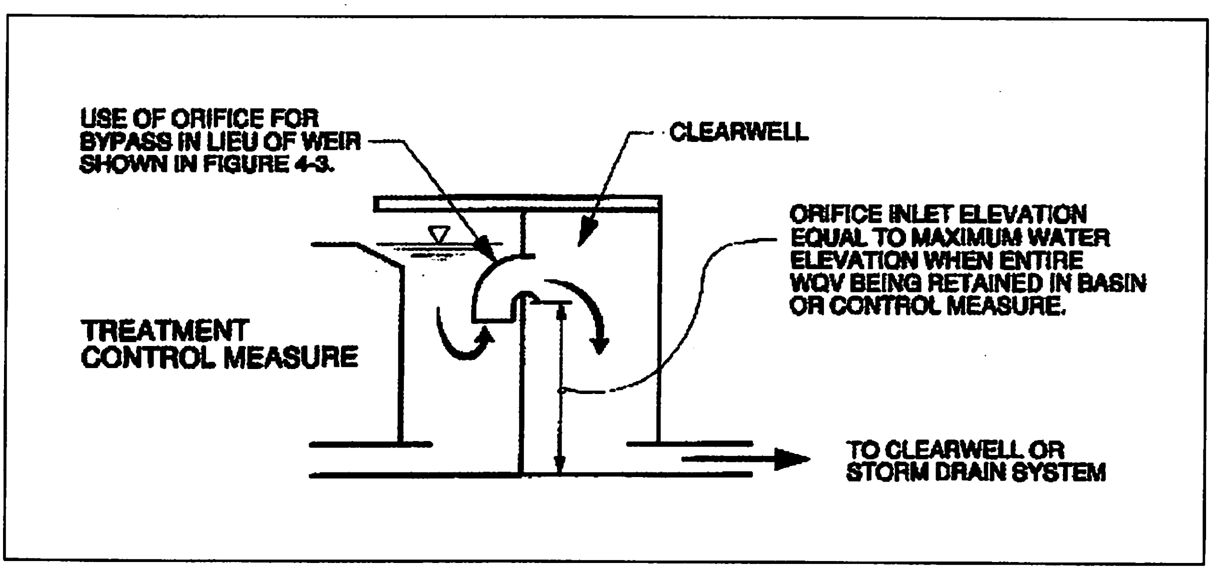


Figure 3.6 Outlet Flow Regulator
(Source: City of Sacramento, 2000)

Chapter 4 – Site Design Stormwater Credits

A set of stormwater "credits" has been developed 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 allowing for a reduction in the water quality treatment volume (WQv). This also reduces the size of structural stormwater control and conveyance facilities for events greater than the water quality treatment (WQv) event.

The better site design practices that provide stormwater credits are listed in Table 4.1. 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.

Note: 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 WQv) and are not further credited under this system.

Table 4.1 Summary of Better Site Design Practices Providing Stormwater Volume 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.

For each potential credit, there is a minimum set of criteria and requirements (e.g., flow length, contributing area, etc.) which identify the conditions or circumstances under which the credit may be applied. Site designers are 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 conservation area over the same site area).

Note: Due to local safety codes, soil conditions, and topography, some of these site design credits may be restricted. Designers are encouraged to consult with the City to ensure if and when a credit is applicable and to determine restrictions on non-structural strategies.

4.1 Stormwater Credits and the Site Planning Process

During the site planning process (see Section 1.5 of the GSMM) the integration of site design credits can be integrated with this process as shown in Table 4.2.

Table 4.2 Integration of Site Design Credits with Site Development Process

Site Development	Site Design Credit Activity
Feasibility Study	• Determine stormwater management requirements • Perform site reconnaissance to identify potential areas for and types of credits
Site Analysis	• Identify and delineate natural feature conservation areas (natural areas and stream buffers)
Concept Plan	• Preserve natural areas and stream buffers during site layout • Reduce impervious surface area through various techniques • Identify locations for use of vegetated channels and groundwater recharge • Look for areas to disconnect impervious surfaces • Document the use of site design credits.
Preliminary and Final Plan	• Perform layout and design of credit areas – integrating them into treatment trains • Ensure unified stormwater sizing criteria are satisfied • Ensure appropriate documentation of site design credits according to local requirements.
Construction	• Ensure protection of key areas • Ensure correct final construction of areas needed for credits
Final Inspection	• Develop maintenance requirements and documents • Ensure long term protection and maintenance • Ensure credit areas are identified on final plan and plat if applicable

Site Design Credit #1: Natural Area Conservation

A stormwater credit can be taken 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 and adhering to the criteria listed below. An added benefit will be that the post- development peak discharges will be smaller, and hence water quantity control volumes (CP_V, Q_{25}, and Q_{100}) will be reduced due to lower post-development curve (CN) numbers.

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

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
- 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
- R_V is kept constant when calculating WQ_V

Example: Residential Subdivision
Area = 38 acres
Natural Conservation Area = 7 acres
Impervious Area = 13.8 acres

$R_V = 0.05 + 0.009\ (I) = 0.05 + 0.009\ (36.3\%) = 0.37$

Credit:

7.0 acres in natural conservation area
New drainage area = 38 – 7 = 31 acres

Before credit:
$WQ_V = (1.2)(0.37)(38)/12 = 1.40$ ac-ft

With credit:
$WQ_V = (1.2)(0.37)(31)/12 = 1.15$ ac-ft

(18% reduction in water quality volume)

Site Design Credit #2: Stream Buffers

This credit can be taken 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, and adhere to the criteria listed below.

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

Criteria:

- The minimum undisturbed buffer width shall be 50 feet, or as required by the City's Buffer Ordinance, whichever is greater.
- 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
- R_V is kept constant when calculating WQ_V

Example: Residential Subdivision
Area = 38 acres
Impervious Area = 13.8 acres
Area Draining to Buffer = 5 acres

$R_V = 0.05 + 0.009\,(I) = 0.05 + 0.009\,(36.3\%) = 0.37$

Credit:

5.0 acres draining to buffer

New drainage area = 38 – 5 = 33 acres

Before credit:
$WQ_V = (1.2)(0.37)(38)/12 = 1.40$ ac-ft

With credit:
$WQ_V = (1.2)(0.37)(33)/12 = 1.22$ ac-ft

(13% reduction in water quality volume)

Site Design Credit #3: Vegetated Channels

This credit may be taken 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 can 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.

This credit cannot be taken if grass channels are being used as a limited application structural stormwater control (i.e. not designed to fully meet the design methodology and criteria) towards meeting the pollutant reduction goal for WQ_V treatment.

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

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 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
- R_V is kept constant when calculating WQ_V

Example: Residential Subdivision
Area = 38 acres
Impervious Area = 13.8 acres

$R_V = 0.05 + 0.009\,(I) = 0.05 + 0.009\,(36.3\%) = 0.37$

Credit:

12.5 acres meet grass channel criteria
New drainage area = 38 – 12.5 = 25.5 acres

Before credit:
$WQ_V = (1.2)(0.37)(38)/12 = 1.40$ ac-ft

With credit:
$WQ_V = (1.2)(0.37)(25.5)/12 = 0.94$ ac-ft

(33% reduction in water quality volume)

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

This credit can be taken when "overland flow filtration/infiltration zones" are incorporated into the site design to receive runoff from small impervious areas (e.g., driveways, small parking lots, etc). This can be achieved by grading the site to promote overland vegetative filtering or infiltration areas (i.e. rain gardens). If impervious areas are adequately disconnected, they can be deducted from total site area when computing the WQv 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 (i.e. the receiving area has the appropriate soils, surface area, length and slope to filer and/or infiltrate the calculated runoff volume for the water quality event), they can be deducted from total site area when computing the water quality volume requirements.*

Criteria:

- Relatively permeable soils (hydrologic soil groups A and B) must be present
- Runoff shall not come from a designated hotspot
- The maximum contributing impervious flow path length shall be 75 feet
- Downspouts shall be 10+ feet away from 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 imperviousness area to a discharge location is 5,000 square feet or less.
- If draining directly to a buffer the stream buffer credit cannot also be used
- R_V is kept constant when calculating WQ_V

Example: Site Area = 3.0
Impervious Area = 1.9 acres (or 63.3% impervious cover)
"Disconnected" Impervious Area = 0.5 acres

$R_V = 0.05 + 0.009\,(I) = 0.05 + 0.009\,(63.3\%) = 0.62$

Credit:

0.5 acres of surface imperviousness hydrologically disconnected
New drainage area = 3 – 0.5 = 2.5 acres

