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Technical Guidance: Stormwater Treatment Credit for Rainwater Harvesting Systems

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Approvals:		Initials Date

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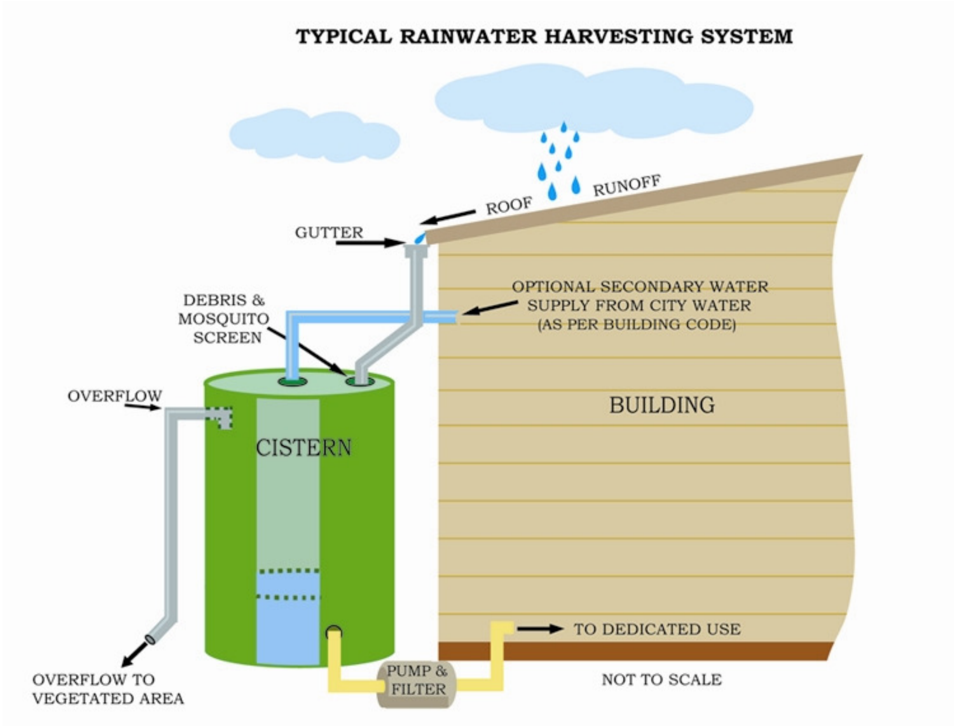
Overview:

It is the policy of the Division of Water Quality to enable and encourage the use of rooftop rainwater harvesting systems (cisterns) to reduce stormwater runoff pollution from an individual site. Collecting and storing rooftop runoff, and providing a consistent, dedicated, and reliable end use, will reduce the volume of runoff and enable the reduction in size of other required stormwater treatment systems on the site. In watersheds requiring nutrient removal from stormwater, dedicated uses of the collected rainwater or proper treatment/infiltration can reduce stormwater nutrient removal requirements. This policy establishes the credit that will be allowed in DWQ permitting programs that consider impervious built-upon areas (BUA) and that rely on calculations of runoff volume and peak flow for sizing stormwater Best Management Practices (BMPs).

Although this does not count the captured rooftop as permeable area in the overall project BUA calculation, the captured roof area can be removed from the percent impervious area when calculating the size of any other BMPs needed on the site.

In order to receive credit, the rooftop runoff must be captured and either (1) used on site, or (2) treated and released, or (3) infiltrated. The captured rainwater can be used for irrigation or vehicle washing and then infiltrates into the ground or evaporates. The captured rainwater can also be used for toilet flushing, which then becomes a wastewater and is then directed into the wastewater system. The captured rainwater can also be "used" by being sent to other stormwater treatment devices such as an infiltration system or bioretention cell. Often, these devices can be smaller in size because of the capability of the cistern to store and slowly release the rainwater. When properly designed, these rainwater harvesting systems can conserve water, save money by reducing the size of other on site BMPs, and save money by reducing the amount of potable water needed for irrigation, vehicle washing, and toilet flushing. Collected rainwater may not be directly sent to the wastewater system without first being used in the above-mentioned uses. If for any reason the designed dedicated end use becomes unavailable because of some change, it will be required that an approved alternative end use or a properly designed BMP treatment system be installed on site to treat the roof runoff.

Typical Components & Layout of a Rainwater Harvesting System:



Cistern – The cistern is the above ground or buried tank that holds the rainwater until it is used. It can be made from various materials; typically plastic or metal.

Filtration / Screens – Screens help filter out debris such as leaves, roof shingle grit, pine straw, and coarse dirt. They can also help prevent mosquito breeding in the cistern. Screens and filters may be added in the gutters and after the pump to provide additional filtration of sediments.

