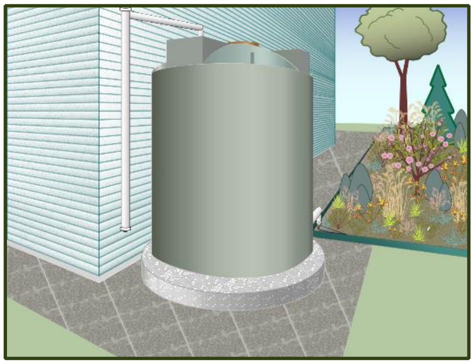
9.15 CISTERNS



Cisterns are stormwater facilities that temporarily store stormwater runoff from rooftops, which is subsequently reused for non-potable uses, such as toilet flushing and vehicle washing. Cisterns can either be indoors or outdoors and above, at, or below grade. The reuse of the stormwater reduces the volume of stormwater runoff that makes it to downstream facilities. Take note that cisterns are not a viable stormwater management choice for sites with little or no demand for reuse.

N.J.A.C. 7:8 Stormwater Management Rules - Design and Performance Standards		
	Nonstructural Strategy	Assist with Strategy #2; See Page 3
	Water Quantity	Yes
GR	Groundwater Recharge	Not Allowed
%	Water Quality	Not Allowed

Stormwater Quantity Control Mechanisms and Corresponding Criteria	
Volume Reduction	
Minimum cistern storage volume	Water Quality Design Storm Volume
Reduced Curve Number	Based on the storage volume of the cistern
Peak Flow Attenuation	
Requires extended detention component	See Pages 8 through 10 and *Chapter 9.4: Extended Detention Basins*

Introduction

Cisterns are stormwater management practices used to capture, collect and reuse roof runoff. Cisterns are ideal for harvesting rainwater for non-potable uses, vehicle washing or toilet flushing. Cisterns are extremely versatile and may be used on a variety of sites ranging from small-scale residential sites to large-scale industrial or commercial sites; they may be placed either indoors or outdoors and above, at, or below grade. They can also be used in various shapes and sizes. Cisterns must be designed based upon on-site water needs; an under-sized cistern may not store sufficient water for site demands, and an over-sized cistern may remain full or near-full most of the time, and thus be unable to provide storage during rain events.

A cistern used to meet any State requirement must have a maintenance plan and must be protected by easement, deed restriction, ordinance or another legal measure that prevents its neglect, adverse alteration or removal.

The following images show a variety of cistern installations. The first image depicts a circular tank; however, as seen in the second image and on the following page, cisterns can be almost any shape.

Applications

The nonstructural stormwater management strategies design standard in the Stormwater Management rules must be addressed for all major developments, pursuant to N.J.A.C. 7:8 – 5.3(a). The design of a cistern can assist in maximizing the following strategy:

- Strategy #2: Minimize impervious surfaces and break up or disconnect the flow of runoff over impervious surfaces;

Cisterns may be designed to reduce the volume of stormwater discharged to downstream facilities and/or to reduce peak runoff rates when designed as an on-line system in combination with an extended detention basin; however, regardless of the design storm chosen, all discharges must be designed for stability and in accordance with the *Standards for Soil Erosion and Sediment Control in New Jersey*.

Design Criteria

Basic Requirements

A cistern may be designed as an above, below, or at grade system. A cistern must be designed and manufactured to remain water tight and must be constructed of impermeable materials. The following criteria apply to both configurations – with or without an extended detention component. Design criteria specific to subsurface cisterns may be found beginning on page 7. Additional requirements for the extended detention option may be found beginning on page 8.

Inflow

- The use of a cistern is limited to the collection of clean, roof runoff and is prohibited in areas where high pollutant or sediment loading is anticipated.

- The intended use of and the demand for the captured stormwater must be considered when choosing a drainage area. Stormwater collected from certain types of rooftops, such as painted roofs, galvanized metal roofs, tar and gravel, sheet metal, asphalt seal-coated roofs, or from roof areas that contain mechanical or electrical equipment, may be contaminated with trace metals or other toxic compounds; therefore, consideration must be given to restricting this type of harvested rainwater to uses where the potential for human contact is not an issue.

- The maximum inflow drainage area is based upon the demand for water reuse at the site. See page 10 for an example based on water reuse and the section below labeled "Cistern Water Reuse."

Storage Volume

- The cistern must have sufficient storage volume to contain the Water Quality Design Storm ("WQDS") runoff volume without overflow.

- No standing water may remain in the cistern 72 hours after a rain event in order to allow for sufficient storage for the next rain event. Additionally, storage in excess of 72 hours may result in anaerobic conditions, odor and both water quality and mosquito breeding issues.

- Cisterns may be constructed as either off-line or on-line systems. In off-line systems, most, or all, of the runoff from storms larger than the Water Quality Design Storm bypass the cistern through an upgradient diversion; this reduces the system's long-term pollutant loading and associated maintenance. On-line systems receive runoff from all storm events; they provide storage for the WQDS to be re-used or pumped into an additional storage tank within 72 hours, and they convey the runoff from larger storms through an overflow. These online systems can attenuate the larger storm events and provide stormwater runoff quantity control if the outlet is set at the water surface elevation of the WQDS.

