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DEVELOPING ON-LOT STORMWATER RUNOFF VOLUME CONTROLS

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ABSTRACT

In 2009 Beaufort County recently enacted Stormwater Volume Controls for new development. These requirements will limit stormwater runoff volume for new development to pre development levels for rainfall events up to 1.95 inch. Unfortunately there were considerable developments that were approved before these controls. It was estimated that about 22,000 lots were in previous subdivision and planned unit development (PUD) approvals or have by-right ability to construct. To address this potential impact, new on-lot controls were developed that require practices to reduce stormwater runoff volume from the individual lots. Credits and design criteria for three volume reduction practices were incorporated into a worksheet and web-based program to meet the on-lot requirements for the design storm event of 1.95 inch.
This paper presents the development and finalization of a web-based program that can be used by homeowners and builders to select the suite of BMPs that can control the excess runoff from this design storm event.

KEYWORDS

Low impact development (LID), on-lot BMPs, runoff volume control, equivalent impervious cover.

INTRODUCTION

Beaufort County, SC is located between Charleston, SC and Savannah, GA. Due to the prime coastal location, the County has long been an attractive location for resort and other types of development. The County's stormwater program has been challenged by its citizens and leaders to be a progressive coastal program that has recently incorporated volume control into its stormwater management criteria. This progressive attitude has kept 85% of our most sensitive water use (Shellfish Harvesting) waters open since water quality controls were first adopted in 1998. This was maintained while the county increased in population by over 30 percent.

The County has several unique coastal characteristics: fifty percent of the County consists of open areas and salt marshes, little upstream freshwater input, shellfish harvesting and

fishing are major economic and recreational activities, and population growth has been rapid in recent decades.

The impetus for the County's stormwater regulations came from shellfish closures in the mid-1990s. These closures led to heightened public awareness and political will on the part of the County Council. The first round of the regulations was adopted in 1998. The innovative approach used at the time was based on an anti-degradation target for phosphorus of 10% "equivalent impervious cover" (EIC). In other words, degradation could be halted if land development projects limited their EIC to 10%. EIC limits can be reached either by reducing impervious cover or treating impervious cover with a stormwater BMP that has credits assigned in the BMP Manual. In subsequent years, the EIC concept was extended to anti-degradation goals for bacteria and nitrogen. The County also adopted a stormwater utility in 2001, which was a recommendation from citizen action in response to the shellfish closings.

After another shellfish closure in the May River in 2009, the County investigated possible causes, and the volume of stormwater came under increased scrutiny. Increased stormwater volume from development projects was implicated in salinity changes, increased discharges into wetlands with observed increases in fecal coliform bacteria concentration at wetland outlets, and impacts to fisheries. With direction from the County Council, the County Stormwater Utility developed a volume-based criterion based on the 95^{th} percentile storm event (derived from the federal facilities standard in the 2007 Energy Independence and Security Act). This storm in Beaufort County is 1.95 inches of rainfall. The County discovered that the EIC concept historically used for water quality compliance could be adapted for the new volume control criterion.

In 2009, the County amended its stormwater ordinance to include volume controls, and in 2010, updated its BMP Manual. The revised manual details volume reduction and EIC credits for six stormwater practices that infiltrate, evapotranspire, and/or reuse runoff:

1. Rooftop practices (green roofs, evaporative cooling on flat roofs)
2. Pervious pavement
3. Runoff capture and use for irrigation
4. Disconnection of impervious areas
5. Rain gardens and other devices
6. Swales for runoff from highways and roadways

The updated manual outlines EIC credits for various combinations of practices, soils, and ponding depth/storage. The manual also contains a compliance worksheet to calculate EIC resulting from using a combination of practices.

These practices and volume reduction credits were described in a presentation at last year's 2010 SCEC conference (Wagner, 2010).

While developing the updated ordinance and manual, the County retained the services of several local design engineers to perform cost estimates of complying with the new

system. This process allowed the design community to become comfortable with the changes, and to see how the volume and water quality criteria could be interwoven.