First Flush Diverter – This optional device bypasses the initial roof runoff (approximately 0.04 inches) that may contain shingle grit, dirt, leaves, pine straw, and pollen. This is not the same as the water quality storm, or "first flush", used for other BMPs (ie. 1", 1.5", pre-post 1-yr, 24-hr runoff).

Gutter System – The gutter system conveys the rainwater from the roof to the cistern. It includes the gutters along the roof edge and the gutter downspouts.

Overflow – The overflow allows rainfall in excess of the designed storage volume of the cistern to discharge.

Pump – The pump is needed in order to get the water to its designated use. A bladder tank may be used with the pump to minimize pressure fluctuations and wear on the pump.

Secondary Water Supply – During drought conditions, an automated secondary water supply may be provided to supplement the rainwater typically captured and used for dedicated water reuse. Local plumbing codes shall be followed to prevent cross contamination of potable water supplies.

Policy Criteria:

Regulatory Credits		**Feasibility Considerations**	
Impervious Area Treatment Credit			
	Roof area captured may be deducted from the impervious area used to size other BMP(s) on the site for treating the remaining impervious area (roof area not captured, parking, sidewalks, etc.). **This does not reduce the impervious area totals when calculating the overall BUA for the site.**	Low	Land Requirement
		Low-Med	Cost of Construction
		Med-High	Maintenance Burden
		Small-Large	Treatable Roof Size
		Low	Possible Site Constraints
		Med-High	Community Acceptance
Water Quantity			
yes	Peak Runoff Attenuation		
yes	Runoff Volume Reduction		

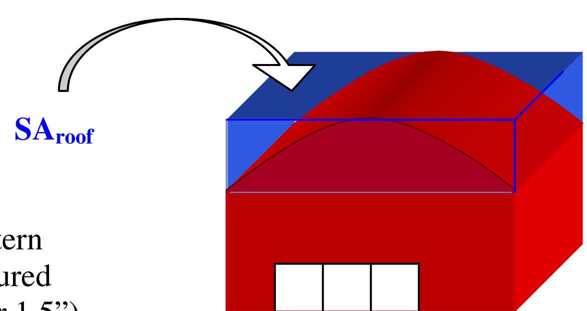
In order to receive credit, the following criteria must be met:

1. The cistern must be sized to treat the design rainfall (ex. 1", 1.5", 1-yr 24-hr storm) from the roof area directed to the water harvesting system. The design rainfall used shall be based on the design storm rainfall depth as specified in Session Law 2006-246 Section 9, Session Law 2008-211 and 15A NCAC 02H .1000. If all of the design volume captured cannot be used, then a scaled reduction in credit will be given. The remaining volume must be treated by a properly designed BMP. The system must be modeled using the water harvesting model developed by NCSU (http://www.bae.ncsu.edu/topic/waterharvesting/), or an equivalent model approved by DWQ, that determines the percent of the design rainfall captured in the system, percent of overflow, and the amount of roof area determined to be treated by the system.
2. A minimum factor of safety equal to 1.2 must be applied to the calculated cistern volume required.
3. All stormwater collected must have a dedicated, year-round, use to assure no overflow of the system during a design rainfall. A water balance calculation must be used to establish the dedicated use volumes and rates. The water balance calculation must demonstrate that the design volume can: (1) be drawn down (used) within 5 days to allow for available volume in the system for the next rain event to be captured and stored, or (2) have an overflow of no more than 14 percent of the annual average historic rainfall, or (3) be drawn down within 5 days and discharged to a properly designed BMP. On a case-by-case basis, reduced credit may be given if the design volume cannot be reliably drawn down within 5 days, or if a year-round reuse is not available. The dedicated water use system must be automated to insure that the water will be used at the rate and volume designed. DWQ may require a meter on the cistern outlet to determine if the water is actually being used at the design dedicated volume.
4. The overflow shall discharge flows in excess of the design volume to a vegetated or natural area, or to another properly designed BMP (ex. rain garden). This discharge shall be non-erosive flow for the 10-yr rainfall event. It shall not discharge directly to impervious surfaces. The elevation of the overflow pipe from the cistern shall be at or above the design volume elevation. See Table 1 for sizing guidance.
5. If a first flush diverter is used, the bypassed water must discharge to a properly designed BMP, and be treated as per Session Law 2006-246 Section 9 and 15A NCAC 02H .1000. The first flush is typically the most polluted water leaving the roof. The first flush can be

directed to a relatively small BMP next to the water harvesting system, or it can be directed to and accounted for in other BMPs on the site.