- Any overflow of clean roof runoff that mixes with runoff that is subject to the stormwater quality standards pursuant to N.J.A.C. 7:8-5.5 must be treated in a downstream facility.

Cistern Water Reuse

- The demand for cistern water reuse on site must be sufficient to empty the cistern within 72 hours after a rain event.

- In many situations, the demand for water reuse will vary depending on the day or time of year. In order to ensure that the cistern volume will be available for storm events, the cistern water reuse must be calculated based upon the lowest 3-day demand that would occur during the year.

- If the lowest 3-day demand is insufficient to empty a cistern sized for the WQDS, but demand is greater on other days, a secondary storage tank must be used. Immediately following a rain event, the cistern water would be transferred into the secondary storage tank for later reuse. The secondary storage tank must be sized sufficiently to hold water from each rain event until it is reused. Refer to example 2 beginning on page 12 for more information on the use of the secondary storage tank.

- Cisterns that require the installation of one or more pumps, valves or other controls to automate or regulate flow must include alarms or other measures to detect flows as well as failure conditions, an emergency shutoff and backup power where required. Pump systems and alarms must be maintained regularly to ensure long-term operation

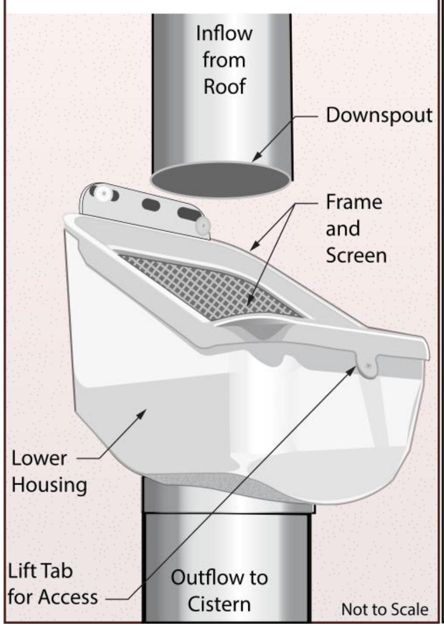
- The Department has prepared a spreadsheet for the calculation of the cistern water reuse, which is available here: http://www.nj.gov/dep/stormwater/bmp_manual/cistern_spreadsheet.xlsx. The spreadsheet uses the NRCS method to estimate the volume of runoff from the roof area and relies on user inputted data to determine if the project site has sufficient demand to reuse the cistern water. The reuse is based upon the lowest 3-day demand and the spreadsheet conservatively assumes that a rain event occurs every 3 days.

Pretreatment

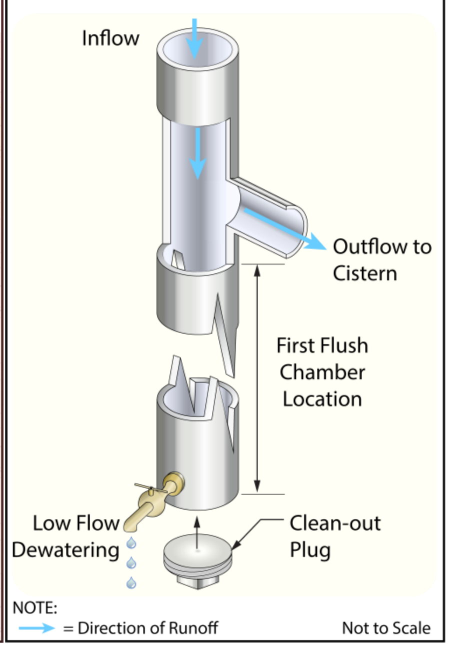
Pretreatment is required for all cisterns to extend the functional life of a cistern by capturing coarser material. Pretreatment options for cisterns may include:

- **Leaf Screens** are mesh screens that separate leaves and other debris from the stormwater runoff, one type of which is shown below, on the left. Leaf screens must be maintained regularly to prevent clogging, which could prevent flow into the cistern. Additionally, poorly maintained leaf screens may lead to the growth of harmful bacteria.