Before credit:
$WQ_V = (1.2)(0.62)(3)/12 = 0.19$ ac-ft
With credit:
$WQ_V = (1.2)(0.62)(2.5)/12 = 0.15$ ac-ft

(21% reduction in water quality volume)

4.2 User Fee Crediting Options

The Unified Sizing Criteria (USC) method is hydrology-based, using imperviousness as the key factor in determining the WQ_V and associated stormwater burden on the City. The User Fee is the City's primary funding mechanism for managing stormwater quality associated with impervious areas. Mitigating stormwater quality impacts through the use of Better Site Design and Best Management Practices can reduce the burden on the City and will be rewarded by a reduction in the User Fee, where applicable. To calculate the User Fee Credit for Water Quality Volume Reduction, use the following method:

1. Calculate the WQ_V that is addressed by the site, based on the USC Methodology.
2. Convert the WQ_V to an area by dividing the WQ_V by the water quality rainfall depth of 1.2 inches. This is the area of which water quality impacts will be fully mitigated (by infiltration and/or filtration) - this will be referred to as the WQ_V Impervious Reduction (IR).
3. Identify the amount of physical imperviousness that the site contains, which the User Fee would be based on – this will be referred to as the Impervious Area (IA).
4. Compare the IR and IA values, and generate a % Reduction that is applied to the fee (i.e. IR/IA = % Reduction). The % Reduction should be rounded to the nearest whole number. User fee crediting will be capped at a maximum % Reduction of 30%.
5. Multiply the % Reduction by the User Fee (based on Impervious Area) to calculate the final amount of the User Fee.

Chapter 5 – Additional BMP Requirements

5.1 Water Surface Dewatering

When discharging stormwater from temporary sediment basins, sediment ponds, or other similar impoundments, utilize outlet structures that only withdraw water from near the surface of the basin or impoundment, unless infeasible. The outlet structure should be capable of conveying the flow of the 10-year, 24-hour storm event.

Typically referred to as "skimmers," water surface dewatering devices are designed to improve sediment trapping efficiency by regulating the filling and draining of a stormwater basin or pond. Since these devices float on the water surface, the skimmer orifice has a constant head that allows the basin to drain slowly at a constant rate from the water surface, where sediment concentrations are typically lowest.

Sediment basins and sediment ponds must be designed to consider the specific site conditions, including soil types, drainage area, sediment generated, rainfall, runoff, and potential risk for downstream impacts. When designing a sediment basin or sediment pond, the engineer should provide appropriate supporting calculations for the skimmer. Several manufacturers of these devices offer design guidance, construction details and specifications.

Appendices

A. Design Aids
- Calculation Worksheets
  - -Volume Calculation Tool
  - -BMP Sizing Tools for:
    - Bioretention
    - Infiltration Trench
    - Dry Enhanced Swale
    - Grass Filter Strip
    - Porous Surfaces
- Standard CAD Details and Notes/Specs
  - Bioretention
  - Infiltration Trench
  - Dry Enhanced Swale
  - Grass Filter Strip
  - Micropool Extended Dry Detention Pond
  - Wet Detention Pond

B. Maintenance Schedules

C. Flood Area Map

Appendix C: Flood Area Map

FEMA_COC
areas.pdf

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or floodways have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations (BFEs) shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by flood control structures. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The projection used in the preparation of this map was Lambert Conformal Conic State Plane South Carolina FIPS 3900. The horizontal datum was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for bench marks shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242 or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided in digital format by Richland County, South Carolina.

This map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information and questions about this map, available products associated with this FIRM including historic versions of this FIRM, how to order products or the National Flood Insurance Program in general, please call the FEMA Mapping Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Map Service website at http://www.msc.fema.gov/. Available products may include previously issued Letters of Map Change, a Flood Insurance Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website. Users may determine the current map date for each FIRM panel by visiting the FEMA Map Service Center website or by calling the FEMA Map Information eXchange.

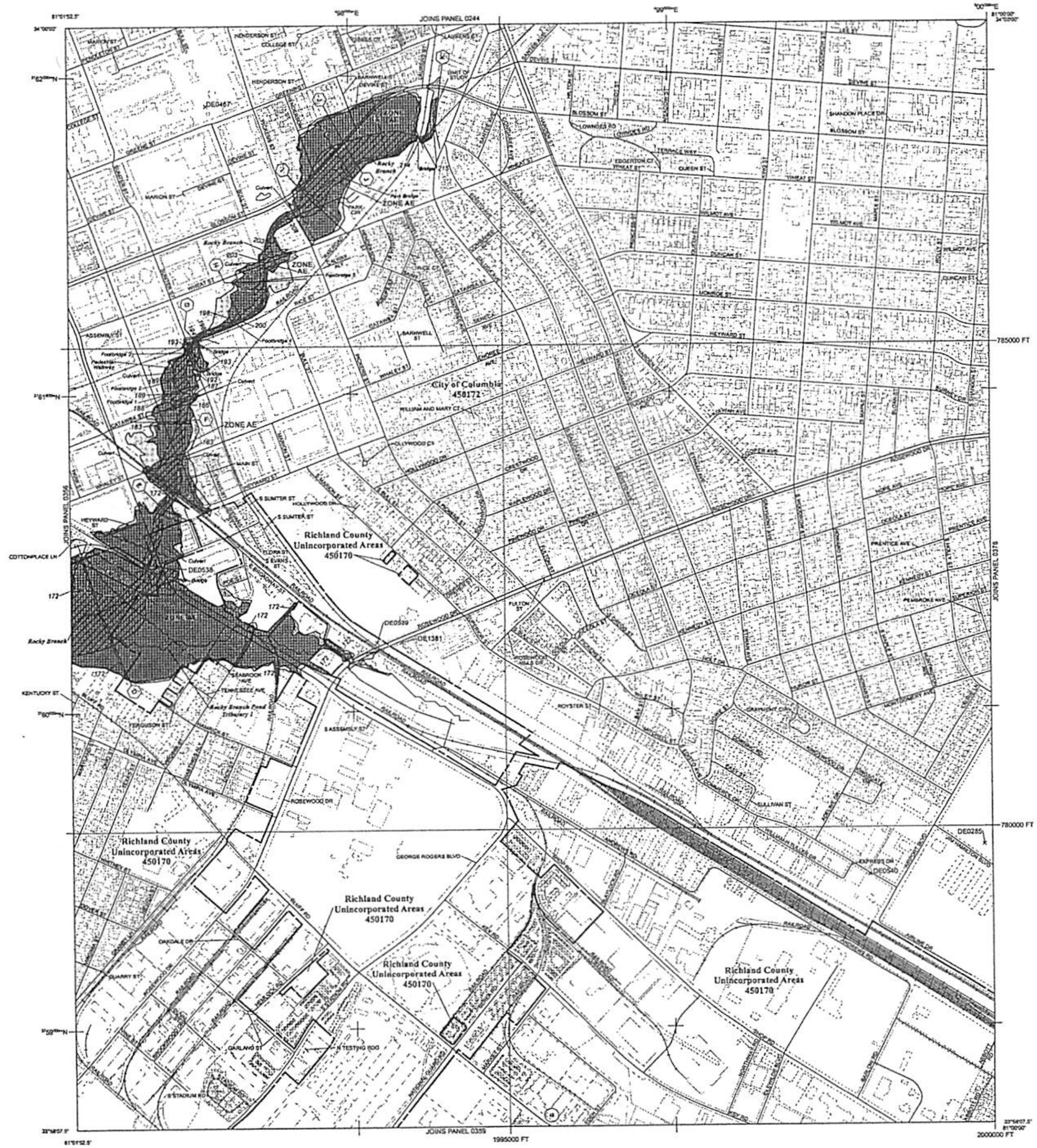
The profile base lines depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the profile base line, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

DNR

This digital Flood Insurance Rate Map (FIRM) was produced through a unique cooperative partnership between the State of South Carolina and the Federal Emergency Management Agency (FEMA). The State of South Carolina has implemented a long term approach of floodplain management to decrease the costs associated with flooding. This is demonstrated by the State's commitment to map floodplain areas at the local level. As a part of this effort, the state of South Carolina has joined in a Cooperating Technical State agreement with FEMA to produce and maintain this digital FIRM.

http://www.dnr.state.sc.us/

APPENDIX C FLOOD AREA MAP



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Areas to be protected from 1% annual chance flood event by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