While the volume-based stormwater criterion is relatively new, the County has already seen some interesting stormwater adaptations proposed, including reusing water from ponds for irrigation, reuse from cisterns for evaporative cooling, and several pervious parking, rain garden, and cistern projects on County property.

APPROVED BUT NOT BUILT UNIVERSE

With the adoption of new development controls, there were questions raised about developments that had been approved before runoff volume controls, but had not been built out. An analysis was conducted to determine the extent of this un-built universe. The analysis indicated that there were over 22,000 residential lots of record that could be built without volume controls. Over 15,000 of these vacant lots were in previously approved Subdivisions (SD) and Planned Urban Developments (PUD). This was significant since the built universe of improved single family residential structures was 39,000 units. It was determined that the additional stormwater runoff from this permitted future building could make the volume problems worse and could lead to further water use impairments.

Beaufort County may be unique in that a zoning permit is required before a builder is able to obtain a building permit. It was determined that this process offered a vehicle to address the excess runoff volume without opening previous agreements.

Ordinance changes were proposed to require that on-lot volume reduction BMPs be developed for individual new homes and modifications of existing homes that are more than 50% of assessed value. This was only required if the volume of the lot was not being treated by a development plan or other method. This allowed the voluntary option of subdivisions and PUDs to opt for a neighborhood retrofit in lieu of only on-lot controls.

The ordinance changes also encouraged minimizing impervious surfaces to reduce the size of the BMPs. The actual wording of the key ordinance change is listed below:

Sec. 106-2865 – On-site Single Family Lot, Best Management Practices (BMP)

(a) Where stormwater runoff is not addressed in an approved community runoff volume control system, construction of new or single family homes that are renovated in excess of 50% of their taxable appraised value, will need to employ and utilize on-site stormwater run-off volume control BMPs.

(b) The actual BMPs to be utilized can be either determined from Stormwater Utility's On-lot Volume Program (Attachment in BMP Manual and web-based program) or other volume practices as described in Beaufort County Best Management Practice

Manual. Both manual and web-based program will be available on the County's web site.

(c) Required practices will be sized based on impervious surface on the property and can be reduced by employing practices that reduce impervious surface like:

a. Pervious driveways
b. Pervious walkways
c. Smaller roof surface

(d) In no case will the imposition of stormwater volume controls for lots of record result in the lots becoming un-buildable. The Zoning Administrator shall be empowered to make this determination at his or her discretion without recourse to the Zoning Board of Appeals for hardship.

One of the key directives the Utility received was to prevent a homeowner or builder having to incur cost to develop an engineered solution to the on-lot runoff control requirements. To address this, a worksheet was developed that mapped out a selection process to develop an approvable solution based on the soil and impervious surface that the homeowner planned to build. The proposed ordinance changes also allowed other volume reducing practices to be used and credited according to the existing BMP manual. This would require a separate calculation program to be submitted.

ON-LOT VOLUME REDUCTION WORKSHEET

The worksheet is attached to this article and requires some calculations and input values from BMP performance charts. This is the official worksheet that will be included as an appendix to the next update the BMP manual. It walks a homeowner and builder through a decision and sizing process for the proposed building and associated impervious surfaces being proposed. This allows homeowner to select and size an acceptable suite of BMPs for the lot in question. It is not the only way runoff volume can be addressed but offers a simple way to develop a solution. It is compatible with the new development standards for new development and is designed handle excess runoff from the 1.95 inch rain event. For this rainfall event, excess post construction runoff (i.e., runoff above what would occur in the pre-development condition) would be 1.15 gals/sqft of impervious surface (for sandy soils) and 0.82 gals/sqft of impervious surface (for clay soils).