Leaf Screen

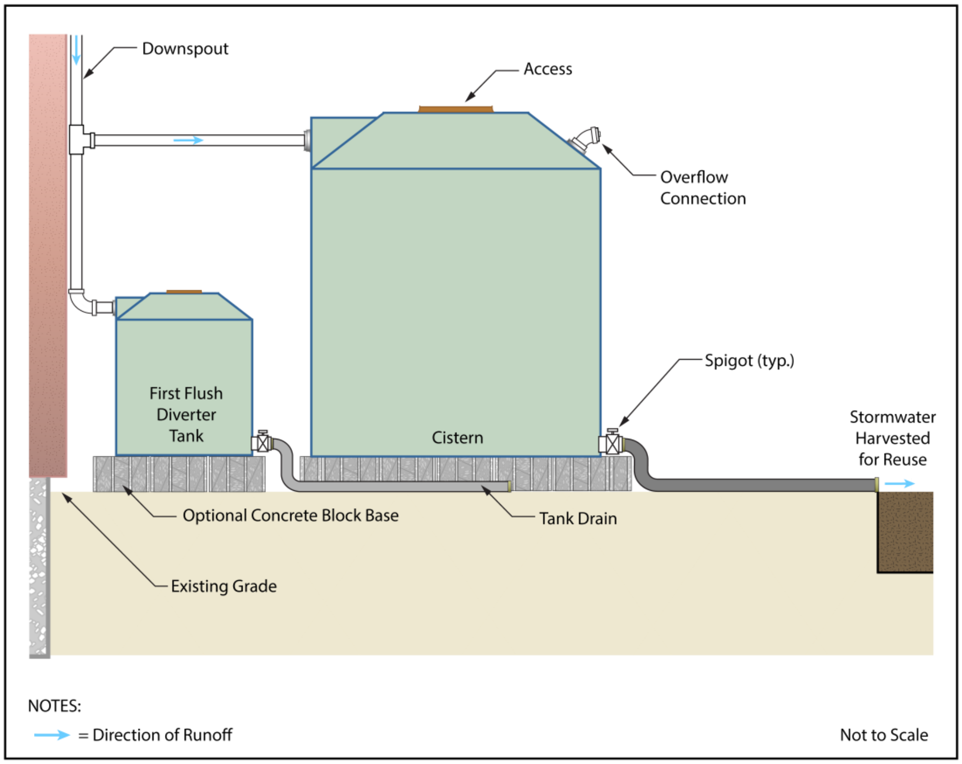


First Flush Diverter

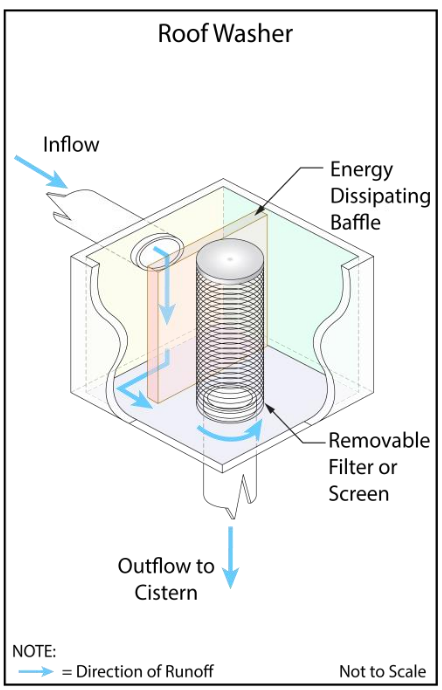


- **First Flush Diverters** are devices that direct stormwater generated at the start of a precipitation event away from a cistern. This *first flush* of runoff tends to wash smaller contaminants that have built up on the rooftop surface into the cistern; these contaminants may include dust, pollen, other airborne pollutants and animal feces. First flush diverters may be simple, manually-operated devices or more complicated automatic systems. One of the many types of first flush diverters is shown above in the illustration on the right. A cistern that drains a large roof may require the use of a tank to capture the entire first flush volume, as shown on the following page. Regardless of the type selected, all first flush diverters must be emptied between storm events to ensure sufficient storage is available for the next storm event.

Surface Cistern with First Flush Diverter Tank



- **Roof Washers** are devices placed just before the inflow into the cistern. Roof washers consist of a storage device that allows for some settling, as well as fine screens over the outlet; these devices are intended to treat the fine particulates in runoff. Roof washers must be maintained on a regular basis to prevent clogging. An illustration of one type of roof washer is shown below.