Floodplain boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities
~~~ 513 ~~~ Base Flood Elevation line and value; elevation in feet*
(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*
* Referenced to the North American Vertical Datum of 1988
(A)—(A) Cross section line
(23)- - -(23) Transect line
97°07'30", 32°22'30" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
4275000mE 1000-meter Universal Transverse Mercator grid ticks, zone 17
6000000 FT 5000-foot grid values: South Carolina State Plane coordinate system (FIPSZONE = 3900), Lambert projection
DX5510 x Bench mark (see explanation in Notes to Users section of this FIRM panel)

MAP REPOSITORIES
Refer to Map Repositories List on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
January 19, 1994

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
February 20, 2002
September 29, 2010

December 21, 2017 - to update corporate limits, to change Base Flood Elevations, to add Base Flood Elevations, to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, to update map format, to add roads and road names, to reflect updated topographic information, and to incorporate previously issued Letters of Map Revision

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 250 500 750 1,000 FEET
150 0 150 300 METERS

NFIP — NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0357L

FIRM
FLOOD INSURANCE RATE MAP
RICHLAND COUNTY, SOUTH CAROLINA
AND INCORPORATED AREAS

PANEL 357 OF 650
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
COLUMBIA, CITY OF	450172	0357	L
RICHLAND COUNTY	450170	0357	L

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.

MAP NUMBER
45079C0357L

MAP REVISED
DECEMBER 21, 2017

Federal Emergency Management Agency
~~~

EXHIBIT B-3

Rocky Branch and Rocky Branch Watershed Improvements

The Buyer, its successors and assigns, shall make necessary improvements to the Bluff Road railroad embankment, remove the railroad trestle downstream of Olympia Avenue and enlarge the Olympia Avenue culvert crossing to enhance water quality and improve flooding conditions in the area to a degree that is acceptable to the Buyer, Seller, and County and as recommended in the Urban Study of the Rocky Branch Watershed by AMEC Environmental & Infrastructure, Inc. dated June 1, 2012, a copy of which is attached as Exhibit B-4 hereto and incorporated herein by specific reference thereto and as set forth in the motion approved by Columbia City Council on June 5, 2012, a copy of which is attached hereto as Exhibit ## and incorporated herein by specific reference thereto.

Buyer, Seller, and the County shall work together to create the optimum flooding, drainage, and water quality situation from Assembly street to the Congaree River. In addition to the three improvements specifically set forth in the previous paragraph, the Buyer shall facilitate and pay for all surveying, plans, permitting, and design of the improvements. In addition, the Buyer shall use its best efforts to perform any mitigation required by DHEC or the Army Corp of Engineers, for the Buyer's relocation of the onsite stream, within Rocky Branch.

EXHIBIT B-4

Urban Study
Rocky Branch Watershed

Urban Study

EXHIBIT B-4

Rocky Branch Watershed
Columbia, South Carolina

Prepared for:
City of Columbia
1136 Washington Street
Columbia, SC 29217

Prepared by:
AMEC Environment & Infrastructure, Inc.
720 Gracern Road
Columbia, SC 29210
(803) 798-1200

June 1, 2012

Project No. 6250-12-0007

Table of Contents

FIGURES

Executive Summary

The purpose of this study is to examine the Assembly Street site with respect to the proposed commercial development to determine the potential impacts that the development could have on the adjacent Rocky Branch. Rocky Branch currently has significant flooding and water quality problems and the effects of developing a large property adjacent to the stream must be studied to determine the potential impacts. When proposed project improvements potentially encroach on a regulatory floodway, the City of Columbia requires a demonstration that these improvements will not raise (ie, no rise) the off-site base flood elevations (BFE) along the waterway. The base flood elevation is defined as the 1% annual chance flood which means it has a one percent chance of occurrence in any given year, also referred to as the 100-year flood.

In addition to modeling the potential hydrologic and hydraulic impacts of the proposed commercial development, other scenarios were examined to identify opportunities to address flooding and water quality problems within Rocky Branch. The study results indicate that the proposed development of the project site could be implemented without significant impacts to the Rocky Branch watershed. Furthermore, immediate opportunities exist to alleviate localized flooding and water quality problems, and long term opportunities exist to develop a comprehensive plan for improving flooding and water quality problems throughout the watershed.

1. Introduction

The City of Columbia contracted AMEC Environment and Infrastructure, Inc. (AMEC) to conduct a study of the urban development impact to the Rocky Branch waterway and drainage basin as a result of the proposed development at 301 Assembly Street, Columbia, SC (project site). The goal of this assignment was to assess the potential hydrologic, hydraulic and water quality impact that the proposed development at the project site could have on the waterway and drainage basin.

1.2 Project Description

Rocky Branch is an urban stream that runs through downtown Columbia, approximately four miles in length, beginning in the Martin Luther King Park area. Rocky Branch flows through and under the Five Points area, through the University of South Carolina campus (USC), past the proposed development just south of Assembly Street, into the Olympia neighbourhood and eventually into the Congaree River. While the majority of Rocky Branch is a channelized urban stream with limited floodplain access, portions of the stream are piped under the Five Points area.

The project site located at 301 Assembly Street is currently a baseball park owned in part by the City of Columbia. The proposed development of the site would likely include the construction of a shopping center with approximately 186,000 square feet of retail stores and approximately 400,000 square feet of parking and other impervious surfaces. The site lies to the southeast of Rocky Branch near the intersection of Assembly Street and Ferguson Street. According to the latest Flood Insurance Rate Map (FIRM) for Richland County dated February 20, 2002, the proposed development would be located within the floodplain. However, the site is not shown to be encroaching in to the regulatory floodway, based on the information available to AMEC. FEMA is currently in the process of revising the floodplain map, which is scheduled to be completed by the end of 2012.

1.2.1 Available data and models

A complete list of the numerous documents reviewed for this study is included in the Appendix.

Among these documents, the Conceptual Site Plan by Freeland and Kauffman, dated 12/14/11, was used to model the proposed site development as directed by the City of Columbia. AMEC also evaluated the following available models:

- Rocky Branch FEMA Flood Insurance Study (FIS), which was conducted in the late 1970s, available as a PDF printout of a HEC-2 model.
- Parson Brinckerhoff (PB) HEC-RAS models showing 5 different scenarios/alternatives of potential modifications to Rocky Branch.
- Pace Engineering study which appears to be based on a HEC-2 model.

AMEC also obtained recent LiDAR data from the U.S. Geological Survey (USGS).

1.3 Regulatory Floodplain Mapping

The current effective regulatory information for Rocky Branch Watershed is outlined in the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Richland County, South Carolina And Incorporated Areas. This published FIS data consists of:

- Flood Insurance Rate Map (FIRM): Panel 94 of 275. Map Number: 45079C0094 H (Dated February 20, 2002).
- FIS Report (Volume 1 and 2): Dated September 29, 2010.

The FIS report (Volume 1) lists the Summary of Discharges for Rocky Branch as outlined in Table 1 below:

Table 1: Effective Summary of Discharges (Source: FEMA FIS Report)

	Drainage Areas (Square Miles)	Peak Discharges (cfs)			
		10-year	50-year	100-year	500-year
At Mouth	3.7	2,210	3,190	3,550	4,780
At Southern Railway	2.9	2,110	3,020	3,360	4,430

The dates listed in the published FIS are indicative of updates to adjacent watersheds and flooding sources in Richland County and its Incorporated Areas. However, the FIS did not indicate that Rocky Branch was re-studied, which explains why the effective Hydrologic and Hydraulic (H&H) study for Rocky Branch watershed traces back to the first effective FIS for the City of Columbia (September 1, 1983). In this first FIS, the hydraulic analyses were conducted in detail using U.S. Corp of engineers (HEC-2) software (Updated release August, 1977) which uses step-backwater method of calculation. HEC-2 is the predecessor of the HEC-RAS hydraulic model which is currently approved and preferred for use in most riverine hydraulic analyses submitted to FEMA.

AMEC obtained a scanned PDF copy of HEC-2 model for Rocky Branch (Run executed on July 17, 1979) and verified that the flows used in the HEC-2 model are consistent with the ones in the current FIS Report listed in Table 1 above. Therefore, the flows listed in Table 1 above were computed in the late 1970s and are the only FEMA regulated flows in the Rocky Branch Drainage Basin.

The current FIS Report mentions that the computed Special Flood Hazard Areas (SFHAs) were re-delineated for streams that were not re-studied (i.e., Rocky Branch). Consequently this means the FIRM map (dated February 20, 2002) already has the needed datum conversions (from NGVD29 to NAVD88) and also has the proper re-mapping of the SFHAs using up-to-date topographic information (at the time of production). This is consistent with FEMA's practice of updating old models and maps to reference the elevations from the old National Geodetic Vertical Datum (NGVD 29) to the North American Vertical Datum (NAVD 88). This type of update does not included any updated underwater channel topographical survey nor does it include any update to the previously computed peak flood flows which are expected to increase due to urbanization.