There are three practices that are proposed in this worksheet. These practices are also described in the current BMP manual for developmental stormwater runoff control. These practices are handled in series. They are

1. **Storage and reuse** – this will be required if a homeowner decides to have an irrigation system and is optional if there is no irrigation planned on the lot. When a homeowner decides to install irrigation on his property, storage and reuse will be required and storage will be a minimum of 0.3 gallons per square foot of

rooftop impervious surface. The maximum storage allowed for the worksheet calculations will be 1.15 gallon per square foot of rooftop impervious surface. Homeowners can have larger storage but it will not carry over to the next practice.

2. **Disconnected Imperviousness** – this will allow credits for the natural infiltration on the lot. The worksheet allows the homeowner to select, as applicable, up to two directions for the unaddressed impervious surface runoff to travel by sheet flow over the pervious surface area on the property. In many rural situations, this practice may be the only one needed and is essentially no additional cost to the homeowner.
3. **Raingardens** – will be sized, if needed, to handle excess runoff volume not handled by the first two practices. The result will be in square feet of standard raingarden per the BMP manual. This is a raingarden with 3 ft of planting media and 6 inch maximum surface ponding depth.

The three practices need to be sized in series and may require modifying storage and reuse and raingarden selections if initial sizing is not appropriate for the site. This means that storage and reuse decisions need to be made before moving to disconnected impervious and then to raingarden selections.

There were concerns that on-lot controls might not be possible in small in-fill lots and that the cost might be too high. The County contracted with a local architect to utilize the worksheet on a number of development projects that were executed before the new volume controls requirements and to evaluate costs for implementing on lot controls (as if the projects were being executed today). The report indicated that the design rainfall event could be controlled on all lot sizes (small urban lots to large rural lot) that were analyzed. This included building on minimum lot size as specified by some of the municipalities in the County. The average cost for implementing the design solution on these small lots was $1.40 per square foot heated home space. This was less than initially estimated and lead to dropping of a plan to limit on-lot requirements to headwaters of our tidal creeks (which are considered to be more sensitive to stormwater runoff and the resulting salinity changes caused by this runoff). The County also did some additional analysis on other situations like mobile homes on ½ acre lots and determined that in these cases, disconnected impervious surface would be adequate to handle the excess stormwater without additional BMPs. This report is on County's stormwater web site (Ramsey, 2011).

Since the worksheet required calculations and might be difficult for some users, it was decided to develop tools that would assist homeowners in utilizing the worksheet. Initially a Microsoft Excel program was developed and this helped explain the worksheet and how it worked to the Beaufort County's Stormwater Utility Board and the County's Planning Commission. When these organizations concurred with the proposed changes to the ordinance, it was decided to invest in a web-based program that would allow homeowners and builders to go on line and utilize the program. The program allows the builder or property owner to enter the following information into the program:
:

1. Impervious Area
   Home Rooftop (home, garage)
   Other impervious (walkway, driveways, patio etc)
2. Total Lot size
3. Soil Type – sandy or clay
4. Area to be irrigated by installed system (if applicable)
5. BMP implementation data, such as pervious area receiving sheet flow from unaddressed disconnected impervious area

The Web-based program will generate a one page printout that lists the following:

1. Homeowner entered information and site identification (e.g., address)
2. Excess stormwater runoff to be controlled for the 1.95 inch storm event
3. Program Approved Practices
    a. Storage and Reuse
        i. Rainbarrels – number and size
        ii. Cisterns – number and size
    b. Disconnected Impervious area
        i. First runoff direction – unaddressed impervious surface and pervious sheet flow area
        ii. Second runoff direction – unaddressed impervious surface and pervious sheet flow area
    c. Raingarden – surface area of standard size raingarden in square feet.

This one page printout (sample generated from program is attached) will be taken to the zoning department as part of applying for the zoning permit. It will be attached to the zoning and building permits and will be used to verify by Building Codes that the practices have been installed.

The web-based program is now operational on the county web site at http://www.bcgov.net/about-beaufort-county/public-service/stormwater-management/index.php . It is hoped that individuals and builders utilizing the Web-based program will develop some comfort with using the worksheet and avoid misunderstanding. The program was debugged in February 2011 and will be revisited as more user feedback is received..