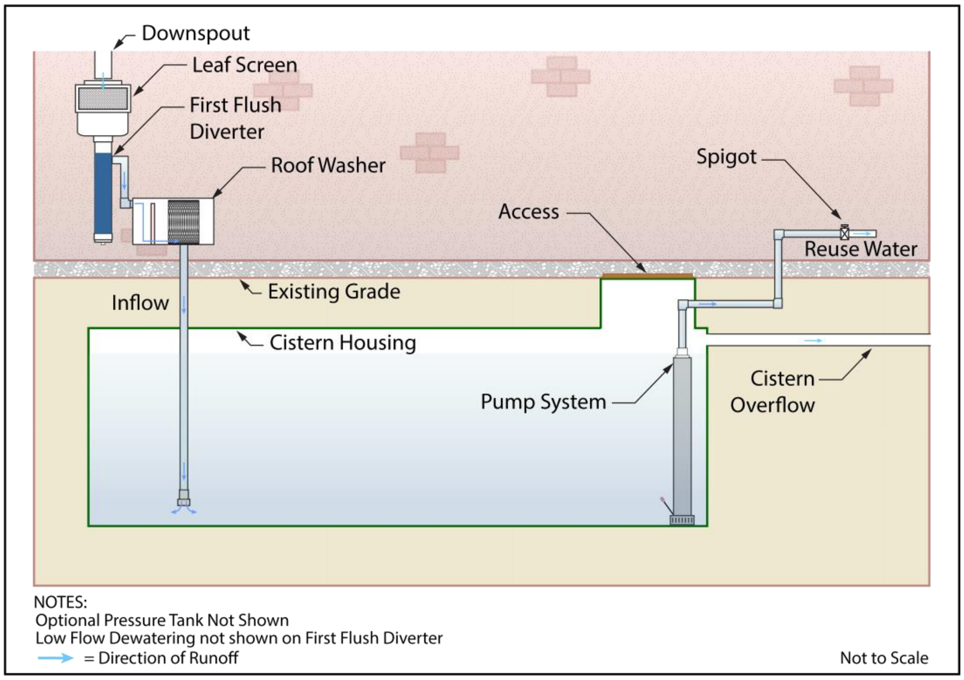
Cistern Location and Placement

- The hydraulic head required to distribute the water to the receiving area must be calculated so that the minimum required elevation of the cistern can be determined. If it is infeasible to place a cistern at the required elevation, a pump will be necessary.

- Subsurface cisterns should be placed above the seasonal high water table. If this is not feasible, proper buoyancy calculations, the installation of hold-down fasteners or other methods to counter uplift must be included in the system design. Refer to the additional requirements regarding the seasonal high water table for cisterns designed with the extended detention option which begins on page 8.

  Subsurface cisterns must not be located under high vehicle loading areas or areas with high volumes of vehicular traffic, which may cause structural damage to the cistern. If this is not feasible, the system must be designed to withstand all anticipated traffic and other design loads. The illustration below shows one possible configuration and flow path of a subsurface cistern and is not intended to limit the design.

Subsurface Cistern



Safety

- Cisterns must be designed to safely convey overflows to downstream drainage systems. The design of the overflow structure must be sufficient to provide safe, stable discharge of stormwater in the event of an overflow. Safe and stable discharge minimizes the possibility of adverse impacts, including erosion and flooding (even in areas outside of the flood hazard area) such as nuisance flooding, in down-gradient areas. Therefore, discharge in the event of an overflow must be consistent with the *Standards for Off-Site Stability* found in the *Standards for Soil Erosion and Sediment Control in New Jersey*.

- Blind connections to downstream facilities are prohibited. Any connection to downstream stormwater management facilities must include access points such as inspection ports and manholes, for visual inspection and maintenance, as appropriate, to prevent blockage of flow and ensure operation as intended. All entrance points must adhere to all Federal, State, County and municipal safety standards such as those for both working in and entering confined spaces.

Structural Considerations

- The combined weight of the cistern and the collected rainwater could be significant; therefore, when placing a cistern on a rooftop, the structural integrity of the rooftop must be considered.
- When cisterns are placed at or below grade, the weight bearing capacity of the soil must be considered with the weight of the cistern at full capacity.
- In some instances, a base or foundation may be necessary. A cistern base may consist of aggregate, concrete or block and must be designed to support the weight of the cistern at full capacity. Failure to adequately design the foundation for a cistern may lead to settling and toppling of the cistern.

Mosquitoes

- Poorly designed cisterns may create habitat suitable for mosquito breeding. All cistern designs must include screens or other measures to prevent mosquitoes and other insects from entering the tanks. If screens are not sufficient, dunks or pellets to control mosquito larvae must be added to cisterns. Refer to the local or county mosquito commission for assistance on controlling mosquitoes.

Cold Weather

- In order to be credited toward compliance with the Stormwater Management rule, cisterns must be able to function year-round. Therefore, a cistern may need to be located 3 feet or more below grade, indoors, or otherwise winterized to prevent collected runoff from freezing. Downspouts and overflow components must be checked periodically for ice blockages particularly after storm events and during snowmelt.

Requirements for the Extended Detention Option

A cistern may be constructed as part of an on-line, combination system to provide extended detention for larger storm events. Runoff from, at a minimum, the Water Quality Design Storm is collected and stored for reuse, while runoff from larger storm events exits the system through a quantity control outlet. Such a system must include a dead storage area for reuse below the temporary storage area that provides detention, similar to that of an infiltration basin that is also operating with a detention function to meet the water quantity requirements.

Storage Volume

- Cisterns with an extended detention component must additionally be designed to meet the requirements of *Chapter 9.4: Extended Detention Basins*, including but not limited to, the requirement to be above the seasonal high water table.
- Cisterns with an extended detention component must be designed to store runoff generated by the WQDS for reuse and may also be designed to temporarily store and attenuate runoff from larger design storms.