The SFHAs are defined as the area that will be inundated by the flood event having a 1-percent chance of being equalled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood.

The proposed project area is within the FIRM SFHA. Attachment-A illustrates portions of the FIRM (FIRMettes) for this reach of Rocky Branch. Downstream of Assembly Street, the regulated computed Base Flood Elevation (BFE) from the HEC-2 model output (FIS profile Panel Number 120P) is 172.3 feet above mean sea level based on the NAVD88 datum while the mapped BFE (rounded) in the FIRM at the proposed development site is 173.0 feet (NAVD88).

1.4 Hydrology

As mentioned above, the effective flows (Table-1) used in the current FIS were based on late 1970s conditions of the Rocky Branch watershed. The Rocky Branch watershed has been subjected to many significant changes (i.e., landcover, landuse, grading, development...etc.) through the years. Therefore, the original flows needed to be updated to reflect the effective imperviousness of the watershed, which has increased. This section details the updates that were made to the flows by other parties, and the extent to which AMEC used that information for the goals of this project.

PB Americas, Inc. in conjunction with MA Engineering Consultants, Inc. was contracted by the City of Columbia to perform updated hydrologic and hydraulic studies of the Rocky Branch Watershed. This updated analysis was finalized in models and a report submitted to the City in October 2007. In this report, we refer to this updated analysis as the PB Study.

The PB Study based its analysis on comprehensive work conducted by the US Army Corps of Engineers (USACE), Charleston District in 2000. In this report, we refer to this work done by the USACE as the USACE Study.

The USACE constructed a comprehensive new hydrologic model of Rocky Branch Watershed using the USACE Hydrologic Engineering Center's Hydrologic Modelling System (HEC-HMS) model. The USACE HEC-HMS model was based on the existing conditions of the watershed which would have been the late 1990s. Due to land development and changes in Rocky Branch Watershed, PB Americas, Inc. updated the USACE HEC-HMS model while maintaining its original model configuration (See Figure-1). After comparing the USACE and PB Studies, only minor changes were noted to the overall drainage area (i.e. 0.008 square-mile difference) and no significant changes to the USACE flows were made).

AMEC performed cursory reviews of the PB Study and inspected its schematic components, connectivity, data input and executions. After inspecting the entire watershed with the most current aerial imagery (using Microsoft Bing), no changes were noted and there was no need to change the PB Study. However, AMEC updated the PB Study which was based on version 3.1.0 of HEC-HMS (Released November 2006) to version 3.5 which is the most recent available release (August 2010). Comparing the results of the two HEC-HMS versions (3.1.0 and 3.5), no differences were noted in the computed flows. Therefore, AMEC used the flows from the PB Study to analyze the current existing conditions of the Watershed.

Figure 1: HMS Schematic of Rocky Branch Watershed

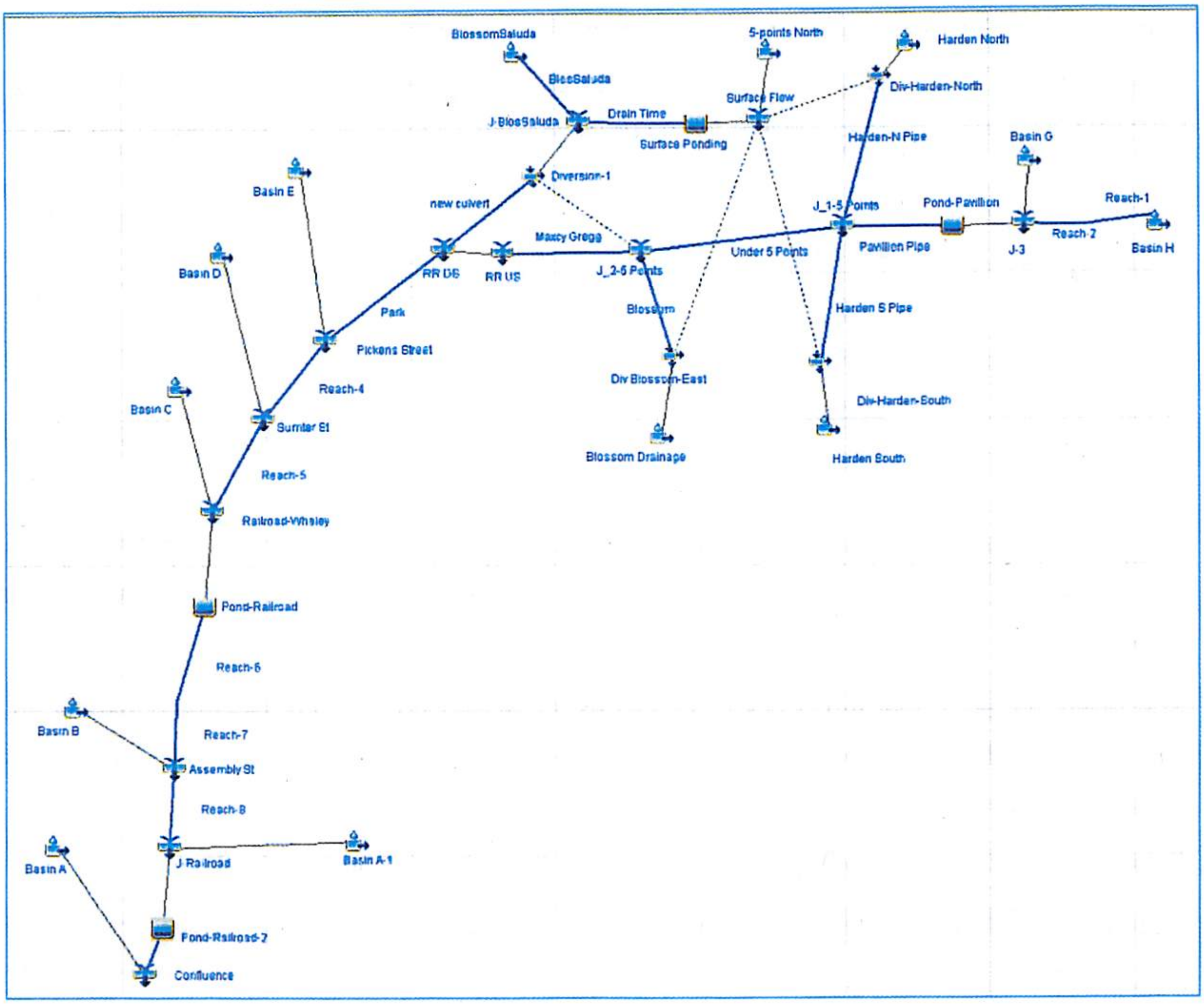


Table 2 below shows the existing peak discharges within the study reach as taken from the PB Study (2, 5, 10, 25, 50 and 100-year return interval floods which have a 50%, 20%, 10%, 4%, 2% and 1% annual chance of occurrence in any given year, respectively). The peak flows for the 1-year event were added by AMEC while analyzing the watershed response to other storm frequencies:

Table 2: Peak Flow Discharges of the Current Existing Conditions

HMS Location	1-year	2-year	5-year	10-year	25-year	50-year	100-year
Sumter Street	1,045	1,436	2,014	2,442	2,982	3,469	3,964
Assembly Street	1,218	1,653	2,320	2,843	3,503	4,062	4,621
J-Railroad (Railroad D/S of Bluff Rd)	1,241	1,700	2,417	2,972	3,692	4,305	4,927
Confluence with Congaree River	1,329	1,842	2,616	3,117	3,668	4,053	4,425

The rainfall events (2, 5, 10, 25, 50 and 100-year) in the PB Study are from the Richland County Climate Report (No. G32). In this Climate Report, the frequency of the 1-year rainfall event is not included.

The newly added 1-year frequency of rainfall event was taken from the National Oceanic and Atmospheric Administration (NOAA) using Atlas 14, Volume 2 and Version 3. The data is listed in Table 3 below:

Table 3: Precipitation Frequency Estimate for 1-year Event (90% Annual Chance)

Duration	5-min	15-min	1-hr	2-hr	3-hr	6-hr	12-hr	24-hr
Depth (Inch)	0.451	0.90	1.54	1.77	1.86	2.21	2.58	3.0

1.5 Hydraulic Modeling

Two kinds of technical evaluations are used for proposed development in a floodplain. All proposed floodplain development must meet the "no adverse effect" criteria, while proposed floodway development must also meet the "no-rise" criteria. For streams with detailed studies

(FEMA AE-zones) and established BFEs, the 100-year floodplain has been divided into two zones: the floodway and the floodway fringe. The floodway is that area that must be kept open to convey flood waters downstream. The floodway fringe is that area that can be developed in accordance with FEMA standards as adopted by local ordinances. Based on the information that AMEC was able to attain, the proposed filling of the development site appears to be located outside the floodway boundary of the regulated floodplain (Attachment-A: FIRMettes).