CURRENT STATUS

The proposed ordinance changes have been approved unanimously by the Stormwater Utility Board and the Beaufort County Planning Commission. The next step in the adoption process is Beaufort County Natural Resources Committee that is composed of seven of the 11 County Council members. At their February 1, 2011 meeting they heard comments from the homebuilders associations that expressed concerns that this would cost more than was presented in the cost analysis report. The committee tabled action on these changes for no more than 4 months so two actions could be taken:

- Address cost concerns of the homebuilders

- Explain the ordinance to neighboring jurisdictions and secure some consensus on its objectives.

This presents an opportunity for reaching out to homebuilders to help them understand how they can reduce impervious surface and reduce the cost of controlling stormwater runoff. The main concern about this ordinance is increased cost affecting home affordability. It became apparent that increasing impervious surface with features such as large (and costly) concrete driveways will drive up the cost of meeting stormwater controls and should not be in the affordable home discussion. The ongoing discussions may lead to the beneficial alternatives of decreasing unnecessary impervious surface.

The second requested action is an opportunity to focus the municipalities and county on the upcoming update of the intergovernmental agreements governing the operation of the Stormwater Utility. The joint county/municipality implementation committee has recommended that one of the operational alternatives of these agreements should be that " Minimum Water Quality Controls in each jurisdiction must be protective enough to reach and maintain state designated water uses" The County Council request allows this recommendation to be addressed above the staff level. This requirement also allowed the utility to reach out to a neighboring county and start a dialogue as they start to develop a new Stormwater Ordinance addressing volume controls.

SUMMARY

Beaufort County found that developing an ordinance to control stormwater runoff volume for new developments would not stop impacts from previously approved but not built portions of subdivisions and PUDs. When these previously approved developments do not have volume controls, the individual lots will have to be controlled to prevent additional water quality impairments. On-lot controls can be simplified and allow for selecting and sizing of BMPs of design storm events without complex design calculations. This was accomplished through a Web-based program. Beaufort County expects to adopt on-lot ordinance to control stormwater runoff from rainfall events up to 1.95 inches.

REFERNCES

CDM, 1998 (updated 2003, 2008, 2010), *Beaufort County Manual for Stormwater Best Management Practices*

Ahern, Dan and Robert Klink. 2010. *Water Quality Improvements with Volume Based BMPs (powerpoint presentation).* SESWA 2010 Annual Conference. October 2010.

Wagner, Richard 2010. *Consideration of Low Impact Development Benefits in Beaufort County,* SCEC 2010 Annual Conference March 2010

Ramsey, Cooter, 2011, *Stormwater Worksheet for Single Family Homes*, Allison Ramsey Architects, January 4, 2011

ACKNOWLEDGEMENTS

Support was provided by three consultants on this project. Applied Technology and Management assisted the County on regulation wording. CDM provided technical support in developing the worksheet and establishing credits for the practices utilized. Alex Anselmi of CreateAndSolve.com developed the web-based program from the developed worksheet.

Appendix 1- On-lot Worksheet

Beaufort County

Stormwater Retention Worksheet for Single Family Lot

February, 2010 (Applicant input in Red Italics)

Section 1 – Lot Information

Total Impervious Area to be created

Home (rooftop) _____ *sq. ft.*
Other Impervious _____ *sq. ft.*
(walkways, driveways, patio etc)

Total Impervious surface _____ sq. ft. *Total Lot Size _____ sq.ft.*
Pervious surface on lot = lot size – impervious surface

Soil Type: __ Sandy __ Clay -- Area of lot to be irrigated _____ sq ft
(will be equal or less to pervious surface)

Section 2 – Post Construction Stormwater Run-off Calculation:

New gallons of rainfall to be displaced by creation of new impervious areas
(Runoff expected from a 1.95 inch storm = 1.85 inch per square foot of impervious surface)

For Sandy soils
_____ sq.ft. X 1.15 gals/sq.ft. = _____ gallons
(total impervious surface)

Less pre-construction run-off for new impervious surface
(for sandy soils there would be no runoff and clayey would be .5 inch from 1.95 inch storm)

For Clay soils
_____ sq.ft. X 0.82 gals/sq.ft. = _____ gallons
(1.15-0.33)

Section 3 – Application of Best Management Practices

Total excess runoff _____ gallons (amount to be retained, infiltrated or reused on property)

Best Management Practices to be used: (apply in order, can use a combination of practices to control excess runoff.)