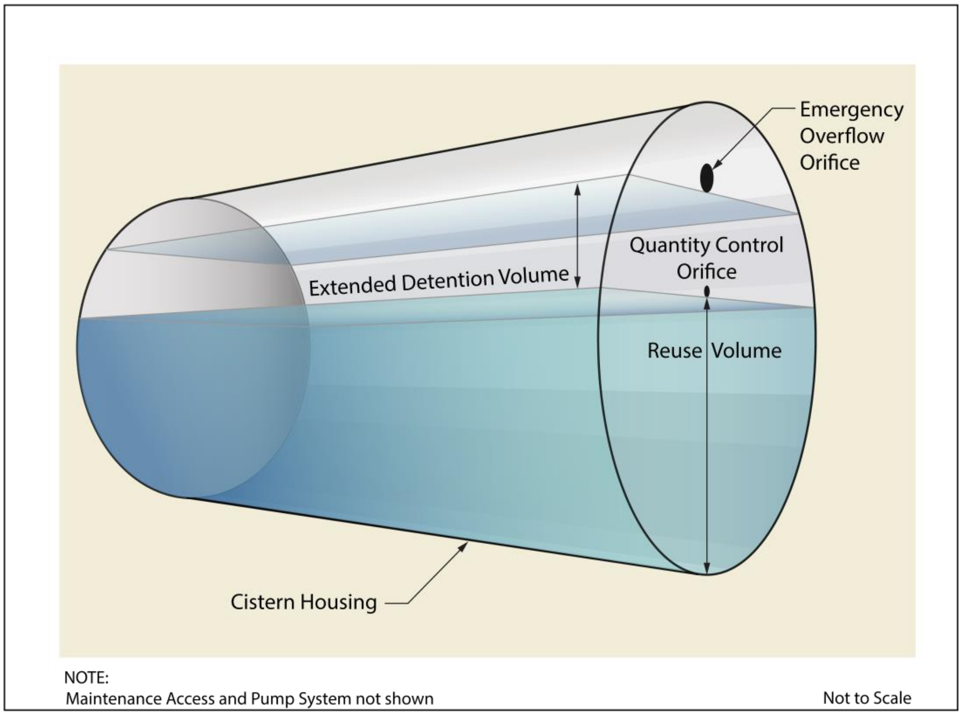
Outlet Structure

In instances where the lowest invert in the outlet or overflow structure is below the flood hazard area design flood or tide elevation in a downstream waterway or stormwater collection system, the effects of tailwater on the hydraulic design of all stormwater quantity control outlets must be analyzed. Two methods to analyze tailwater are:

- A simple method entails inputting flood elevations for the 2-, 10-, and 100-year events as static tailwater during routing calculations for each storm event. These flood elevations are either obtained from a Department flood hazard area delineation or a FEMA flood hazard area delineation that includes the 100-year flood elevation or derived using a combination of NRCS hydrologic methodology and a standard step backwater analysis or level pool routing, where applicable. In areas where the 2-year or 10-year flood elevation does not exist in a FEMA or Department delineation, it may be interpolated or extrapolated from the existing data. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the detailed method below can be used or the BMP must be redesigned.
- A detailed method entails the calculation of hydrographs for the watercourse during the 2-, 10-, and 100-year events using NRCS hydrologic methodology. These hydrographs are input into a computer program to calculate rating curves for each event. Those rating curves are then input as a dynamic tailwater during the routing calculations for each of the 2-, 10-, and 100-year events. This method may be used in all circumstances; however, it may require more advanced computer programs. If this method demonstrates that the requirements of the regulations are met with the tailwater effect, then the design is acceptable. If the analysis shows that the requirements are not met with the tailwater effects, the BMP should be redesigned.

The illustration on the following page depicts a subsurface cistern with extended detention. For additional information on the design, operation and maintenance of the extended detention components, refer to *Chapter 9.4*: *Extended Detention Basins*.

Subsurface Cistern with Extended Detention



Designing a Cistern

A cistern stores runoff from the WQDS to be reused over the course of three (3) days, following rainwater capture. Therefore, it is necessary to ensure that the cistern water reuse demand at the project site is sufficient to ensure that the cistern is emptied in time for the next rain event. A cistern-analysis spreadsheet intended to help size a cistern for site-specific conditions may be found at: http://www.nj.gov/dep/stormwater/bmp_manual/cistern_spreadsheet.xlsx. The following examples illustrate how to use a cistern to reduce the volume of runoff from a rooftop and how to use the spreadsheet to aid in the sizing of the cistern. These examples show possible configurations and flow paths and are not intended to limit the design.

Example 1: The runoff from a 2,500 sf roof will be collected in a subsurface cistern and will be reused inside a building to flush toilets and urinals. The following parameters apply:

Roof Area	**2,500 sf**
First Flush Diversion	**0.01 inches**
Weekday Building Occupancy	**100**
Weekend Building Occupancy	**50**

Step #1: Input Basic Parameters

Begin on the first worksheet of the cistern sizing spreadsheet, entitled *INPUTS AND RESULTS*. The first input is the area of the roof that will drain to the cistern; for this example, the area of the rooftop is 2,500 sf. The next is the amount of rainfall that will be diverted by the first flush diverter; which is set at at 0.01 inches. The final input that is needed is the curve number of the roof, which in most situations will be 98, unless a green roof is being used.