Effective Model

As mentioned earlier, the effective hydraulic model of Rocky Branch Watershed was developed in the late 1970s using the USACE HEC-2 Computer Software. A copy of the PDF printout of this model (input and output data) is included for the multiple and floodway runs (See Attachment B). The current FIS (Map and Report) for the study area uses the elevations generated from this model after converting the datum to NAVD88. The peak discharges in this model were listed in Table-1 above. The elevations based on the NAVD88 datum were computed by lowering the NGVD29 elevations by 0.8 feet (See Section 3.3 in the FIS Report Vertical Datum).

The model output printout as provided in Attachment B (See also FIS profile 119P-120P) shows that the BFE downstream of Assembly Street is approximately 172.3 feet (NAVD88) and remains almost the same (for approximately 1,500 feet) until the reach downstream of the Bluff Road railroad embankment located just downstream of Bluff Road.

Duplicate Effective Model

The effective model (HEC-2) was reproduced (with the same data and flows) using the latest U.S. Army Corps of Engineers (HEC-RAS) software, version 4.1.0. This new HEC-RAS model is referred to as the Duplicate Effective Model. Comparisons of output data between the Effective Model (i.e. original FIS published results) and Duplicate Effective Model show changes in flood elevations (increase of 1.7 feet). These changes are attributed to computational differences between succeeding versions of the model software, such as: method of conveyance calculations, critical depth default, differences in bridge/culvert modeling routines, and many other updates to computational algorithms.

The HEC-RAS User's Manual and the HEC-RAS Hydraulics Reference Manual provide details on computational differences between the HEC-2 and HEC-RAS and guidance on simulating HEC-2 results; such manuals should be consulted to explain the differences between the Effective and Duplicate Effective Models. The HEC-RAS software and manuals can be downloaded from the internet at: (*http://www.hec.usace.army.mil/*). Another useful reference is FEMA's "HEC-RAS Procedures for HEC-2 Modelers," dated April 2002. This publication can be downloaded from FEMA website at: (*http://www.fema.gov/fhm/dl_fpmm.shtm*).

The original Duplicate Effective Model was constructed by Pace Engineering. The digital model and output printout as provided in Attachment C shows that the BFE downstream of Assembly Street (Section 67.8) is approximately 174.0 feet (NAVD88) and remains almost the same (for approximately 1,500 feet) until downstream of the railroad embankment downstream of Bluff Road.

Existing Condition Model:

The existing HEC-RAS model for Rocky Branch Watershed was developed by USACE (along with their HMS model) and updated by PB Americas, Inc. using HEC-RAS (3.1.3). The PB Study Report (October, 2007) explained the modifications made to the USACE model.

AMEC performed cursory reviews of PB Study and inspected its schematic components, applied flows, data input and executions. After inspecting the overall model, no changes to the PB model were needed as the model reasonably represents the condition of the stream. However, AMEC updated the PB Study from version 3.1.3 of HEC-RAS (Released May 2005) to version 4.1 which is the most recent available release (January 2010).

After comparing the results of the two HEC-RAS versions (3.1.3 and 4.1), negligible differences were noted in the computed elevations within the Study Reach. The new run of HEC-RAS based on Version 4.1 has, in general, had higher elevations comparing to the older release of

HEC-RAS (See Attachment D for a complete table). Table 4 below highlights the differences in BFEs, within the Study Reach, which were limited to +/- 0.01 feet.

Table 4: Difference in computed BFE based on the new release of HEC-RAS

Physical Location	HEC-RAS Stations	100-year Elevations in Feet (NAVD 88)		Difference in Elevations (ft)
		Version 3.1.3	Version 4.1	
Southern Railroad Bridge (Upstream)	6,376	175.39	175.4	-0.01
Southern Railroad Bridge (Downstream)	6,354	175.26	175.26	0
	6,250	175.3	175.31	-0.01
Dreyfuss Street (Upstream)	6,162	175.3	175.31	-0.01
Dreyfuss Street (Downstream)	6,112	175.3	175.3	0
	5,721	175.3	175.3	0
Bluff Road (Upstream)	5,231	175.3	175.3	0
Bluff Road (Downstream)	5,181	175.29	175.29	0
Southern Railroad Culvert (Upstream)	5,166	174.63	174.63	0
Southern Railroad Culvert (Downstream)	4,986	152.13	152.12	+0.01

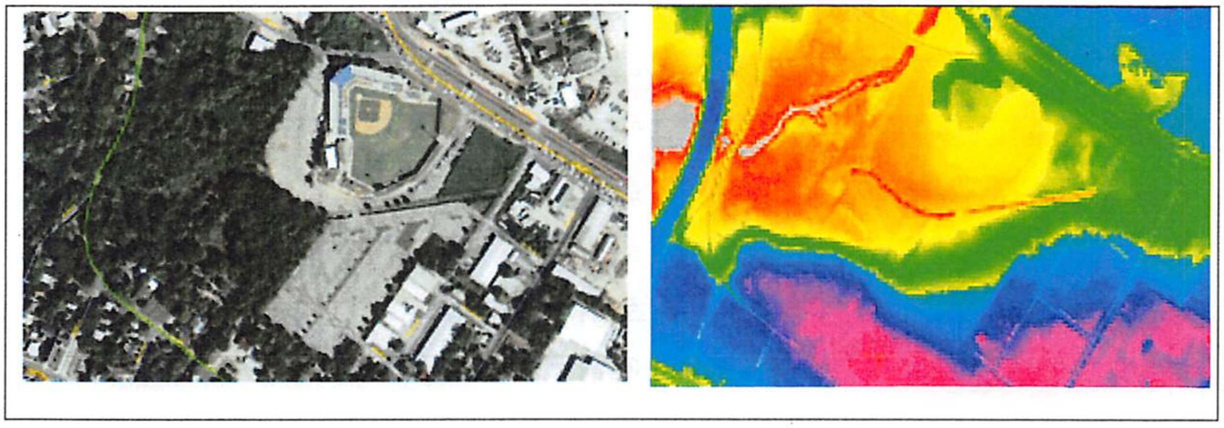
This existing model (version 4.1) is considered the Corrected Effective Model, since it reflects the updated flow conditions and/or undocumented, man-made changes that have occurred within the floodplain since the effective study was adopted. The model is also considered to be the Pre-Project Conditions and was used to analyze the impact of the proposed site on the floodplain. The BFE downstream of Assembly Street is approximately 175.3 feet (NAVD88), which is approximately 1.3 feet higher than the BFE in the duplicate effective model.

Post-Project Model:

The Pre-Project Condition Model was revised to reflect Post-Project Conditions (Proposed Model). The proposed model incorporates physical changes to the floodplain and terrain as a result of constructing the project. The proposed project would include a grading change that will place fill in the floodplain area, above the current floodplain elevation.

AMEC obtained recent LiDAR data and high resolution Digital Elevation Model (DEM) covering the entire Rocky Branch Watershed from the USGS.

Figure 2: Location of the proposed site with the ground DEM



This ground DEM was modified to show the proposed grading and wall with a top elevation of 185 feet. The pre-project condition model was based on surveyed structures and channel data. The left overbank of cross section 5721, located at 416 feet downstream of Dreyfuss Street, is affected by the proposed development and hence changing its overbank geometry generated the post-project model (See Attachment E). Table 5 below compares base flood elevations (BFE) for the pre-project model and post-project model. The base flood (100-year) is the only profile that was used for mapping the floodplain.