1. Storage and reuse for irrigation on the property (required if irrigation system proposed – optional othwise)
This will require cistern or rain barrels to retain runoff from rooftops to be utilized between rainfall events according to notes and conditions. Note maximum and minimum credit. Practice will be required if home is installing underground irrigation system.

Storage and Reuse Credit

a. Rainbarrel

___ number X ___ size of rainbarrel-gals = ____ gallons of excess runoff controlled

b. Cistern

_____ size of cistern-gals = _____ gallons of excess runoff controlled

(credit size is limited to rooftop impervious surface X 1.15 gal/sq.ft)

2. Disconnected Impervious Area – allowance based on amount of impervious surface that sheet flows over pervious surface before leaving property.

- Allowance also varies for soil type and amount of area runoff sheet flows over.
- If storage and reuse practice is used must only use unaddressed impervious surface
- May have to do multiple calculations if water flows off lot in two or more directions. Generally front and back

First Runoff direction.

_____ *sq.ft. divided by* _____ *sq.ft. =* _____ *Disconnected Impervious ratio*

(unaddressed impervious to pevious surface) (pervious sheet flow area)

Second Runoff direction *(if applicable)*

_____ *sq.ft. divided by* _____ *sq.ft. =* _____ *Disconnected Impervious ratio*

(unaddressed impervious to pevious surface) (pervious sheet flow area)

Credit Table for Disconnected Impervious Area

Disconnected Impervious Ratio	Runoff reduction Gal/sq.ft-impervious area	Runoff reduction Gal/sq.ft-impervious area
	Clayey	Sandy
0.1	.40	1.15
0.2	.40	1.12
0.4	.38	1.08
0.8	.33	1.01
1.0	.31	.98
2.0	.24	.84
3.0	.19	.74
4.0	.16	.67
5.0	.14	.60

Disconnected Impervious area credit

First Runoff Direction

_____ sq ft X _____ gal/sq ft = _____ gallons of excess runoff controlled

(Unaddressed impervious to pervious surface) (from credit table)

Second Runoff Direction

_____ sq ft X _____ gal/sq ft = _____ gallons of excess runoff controlled

(Unaddressed impervious to pervious surface) (from credit table)

Sum of Disconnected Impervious Area _____ plus _____ = _____ gallons of excess runoff controlled (first direction) (2nd Dir)

3. **Excess Runoff to Raingarden** Volume not controlled by the first two practices will be addressed by this last treatment train. Location will depend where uncontrolled volume is.

This will be for a standard designed raingarden of three foot planting media depth and a 6 inch maximum ponding depth. Raingardens will be used primarily for surface impervious surface but can be used for rooftop impervious surface in small lots without sufficient pervious surface. BMP manual requires storage in raingarden of 1.5 inch per impervious acre and suitable site (generally above water table)

Runoff to Raingarden
_____ gal of Excess Site Runoff - ____ gal of Storage - ____ gal of disconnected impervious area = _____ gal runoff to raingarden
(Conversion of gallons to Impervious surface controlled
____ gal of runoff to raingarden divided by 1.15gal/sq.ft. = _____ sq ft of impervious circle.)