Initial Inputs

	A
1	INPUTS
2	
3	WHAT IS THE ROOF AREA THAT DRAINS TO THE CISTERN? (SQUARE FEET)
4	2,500.00
5	WHAT AMOUNT OF RUNOFF IS DIVERTED BY THE FIRST FLUSH DIVERTER? (INCHES)
6	0.01
7	CURVE NUMBER ROOF - ASSUMED 98, UNLESS USING A GREEN ROOF
8	98

Step #2: Input Water Reuse Information

Next, move on to the second worksheet, entitled *WATER USE (TOILETS)*. The first set of inputs will determine the daily toilet/urinal use based on 1.6 gallons/toilet flush and 1.0 gallons/urinal flush; these inputs include the number of people that use the building, the percentage of users that exclusively use toilets and the percentage of weekday use that is expected on weekends. This worksheet assumes 3 flushes/8-hour workday/person. It also assumes that of those 3 flushes by males 2 are for urinals and 1 is for toilets. If the water use of toilets and urinals in the building are known, and differ from these default usage numbers, these can also be directly input into the worksheet.

Toilet/Urinal Reuse

	A	B	C
1	CALCULATED TOILET USE PER DAY (GALLONS)		
2			HOW MANY PEOPLE USE THE BULDING?
3	WEEKDAY		100
4	840.00		WHAT PERCENTAGE OF THE PEOPLE EXCLUSIVELY USE TOILETS?
5	WEEKEND		50
6	420.00		HOW MUCH WATER IS USED BY EACH TOILET? (GALLONS/FLUSH)
7			1.6
8			HOW MUCH WATER IS USED BY EACH URINAL? (GALLONS/FLUSH)
9			1
10			HOW MANY HOURS PER DAY IS THE BUILDING USED?
11			16
12			WHAT PERCENTAGE OF WEEKEDAY USE IS EXPECTED ON WEEKENDS?
13			50

Step #3: Review of Cistern Size

Once all the information is entered, proceed back to the first worksheet, entitled *INPUTS AND* RESULTS. The green cells on the left hand side will show both the minimum volume of water the building will use in a three (3) day period and the minimum capacity of the cistern based on the WQDS in both gallons and cubic feet. The spreadsheet will identify if the building's water usage is sufficient to justify the size of the cistern. It is important to review the calculated information to determine if the parameters are appropriate.

Results

9	MINIMUM VOLUME OF WATER, BUILDING UTILIZES DURING A THREE (3) DAY PERIOD. (GALLONS)	
10	1,680.00	
11	MINIMUM VOLUME OF WATER, BUILDING UTILIZES DURING A THREE (3) DAY PERIOD. (CUBIC FEET)	
12	224.58	
13	WATER QUALITY DESIGN STORM VOLUME (CISTERN'S MINIMUM CAPACITY) (GALLONS)	
14	1,596.74	
15	WATER QUALITY DESIGN STORM VOLUME (CISTERN'S MINIMUM CAPACITY) (CUBIC FEET)	
16	213.45	
17		
18	RESULT - 1ST STEP	
19	BUILDING'S WATER USAGE IS SUFFICENT TO JUSTIFY A CISTERN	
20	1,294.41	GALLONS

Step #4: Optional Detention for Larger Storm Events

If desired, the cistern may also be used for the detention of larger storm events. The volume calculated by the spreadsheet would be located below the quantity control outlet(s) of the cistern and a temporary storage volume above the outlet(s) would be used to provide detention. This temporary storage volume would be sized using a routing calculation. For additional information on the design, operation and maintenance of the extended detention components refer to Chapter 9.4: *Extended Detention Basins*.

Example 2: The runoff from a 3,000 sf roof will be collected in a subsurface cistern and will be reused inside the building to flush toilets and urinals and can also be used for vehicle washing. The following parameters apply:

Roof Area	**3,000 sf**
First Flush Diversion	**0.01 inches**
Weekday Building Occupancy	**100**
Weekend Building Occupancy	**50**

Step #1: Input Basic Parameters

As done in the previous example enter the appropriate information in the orange cells on the first worksheet, entitled *INPUTS AND RESULTS*. The first input is the area of roof that will drain to the cistern; for this example, the area of the rooftop is 3,000 sf. The next input is the amount of rainfall that will be diverted by the first flush diverter, just as before, the diversion is set at 0.01 inches. The final input that is needed is the curve number of the roof, which as mentioned previuosly in most situations will be 98, unless a green roof is being used.

Initial Inputs

	A
1	INPUTS
2	
3	WHAT IS THE ROOF AREA THAT DRAINS TO THE CISTERN? (SQUARE FEET)
4	3,000.00
5	WHAT AMOUNT OF RUNOFF IS DIVERTED BY THE FIRST FLUSH DIVERTER? (INCHES)
6	0.01
7	CURVE NUMBER ROOF - ASSUMED 98, UNLESS USING A GREEN ROOF
8	98

Step #2: Input Water Reuse Information

As done in the previous example, enter the appropriate information in the orange cells on the second worksheet, entitled *WATER USE (TOILETS)*. These numbers correspond with the numbers used in the previous example. Remember, if the water use of toilets and urinals in the building is known and differs from the default usage numbers, these values can also be directly input into the worksheet.