6. At a minimum, a 1mm or smaller screen at the entrance to the cistern from the gutter system shall be provided to filter out debris and to keep mosquitoes out of the cistern. Screens in the gutters may also be provided on the gutters to prevent large debris from entering the gutter system.
7. If a secondary or makeup water supply is used, it shall be designed to place a minimal amount of volume in the cistern at any one time. The design must allow for adequate storage for the full volume of the next design storm. The secondary water supply must not be used to completely fill up the cistern. Local plumbing codes shall be followed to prevent cross contamination of potable water supplies.
8. A properly designed footing for the cistern must be designed if the load of the cistern at full capacity is greater than the soils will support. If it is buried, buoyancy calculations must be provided to show the cistern will not float when empty. Buoyancy calculations and flotation constraints must be provided if any part of the buried cistern is below the seasonal high water table, or if the area is subject to flooding.
9. An appropriate pump shall be selected to provide adequate pressure for its designated uses at the required pressures.
10. The gutter system and overflow shall be sized appropriately for the system's geographic location. See tables 1, 2, and 3 for sizing guidance.
11. Above ground cisterns shall be made of a material or color that prevents light from entering the cistern, which helps prevent algae growth within the cistern.
12. Metal cisterns may require the use of an internal waterproof bladder to minimize leakage.
13. If the only use is for irrigation, provide a detailed plan that assures year-round usage, which probably will require the inclusion of automatic mechanisms for rainfall detection and soil moisture monitoring. All irrigation use plans shall note that excessive irrigating or irrigating during a rainfall will create more runoff from the site. Irrigation water from a cistern shall be applied so that the water infiltrates into the ground.
14. If for any reason the designed dedicated end use becomes unavailable because of some change, it will be required that an approved alternative end use or a properly designed BMP treatment system be installed on site to treat the roof runoff.
15. The harvesting system shall be labeled and identified as non-potable water.
16. The harvesting system shall meet all local and state building and plumbing codes.

<u>Water Harvesting System Design Sizing & Calculations:</u>



Cistern Volume Calculation:

$V_{mReq'd} = SA_{roof} \times R_D \times FoS$

$V_{mReq'd}$ – minimum required volume for the cistern
SA_{roof} – horizontal surface area of the roof captured
R_D – design storm rainfall depth (typically 1" or 1.5")
FoS – factor of safety (minimum of 1.2 required)

Cistern Overflow Pipe Sizing:

Table 1: Determining overflow pipe diameter for a given captured roof area (ft²) for select cities

	Overflow Pipe Dia.					
City	½”	1”	2”	2.5”	3”	4”
Asheville	38	157	720	1,170	1,740	3,320
Boone	33	144	631	1,020	1,530	2,910
Charlotte	37	155	710	1,150	1,720	3,280
Elizabeth City	32	132	603	981	1,460	2,780
Fayetteville	33	142	624	1,010	1,510	2,880
Franklin	38	165	724	1,170	1,760	3,340
Greenville	31	131	598	973	1,450	2,760
Raleigh	38	160	715	1,160	1,740	3,300
Rocky Mount	36	150	687	1,110	1,670	3,170
Wilmington	26	110	498	810	1,210	2,300
Winston-Salem	40	165	756	1,230	1,830	3,490

Modified from Jones, M. P. and Hunt, W. F.

Gutter Sizing:

Table 2: Determining Gutter size for a given gutter slope and captured roof area (ft²) for select cities

	Gutter Size for ½% Gutter Slope				Gutter Size for 1% Gutter Slope			
City	3”	4”	5”	6”	3”	4”	5”	6”
Asheville	216	457	794	1,210	305	648	1,110	1,720
Boone	189	401	697	1,070	267	568	980	1,510
Charlotte	213	451	784	1,200	301	640	1,100	1,700
Elizabeth City	181	383	665	1,020	255	543	936	1,440
Fayetteville	187	397	689	1,050	264	562	969	1,490
Franklin	217	460	799	1,220	307	652	1,120	1,730
Greenville	179	380	660	1,010	253	538	929	1,430
Raleigh	214	454	789	1,210	303	644	1,110	1,710
Rocky Mount	206	436	758	1,160	291	618	1,060	1,640
Wilmington	149	316	550	844	211	449	773	1,190
Winston-Salem	227	480	833	1,280	320	680	1,170	1,810

Modified from Jones, M. P. and Hunt, W. F.

Gutter Downspout Sizing:

Table 3: Determining Gutter downspout diameter for a given captured roof area (ft^2) for select cities

	Gutter Downspout Dia.		
City	2"	3"	4"
Asheville	914	2,790	5,840
Boone	802	2,450	5,120
Charlotte	902	2,750	5,760
Elizabeth City	765	2,340	4,890
Fayetteville	793	2,420	5,060
Franklin	920	2,810	5,870
Greenville	759	2,320	4,850
Raleigh	908	2,770	5,800
Rocky Mount	872	2,660	5,570
Wilmington	632	1,930	4,040
Winston-Salem	960	2,930	6,130

Modified from Jones, M. P. and Hunt, W. F.