Size of standard raingarden
____ sq.ft impervious surface divided by(7 for sandy and 4 for clayey soils) = _____ sq ft of standard raingarden
(impervious surface directed to raingarden)

Raingarden Credit
_____ sq. ft. impervious surface X 1.15 gals/sq.ft. = _____ gallons runoff controlled
(unaddressed impervious surface directed to raingarden)

Section 4 – Summary of Volume Reduction Practices

Practice Reductions (from section 3)

Storage for Reuse	_____ gallons (required if lot is to be irrigated)
Disconnected Drainage	_____ gallons
Raingarden	_____ gallons (used to treat remaining volume)
Total	_____ gallons
Total Required (from section 2)	_____ gallons

Section 5 – Notes and Conditions

1. Sandy Soils are considered A and B soils and Clayey soils are considered C and D soils. SCS soils map can be used to determine classification or utilize infiltration rates. Sandy soils have infiltration above .5 in/hr and clayey soils are below this.
2. Storage from rainbarrels and cisterns should be utilized between rainfall events and a minimum of 10 percent should be utilized for irrigation if it had not rained the previous day.
3. When in ground irrigation system is installed the minimum storage requirement is 0.3 gallon per square foot of rooftop impervious surface. The maximum allowed

credit is 1.15 gallon per square foot. Storage can be greater to reduce irrigation needs, but will not receive credit greater than 1.15 gallon per square foot.

4. When storage is utilized, the amount of rooftop impervious surface going to the disconnected impervious surface step is reduced by storage. Example: If rooftop square footage is 2500 and storage is 1,150 gallon then the impervious surface in the disconnected impervious surface step is reduced by 1000 square feet. The unaddressed rooftop impervious surface is going to the disconnected impervious surface step is now 1,500 square feet.
5. Credits for non standard raingardens can be developed from criteria in Beaufort County BMP manual page 5-48

Definitions and Conversion explanations

Definitions

Impervious Surface – hard surface that allow rainfall to run off and not infiltrate into soil.
Rooftop impervious surface – horizontal surface area of rooftops including overhangs and other detached buildings/sheds.
Other impervious – generally hard surfaces on the ground like driveways, patios, walkways and sidewalks.
Pervious Surface – surface that is not hard, might be grass, garden or tree area.
Irrigated area is area that would be served by an installed irrigation system.
Unaddressed impervious surface – term used to determine amount of impervious surface that had not been controlled by a previous practice.
Standard Raingarden – raingarden that has 3 ft of fill material and a 6 inch maximum ponding depth. Different sizes can be constructed but then credits must be computed from Beaufort County BMP manual. BMP manual requires storage of 1.5 inch per acre of impervious surface.

Conversions

Rainfall to gallons of Runoff
Design storm is 1.95 inch of which 1.85 inch is available to run off impervious surface. 1.85 inch on 1 square foot of impervious surface is equivalent to 1.15 gallon of runoff
Preconstruction Runoff
Clayey Soils – 0.53 inches run off for a 1.95 inch storm. 0.53 inch on 1 square foot is equivalent to 0.33 gallon of runoff.
Sandy Soils – No runoff for a 1.95 inch storm
Raingarden
Square foot of impervious surface per square foot of standard raingarden

- Clayey soils 4 sqft of impervious surface to 1 sqft of standard raingarden
- Sandy soils 7 sqft of impervious surface to 1 sqft of standard raingarden

Appendix 2 - printout **Go Back** - Print this page

Projected Web Based Zoning Permit Attachment

Date: 2/12/2011

Builder/Homeowner Input

Address	**123 Affordable Clay St**
Parcel Number	**R 123- 234**

Home/Rooftop	**1500**Square Feet
Other Impervious	**100Square Feet**
Total Lot Size	**16000Square Feet**
Soil Type	**Clay**
Area to be Irrigated	**0 Square Feet**

Excess Stormwater from Homeowner Input = 1312

Program Approved Practices

Storage and Reuse

Practice	Number	Size	Quantity
Rainbarrel	2	60	120
Cisterns	0	0	0

Disconnected Impervious Area

Practice	Impervious	Runoff Area	Quantity
First Runoff Direction	1496	12000	598
Second Runoff Direction	0	0	0

Raingarden

Size	**129** Square Feet

Excess Stormwater controlled from practices = 1312 Gallons