Toilet/Urinal Reuse

	A	B	C
1	CALCULATED TOILET USE PER DAY (GALLONS)		
2			HOW MANY PEOPLE USE THE BULDING?
3	WEEKDAY		100
4	840.00		WHAT PERCENTAGE OF THE PEOPLE EXCLUSIVELY USE TOILETS?
5	WEEKEND		50
6	420.00		HOW MUCH WATER IS USED BY EACH TOILET? (GALLONS/FLUSH)
7			1.6
8			HOW MUCH WATER IS USED BY EACH URINAL? (GALLONS/FLUSH)
9			1
10			HOW MANY HOURS PER DAY IS THE BUILDING USED?
11			16
12			WHAT PERCENTAGE OF WEEKEDAY USE IS EXPECTED ON WEEKENDS?
13			50

Step #3: Review of Cistern Size

As done in the previous example, once all the information is entered, proceed back to the first worksheet, entitled *INPUTS AND* RESULTS. The green cells will show both the minimum volume of water the building will use in a three (3) day period and the minimum capacity of the cistern based on the WQDS in both gallons and cubic feet. The spreadsheet will identify if the building's water usage is sufficient to justify the size of the cistern. It is important to review the calculated information to determine if the parameters are appropriate. The results are shown on the following page.

Results

9	MINIMUM VOLUME OF WATER, BUILDING UTILIZES DURING A THREE (3) DAY PERIOD. (GALLONS)
10	1,680.00
11	MINIMUM VOLUME OF WATER, BUILDING UTILIZES DURING A THREE (3) DAY PERIOD. (CUBIC FEET)
12	224.58
13	WATER QUALITY DESIGN STORM VOLUME (CISTERN'S MINIMUM CAPACITY) (GALLONS)
14	1,916.08
15	WATER QUALITY DESIGN STORM VOLUME (CISTERN'S MINIMUM CAPACITY) (CUBIC FEET)
16	256.14
17	
18	RESULT - 1ST STEP
19	BUILDING'S WATER USAGE IS INSUFFICENT TO JUSTIFY A CISTERN
20	
21	RESULT - 2ND STEP

Step #4: Toilet/Urinal Reuse Not Sufficient

Unlike in the previous example, here the building's lowest 3-day cistern water reuse (toilet & urinals) is not sufficient to empty the cistern. It is important to note that, since the building in this example has lower cistern water reuse demand on weekends, those lower weekend numbers were used to determine if the cistern would be emptied after 3 days. If the average demand is high enough to empty the cistern in 3 days, then the use of a cistern is still possible, but will require a secondary storage tank.

Step #5: Secondary Storage Tank

As noted earlier in this Chapter, water from the cistern can be pumped into a secondary storage tank for later reuse, which will ensure that the cistern is empty for the next storm event. In situations like this example, where the lowest 3-day cistern water reuse is insufficient to empty the entire cistern, the secondary tank is necessary. However, the designer must still ensure that there is sufficient demand at the project site to use the water in the secondary storage tank.

Step #6: Vehicle Washing

In this example, vehicle washing will also occur, which will use additional cistern water. Move to the third worksheet, entitled *WATER USE (OTHER)* and input the vehicle washing reuse numbers. One can assume that each vehicle takes approximately 100 gallons of water to wash, unless the facility has a more efficent system. In this example, ten (10) vehicles will be washed every Friday, totaling 1,000 gallons of water a week. This section of the worksheet is shown on the following page.

Vehicle Washing Reuse

HOW MUCH WATER WILL BE USED TO WASH VEHICLES? (GALLONS)		WEEKLY AMOUNT (GALLONS)
MONDAY		1,000.00
0.00		
TUESDAY		
0.00		
WEDNESDAY		
0.00		
THURSDAY		
0.00		
FRIDAY		
1,000.00		
SATURDAY		
0.00		
SUNDAY		
0.00		

Step #7: Secondary Storage of Cistern Size

As done earlier in this example, once all the information is entered, proceed back to the first worksheet, entitled *INPUTS AND* RESULTS.There is now a new field called *Result – 2nd Step*. The spreadsheet will identify if the building's additional water usage is sufficient to justify the size of the cistern. It is important to review the calculated information to determine if the parameters are appropriate. Note that numerical value appearing below the yellow cell identifies the minimum size of the temporary storage tank necessary to allow the cistern to work appropriately. Here, the additional water usage is sufficient to justify a cistern, as long as an additional storage tank that stores approximately 1,703 gallons is also constructed to ensure the cistern is able to be emptied within a week.

Results

RESULT - 2ND STEP	
ADDITIONAL WATER USAGE IS SUFFICIENT TO JUSTIFY A CISTERN	
ADDITIONAL STORAGE TANK NECESSARY (GALLONS)	
1,703.08	GALLONS

Considerations

Plumbing Code

This chapter does not directly address indoor or outdoor plumbing codes. Designers and reviewers should consult with the New Jersey Plumbing Code N.J.A.C. 5.23-3.15 as well as with any applicable municipal plumbing codes. In cases where stormwater is being harvested for indoor use cisterns should have backflow preventers or air gaps to keep collected stormwater separate from the potable water supply. Any pipes or spigots that use harvested rainwater should be clearly labeled as non-potable. All rainwater harvesting design plans should be signed and sealed by a certified professional.