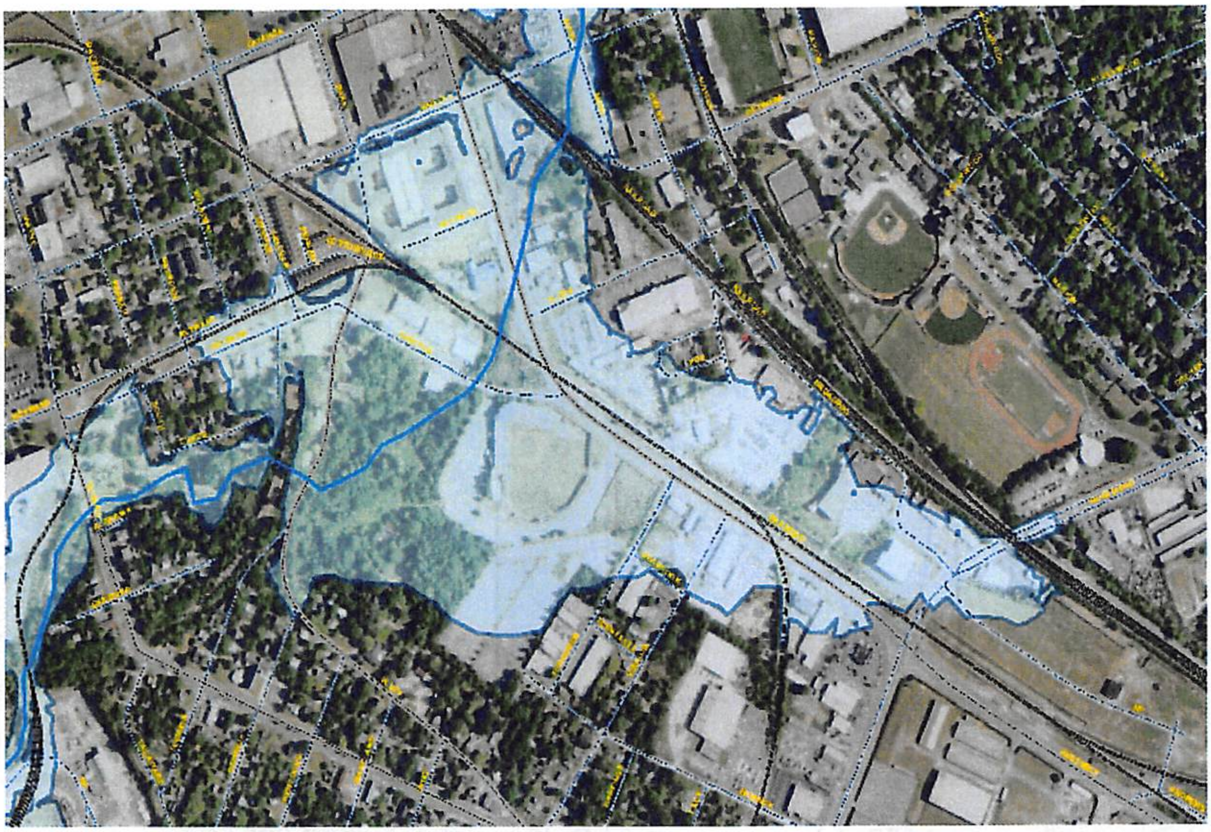
After analyzing the results of pre-project versus post-project conditions, it was shown that the BFEs are not changed, when rounded to tenths of a foot, and very insignificant changes were seen when rounded to hundredths of a foot. FEMA FIS Reports show only water surface elevations rounded to a tenth of a foot to display models' results. The results show that developing the site with this proposed plan is not expected to have an adverse effect on the BFE and SFHA.

Table 5: Computed Base Flood Elevations, before and after the proposed project

Physical Location	HEC-RAS Stations	Base Flood Elevation (BFE)	
		Pre-Project Model	Post-Project Model
Southern Railroad Bridge (Upstream)	6,376	175.4	175.4
Southern Railroad Bridge (Downstream)	6,354	175.26	175.27
	6,250	175.31	175.32
Dreyfuss Street (Upstream)	6,162	175.31	175.32
Dreyfuss Street (Downstream)	6,112	175.3	175.3
	5,721	175.3	175.3
Bluff Road (Upstream)	5,231	175.3	175.3
Bluff Road (Downstream)	5,181	175.29	175.29
Southern Railroad Culvert (Upstream)	5,166	174.63	174.63
Southern Railroad Culvert (Downstream)	4,986	152.12	152.12

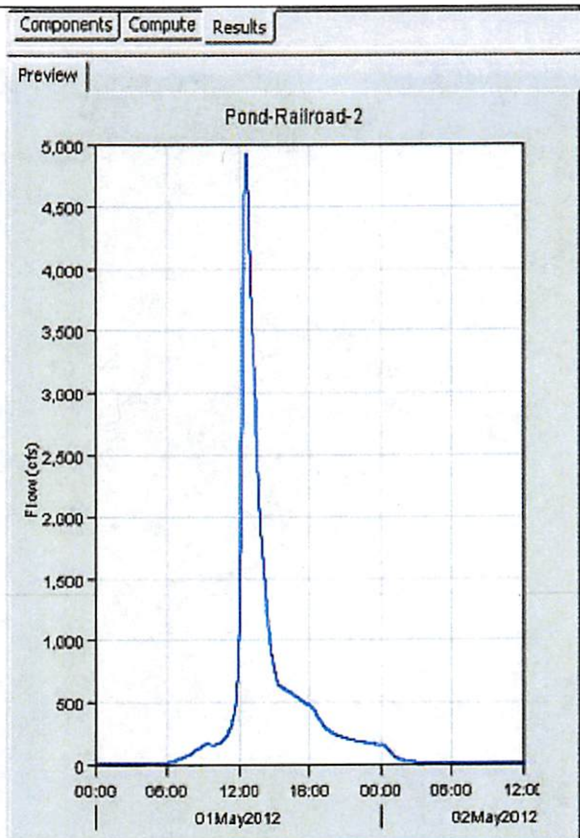
The entire proposed project is located in the backwater (ineffective flow areas) outside the effective conveyance portion of the stream. Fill in such a backwater area is not expected to impact the BFE.

Figure 3: Existing Floodplain (SFHA)

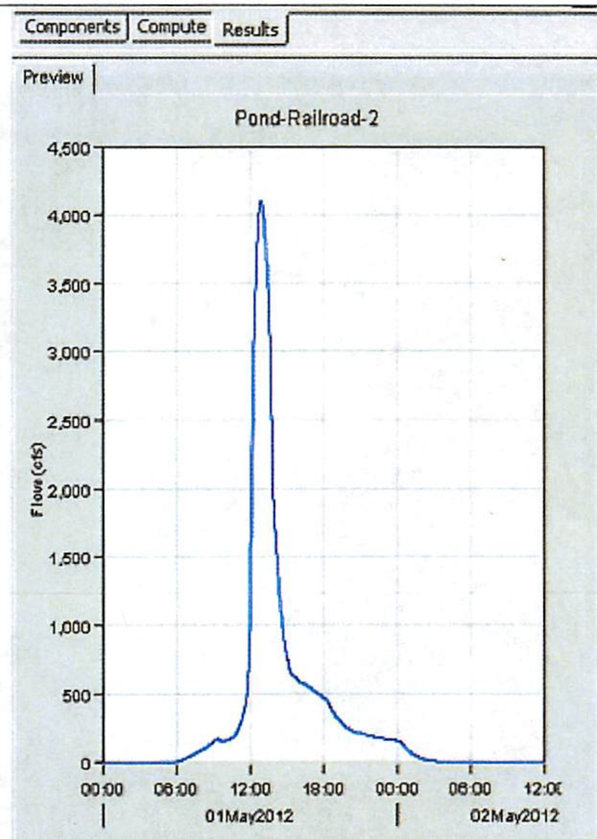


Upon inspecting the base profile (100-year) in the existing HEC-RAS model (or even the profile Panels 119-120P), it can be seen that the BFE is being controlled by the high embankment areas at the railroad culvert just downstream of Bluff Road. This embankment is affecting flooding conditions upstream and at the location of the proposed site development, and behaves as an in-line pond with the ability to lower (attenuate) the exiting flows. Figure 4 shows the hydrologic hydrographs upstream and downstream of this confining railroad culvert. Those hydrographs show the relationship of stream flow to the start of storm runoff.

Figure 4: Hydrographs of the Base Flood at Southern Railroad Culvert



Inflow (100-year = 4,927 cfs)



Outflow (100-year = 4,096 cfs)

Therefore, it will be important to use these attenuated flows for cross-sections downstream of the Bluff Road railway embankment to get a proper assessment of the impacts from proposed alterations to that crossing. The following section (Results) will focus on and provide the details regarding alternative design analyses which include reducing flood stages for the Assembly Street site, hydrologic impacts to downstream areas, and the potential mitigating measures that could be taken.

2. Results and Conclusions

The results of AMEC's analyses are provided below, in the form of responses to the primary questions asked by the City. Tables and figures have been provided to show and compare the critical information from the modeling analyses. The full modeling results can be found in the Appendix.

How did the AMEC analyses compare with past studies?