Operation & Maintenance:

Important maintenance procedures:

- The roof area will be maintained to reduce the debris and sediment load to the system. Excess debris can clog the system and lead to bypass of the design storm, and reduced reuse volume.
- To ensure proper operation as designed, a licensed Professional Engineer, Landscape Architect, or other qualified professional will inspect the system annually.
- The system components will be repaired or replaced whenever they fail to function properly.
- If the outlet is metered, use must be recorded at a minimum of monthly. These records shall be kept on site for inspection by DWQ.

The system will be inspected by the owner/operator at least **monthly and within 24 hours after each rain event**. Records of operation and maintenance will be kept in a known set location and will be available upon request.

Inspection activities shall be performed as follows. Any problems that are found shall be repaired immediately.

Table 4
Sample Operation and Maintenance Provisions for Water Harvesting Systems

BMP element:	**Potential problems:**	**How to remediate the problem:**
The entire system	A component of the system is damaged or leaking.	Make any necessary repairs or replace if damage is too large for repair.
	Water is flowing out of the overflow pipe during a design rainfall or smaller (usually a 1″ or 1.5″ rainfall).	Check system for clogging and damage. Repair as needed so the design volume is stored properly without discharging during a design storm. Check that the pump is operating properly and that the water is actually being used at the volume designed. If it is still not operating properly, then consult an expert.
The captured roof area	Excess debris or sediment is present on the rooftop.	Remove the debris or sediment as soon as possible.
The gutter system	Gutters are clogged, or water is backing up out of the gutter system.	Unclog and remove debris. May need to install gutter screens to prevent future clogging.
	Rooftop runoff not making it into gutter system.	Correct the positioning or installation of gutters. Replace if necessary to capture the roof runoff.
The cistern	Sediment accumulation of 5% or more of the design volume.	Remove sediment.
	Algae growth is present inside the cistern.	Do not allow sunlight to penetrate the cistern. Treat the water to remove/prevent algae.
	Mosquitoes in the cistern.	Check screens for damage and repair/replace. Treat with 'mosquito dunks' if necessary.
The screens and filters	Debris and/or sediment has accumulated. Screens and filters are clogged.	Search for the source of the debris/sediment and remedy the problem if possible. Clean/clear debris/sediment from screen or filter. Replace if it cannot be cleaned.

BMP element:	**Potential problems:**	**How to remediate the problem:**
The pump	Pump is not operating properly.	Check to see if the system is clogged and flush if necessary. If it is still not operating, then consult an expert.
The overflow pipe	Erosion is evident at the overflow discharge point.	Stabilize immediately.
	The overflow pipe is clogged.	Unclog or replace if it cannot be unclogged.
	The outflow pipe is damaged.	Repair or replace the pipe.
The secondary water supply	Not operating properly.	Consult an expert.

Required Items to be Submitted for Review:

1. Plans and details (prepared by a licensed Professional Engineer or Landscape Architect)
2. Water Harvesting Supplement Form
3. System model input and output (prepared by a licensed Professional Engineer or Landscape Architect)
4. System design calculations, including volume and storage calculations, pump, overflow, gutter, and downspout sizing calculations (prepared by a licensed Professional Engineer or Landscape Architect)
5. Water balance calculations for dedicated uses (prepared by a licensed Professional Engineer or Landscape Architect)
6. Buoyancy calculations for underground systems (prepared by a licensed Professional Engineer or Landscape Architect)
7. Operation & Maintenance Plan to be supplied to the owner (this must include information for the owner about dedicated use requirements)

Note: Retrofitting of a private home, or construction of a new home, with a stormwater harvesting system for a purpose other than meeting a stormwater treatment requirement for obtaining a stormwater permit does not require the use of a licensed Professional Engineer or Landscape Architect.

References:

Jones, M. P. and Hunt, W. F. *Rainwater Harvesting: Guidance for Homeowners*. N.C. Cooperative Extension publication AG-588-11. Raleigh: N.C. State University

Jones, M. P. and Hunt, W. F. (2006). *Choosing a Pump for Rainwater Harvesting*. N.C. Cooperative Extension publication AG-588-08. Raleigh: N.C. State University

NCSU BAE Stormwater Engineering Group
http://www.bae.ncsu.edu/stormwater

Rainwater Harvesting at North Carolina State University
http://www.bae.ncsu.edu/topic/waterharvesting/

The Texas Manual on Rainwater Harvesting (2005, 3rd Ed.), Texas Water Development Board. Austin, Texas