Freeboard

In cases where larger storms will not be diverted around this cistern, sufficient freeboard should be included above the outlet to allow for large storm events to pass through the cistern without backing up into upstream pipes or spilling out onto nearby surfaces. It is recommended that such systems have a high water alarm system with emergency power backup and that the maintenance plan include periodic testing of the alarm system.

Disposal of Vehicle Wash Water

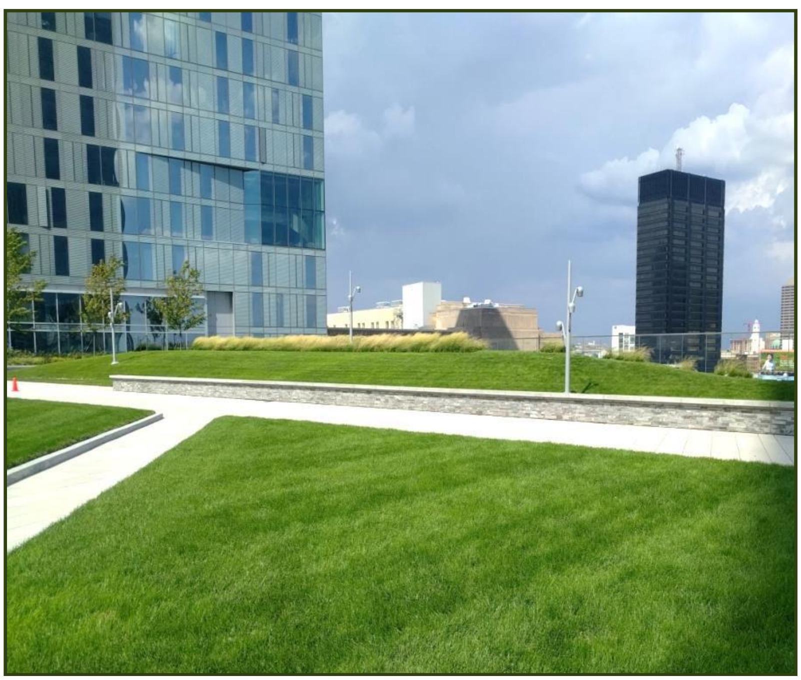
If stormwater runoff collected in a cistern will be reused for vehicle washing, it is important to keep in mind that any wastewater from vehicle washing is not permitted to enter into any storm sewer inlets or be discharged into any waters of the State. This wastewater can either be discharged into a sanitary sewer or it may be temporarily contained in a holding tank to be pumped and hauled to an appropriate wastewater treatment facility.

Additional Storage Volume

It may be necessary to include an additional dead storage area or sump so that the pump will not run dry. When selecting a cistern, this additional storage volume should be included in the cistern sizing calculation.

Alternative Designs

Cisterns are not limited to designs involving a storage tank type housing. As previously mentioned, cisterns may be above-grade structures. A novel approach is to make it part of a roof design, such as what is shown in the photo below. The open cell plastic layer between the pavers and the drainage structure is a broad, shallow cistern. Stormwater runoff collected from the paver areas flows down into the open cell layer, where it is stored and later harvested to support the green roof vegetation shown in the second image.



Maintenance

Regular and effective maintenance is crucial to ensure effective cistern performance. A cistern used to meet any State requirement must have a maintenance plan. For projects that are major developments, there are a number of required elements in all maintenance plans, pursuant to N.J.A.C. 7:8-5.8; these are discussed in more detail in *Chapter 8: Maintenance of Stormwater Management Measures*. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) Rules, N.J.A.C. 7:14A. Specific maintenance activities for cisterns are presented below; these activities should be included in the cistern's maintenance plan.

General Maintenance

- Cisterns (including any secondary storage tanks) must be inspected at least four times annually and after every storm event exceeding 1 inch of rainfall.
- All structural components must be inspected for cracking, subsidence, spalling, erosion and deterioration at least once annually.
- Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.
- Access points for maintenance are required on all cisterns; these access points should be clearly identified in the maintenance plan. In addition, any special training required for maintenance personnel to perform specific tasks must be included in the plan.
- All pretreatment options must be cleaned regularly to ensure that the cistern is operating as intended and flow is not being directed away from the cistern due to the buildup of debris.
- All pumps, controls and alarms must be inspected at least annually and maintained in accordance with the manufacturer's requirements. Should a component fail, corrective action must be taken immediately. The maintenance log book must include a section to record all maintenance information regarding pumps, controls and alarms.

Drain/Reuse Time

- The cistern must be inspected regularly to ensure that it is empty within 72 hours of the end of a rainfall event. If the cistern fails to be emptied within 72 hours, corrective action must be taken immediately.

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