AMEC was able to leverage the work performed in previous studies by PACE Engineering (2011) and PB Americas, Inc. (2007), which was collected by AMEC in the initial data collection steps of the project. AMEC's review of that available modeling information resulted in the following conclusions:

- PACE Engineering used the effective FEMA model, which was in the HEC-2 format and used the original Flood Insurance Study flows which did not reflect recent increases in urbanization. This was a reasonable first step to take by PACE Engineering, considering that this was an early assessment of floodplain behavior.
- PB Americas Inc. developed a new hydraulic model that was updated to reflect more recent watershed conditions (2006) including updated flows, which were developed with a widely accepted hydrologic model called HEC-HMS. The new hydraulic model (HEC-RAS), with its updated and higher flows, predicted flood stages that were higher than those predicted in the PACE Engineering model.
- A detailed review of the PB Americas Inc. HEC-RAS model determined that those cross-sections needed to be extended laterally to properly model flows for the highest flood stages. Therefore, AMEC used existing topographical data to extend the HEC-RAS

model cross-sections. This resulted in the prediction of similar stages as compared to the PB Americas model, but the AMEC hydraulic model shows wider and more accurate floodplain widths (See Map 1). The AMEC HEC-RAS model floodplain limits were similar than those in the effective FIRM, as can be seen in Map 2.

- The PB Study did model crossings causing large backwater conditions, such as the Bluff Road railway embankment, as dams and lakes in the HEC-HMS model. Doing so incorporates the effects of in-stream storage which can result in lower (attenuated) flows to downstream areas. The PB Study did not include attenuated flows in the HEC-RAS model, and instead chose to use conservatively higher unattenuated flows for the reach downstream of the Bluff Road railway embankment. That decision is common practice for studies that are focused on the hydraulic performance of a stream. However, AMEC did use hydrologic routing through these pond areas, which is discussed later in this section.
- Questions about the potential adverse downstream and upstream effects of the proposed fill to the project site, as well as the potential benefits of various stream crossing modifications, will be addressed later in this report.

In summary, AMEC found the previous studies by PACE Engineering and PB Americas, Inc. to be reasonable for their purposes, but the following changes were required by AMEC to address the goals of this project:

- Use the HEC-RAS model geometry from the PB Study, with extended cross-sections added by AMEC
- Use the updated flows from the HEC-HMS model developed in the PB Study, but change the flows downstream of the Bluff Road railway embankment to reflect the attenuated flows from the in-stream storage.

Would the proposed fill from the site cause a rise to the floodplain due to loss of conveyance?

AMEC used the available site design concept plan to modify the AMEC baseline HEC-RAS model. As can be seen in Map 3, the site limits lie in the backwater area, created by the severely undersized culvert through the railway embankment downstream of Bluff Road. This backwater area has a lesser conveyance capacity and is sometimes referred to as a "dead-water area". Therefore, when modeled, the stream's conveyance capacity was not shown to be affected by the proposed fill in this portion of the floodplain. It was determined that the proposed site development concept could likely be implemented without a rise in upstream water surfaces. Figure 1 provides a comparison of the flood stages at the site, which also depicts the proposed fill that was simulated in AMEC's HEC-RAS model.

It should be noted that AMEC's interpretation of the limits of fill may be different from a final design, and these rise calculations should be revised upon completion of final design. However, any such rises, if they occur, could likely be mitigated with downstream capacity increases, which are discussed later in this section. It should also be pointed out that the risk of negative impacts from the proposed site fill (i.e storage volume that would be lost) was also considered. This issue is addressed later in this section also.

Would the fill reduce the storage volume of the floodplain and cause adverse impacts?

To address this question, AMEC validated the PB Study HEC-HMS model, which included a storage node for the Bluff Road railway embankment. That model resulted in reduced outflows from the railway culvert to the lower reach of Rocky Branch Creek (Olympia Avenue to the Congaree River). AMEC computed an independent in-stream storage estimate using available topographic data in the form of a Digital Elevation Model (DEM). As a result, AMEC's estimates of the available in-stream storage behind the Bluff Road railway embankment were higher than those used in the PB Study model. The increase in available storage is considered to be the result of a more accurate DEM than what was available to PB Americas, Inc. Additionally, AMEC calculated the estimated proposed fill volume based on the conceptual site design. A comparison of those storage volumes is provided in Table 6.

Table 6 – Comparison of Floodplain Storage (for Elev 170)

Source	Storage (ac-ft)
PB Americas, Inc.	179.2
AMEC	328.7
Added Site Fill	241.0

When the HEC-HMS model was modified to include the greater in-stream storage capacity found to exist behind the Buff Road railway embankment, the peak flows predicted to be exiting the Bluff Road railway culvert did not significantly differ from what was predicted in 2006 by PB Americas Inc. The peaks flows that were used in the hydraulic models by AMEC for the railway embankment ponding (inflows) and areas immediately downstream (outflows) are provided in Table 7. The results in Table 7 indicate that there is a potential for lower flood stages, as compare to the PB Study, downstream of the Bluff Road railway embankment for flood events greater than the 10-year event. This could lead to impacts from proposed downstream improvements (i.e. the Bluff Road RR upgrade/removal), intended to reduce upstream flooding. This topic will be discussed later in this section.

AMEC also computed the potential loss of in-stream storage capacity in the ponding near the development site due to the proposed fill (see Table 6). That reduction in volume had no impacts on the outflow from the Bluff Road railway culvert. Therefore, AMEC determined that the proposed fill on the development site would not be expected to have an impact on downstream flows due to that change to the hydrologic routing of the stream.

Table 7 – Bluff Road Railway Culvert Flows

Storm Event	2-year	5-year	10-year	25-year	50-year	100-year
Inflow (cfs)	1,700	2,417	2,972	3,692	4,305	4,927
Outflow (cfs)	1,697	2,396	2,846	3,357	3,732	4,096
Change (cfs)	-3.8	-20.8	-126	-335.6	-572.7	-831.8
% Change	-0.2%	-0.9%	-4.2%	-9.1%	-13.3%	-16.9%

Can improving the downstream crossings move flooding downstream?

As noted earlier in this section, there is the potential to move flooding (adjacent to the site) to a downstream location by increasing the capacity of downstream stream crossings. Specifically, there was concern that the attenuated culvert outflow rates from the Bluff Road railway culvert could be increased if that crossing was hydraulically improved. Therefore, AMEC further modified the baseline HEC-RAS model to assign the attenuated flows in Table 7 to the stream reach downstream of the Bluff Road railway. The results of that modeling can be seen in Profiles 2 through 4, which compare the flood stages with and without the Bluff Road railway embankment If the Buff Road railway embankment were to be removed it would reduce upstream stages, and increase downstream flows and stages, due to the absence of the backwater effect from the currently under-sized culvert. The peak flood stage increases downstream of Olympia Avenue are approximately as follows:

- 100-yr: 1.5 ft
- 50-yr: 1 ft
- 10 to 25-yr: <0.5 ft

- 1 to 5-yr: no rise

Potential mitigation measures to prevent this impact from occurring are discussed in the later in this section.

Can improving the downstream crossings improve the flooding conditions?

As shown in Profiles 2-4, improving the hydraulic capacity of the Bluff road railway embankment can dramatically reduce the backwater effect and flood stages in the Assembly Street area. It should also be noted that the results shown in Figures 2-4 reflect the greatest benefits that could be achieved, without regard to cost or convenience. This supports the trend identified by PACE Engineering, which included more detailed design alternatives. Complete removal of the Bluff Road railway embankment would provide the maximum upstream benefit (i.e. flood stage reduction) but would generate the maximum downstream impacts (i.e. flood stage increases).

As noted previously, improvements in the hydraulic conveyance of flood flows through the Bluff Road railway embankment will increase downstream flows and stages. To better understand the potential mitigation of these downstream impacts, AMEC simulated improved hydraulic conveyance at Olympia Avenue by removing that embankment from the model. The results can be viewed in Profiles 5-10. The following can be concluded from those results:

- The flood stage reduction benefits to the reach upstream of the Bluff Road railway culvert, as a result of removing/upgrading the Bluff Road railway and Olympia Avenue crossings, diminish depending on the flood event:
  - Benefits for the 100-year event stop at the Southern Railway crossing
  - Benefits for the 50-year event stop at Assembly Street
  - Benefits for the 2- through 10-years event stop at Dreyfuss Avenue
- Improving the Olympia Avenue crossing would mitigate potential rises between Olympia and Bluff Road – potentially below current flood stages.

  - Removing or modifying the abandoned railway and quarry access road crossings further downstream of Olympia Avenue could also mitigate those rises

- Downstream of Olympia Avenue, the 100-yr floodplain could be approximately 50-60 feet wider than currently predicted, if the crossings are improved or removed. However, that appears to be related to (at least in part) the backwater from the quarry access bridge, which could be upgraded if that increase in floodplain width causes problems for adjacent property owners.
  - That access crossing is already overtopped by the 10-yr, flood event so it may not be an issue.
- Further downstream of Olympia Avenue, the flood stages are contained within the channel. Therefore, those stage increases would potentially be tolerable.

Can water quality be addressed?

Water quality could be improved if the Bluff Road railway culvert capacity was improved. As seen in Table 8, the current exit velocities are extremely high for the Bluff Road railway culvert which contributes to:

- Streambed scouring;
- Loss of vegetation and trees;
- Streambank destruction;
- Sediment deposition in the lower reaches of Rocky Branch; and
- Sediment deposition at the confluence of the Congaree River.

Reducing scour and in-stream velocities would also help to sustain potential stream restoration efforts in the Olympia Avenue area.

Table 8 – Existing Culvert Exit Velocities (fps)

Storm Event	2-year	5-year	10-year	25-year	50-year	100-year
Bluff Rd. RR	10.7	14.4	17.2	20.7	23.7	26.7
Olympia Ave.	14.4	12.1	10.9	9.9	9.4	8.1

However, AMEC sees no significant water quality benefits from the existing floodplain storage upstream of the Bluff Road railway embankment. As shown in Table 7, the storage volume and detention time for events that occur more frequently than the 2-year flood event are negligible. The 2-year flood event is larger than the events that are generally of concern when addressing water quality issues. In other words, there is not any significant ponding occurring for the more frequent flow events (i.e. <1yr event), and benefits from the trapping of in-stream pollutants would be minimal, if not negligible.

What impacts does flooding on the Congaree River have on the area?

The limits of flooding due to the backwater from the Congaree River are shown in red on Profiles 5, 6 and 8 – based on information from the FIS. The 100-year event does extend up toward Olympia Avenue, and therefore could supersede the aforementioned rises downstream of Olympia Avenue. The 50-year event does extend up toward the quarry access road, and could supersede the aforementioned rises at that location. More frequent events in the Congaree River are expected to be below the stages in Rocky Branch Creek.

How much of the watershed can be served by improvements near the site?

No significant benefits, in the form of reduced flood stages, are expected to extend upstream of the Assembly Street area. However, downstream water quality can be significantly improved if the exit velocities from the Bluff road railway and Olympia Avenue culverts can be decreased through increases in hydraulic capacity.

3. Recommendations

Based on the results in the preceding section, AMEC offers the following conclusions and recommendations:

- Developing the Assembly Street site may require some floodplain management measures to mitigate impacts to both upstream and downstream locations:
  - The AMEC analyses did not indicate that an increase in the 100-year flood stage would occur due to the proposed site fill. However, another detailed analysis should be performed when a final detailed site plan is provided to affirm that conclusion.
  - If a rise is projected to occur due to the proposed site fill, it should be mitigated. This can be done with an increase in the hydraulic capacity of the Bluff Road and railway culverts.
  - Increasing the hydraulic capacity through the Bluff Road railway embankment will lead to increased flows (10-year and greater) and flood stages in the downstream areas. However potential remedies have been identified.
- The suggested remedy (by PACE Engineering) of increasing the capacity of downstream crossings (Olympia Avenue) to mitigate a rise they expected due to site fill, offers the following advantages and potential impacts:
  - A potentially significant reduction in upstream flood stages, which would likely stop at the Assembly Street crossing. The actual magnitude and extent of the reduced flood stages would depend on the actual improvement made (moderate increase, complete removal, etc.)

- An increased level of protection and service for Bluff Road and Olympia Avenue, which are projected to be overtopped by frequent events.
- Reduced exit velocities from the Bluff Road railway culvert, which are considered to be a major contributor to the in-stream degradation seen along Rocky Branch (i.e. Olympia Park area, confluence with the Congaree River).
- Increased flow rates from the Bluff Road railway culvert to the downstream culverts. These increased flows will lead to increased flood stages at and downstream of Olympia Avenue.
  - For Olympia Avenue, an increase in the hydraulic capacity of the culvert would be needed to prevent increased overtopping.
  - The flood stage increases to the areas downstream of Olympia Avenue are not expected to expand the floodplain width significantly. In many locations, the flows are still contained within the streambanks. However, the limits of this study prevent AMEC from assessing potential structures at risk for such stage increases. If those rises are found to lead to damages, they can be mitigated by increasing the hydraulic capacity of other downstream crossings (abandoned railway crossing & quarry access road).

- The improvements to the Bluff Road railway embankment and Olympia Avenue may offer an opportunity for watershed restoration.
  - Because the railway embankment just downstream of Bluff Road is not in service, it may be feasible to provide a pedestrian walk way (tunnel or open cut) that could be the key node in developing a pedestrian walkway from the USC housing areas by Olympia Street to the Assembly Street site.
  - In addition to providing the connectivity between the areas downstream of Olympia Avenue and Assembly Street, this initial segment can provide support

for more greenway segments, as well as for restoring the health of the Rocky Branch watershed through public awareness.

- This awareness could also support in-stream restoration of that stream segment, which would be more sustainable with the reduced exit velocities from the Bluff Road railway and Olympia Avenue culverts (if improved).

- Although the actions previously noted cannot provide direct improvements to the upstream portions of the watershed, such as Five Points, AMEC suggests that the following steps be considered:
    - Instead of more costly and disruptive full culvert replacements, we suggest looking at culvert inlet modifications. In many cases, the meandering alignment of the stream may not provide for efficient inlet flow, and the available capacity of the existing culverts may not be fully utilized. Inlet modifications (e.g. wing walls) are cheaper than full culvert upgrades and have the ability to improve hydraulics by up to 30%.
    - In other upstream areas, such as the paved ditch and parking area in the Sumter Street area, underground storage could be added that could be designed to draw flow off line and fill as flood stages begin to crest. This is known as "peak shaving", and can be used not only to reduce flooding for frequent events, but could also serve water quality goals. Such a design could reduce the duration of bank-full flood stages which are the greatest contributor for in-stream erosion and bank destabilization.
    - For these suggested upstream improvements, AMEC recommends that a dynamic model, such as the SWMM model previously developed, be employed. Dynamic models, while more being complex and require a higher level of expertise, link the hydraulic, hydrologic and in-stream routing aspects. Dynamic models offer the ability to perform continuous simulations and provide a more comprehensive assessment. That would better ensure that a particular solution

would not lead to an unintended impact upstream or downstream (changes in flows or stages).

  - If dynamic modeling is used, the available USGS gage data should be leveraged to attempt to tailor the rainfall patterns and their return frequencies to this small watershed. The typical 24-hr events, using the SCS methodology, were appropriate for the purposes of this study. However, if a greater investment is made to pursue the recommendations in this report, calibration would help to receive a higher return on that investment.

- There are additional Green Infrastructure techniques that could be used in the upper watershed areas, and are recommended for potential use during the development of the Assembly Street site that reduce runoff:
  - One or more of the following should be considered and used when possible; "Green Roofs"; pervious pavement; and bioretention features. These features can capture and reduce runoff from the initial portion of a rainfall event, and also reduce the effective imperviousness of a given site such as the proposed Assembly Street development site. These practices have been shown to effectively improve site runoff water quality.
  - Cisterns that use water for other purposes may be viable options. They can come in the simplest form of a planter box that draws runoff for plantings and trees, which evapotransporates the runoff with reduced irrigation costs. Or they can come in the form of "Blue Roofs" which are storage containers that use rainfall for purposes such as cooling water or vehicle washing.
  - Promoting more non-concentrated flow through sheet flow (e.g. downspout disconnection) and using open swales may have limited applications in an urbanized basin, but should be assessed for their suitability including the proposed Assembly Street development. While each such installation may not be able to serve a large area, the opportunities throughout the watershed will

multiply such that their cumulative effect could provide water quality improvements to the smaller tributaries to Rocky Branch Creek.

- Finally, based on AMEC's observation at recent Rocky Branch Watershed Alliance Technical Committee meetings, many of the aforementioned issues and recommendations could benefit from their (and other stakeholder) cooperation:
    - Integrating public outreach into features such as a greenway, to draw interest in and support for improvements to the upper reaches of the watershed.
    - Identifying opportunities for stream restoration or flow reduction in the Five Points and USC areas.
    - Identifying and applying added resources (previous Master Plans, time from professors and students).
    - Cooperating with USGS to gather more-detailed rainfall and stream stage/flow information from the available gages, or possibly to add more gages in strategic locations.
    - Finding potential locations for runoff diversion and capture locations, as well as those locations that are suitable for Green Infrastructure techniques.