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| Project Name | | Minnesota Stormwater Manual Harvest and Use Updates | Date | | 2-10-2016 |
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| Regarding | | Task B. Overview of Harvest and Use DRAFT | | |

# Latest revision: August 24, 2016 (includes tech team member comments and tech team August 22 meeting comments)

# Definitions and Terminology

Backwash: Water that is pumped in reverse through filters, removing trapped sediment and other collected material

Beneficial use of stormwater: Use of stormwater to meet water demands, including but not limited to: irrigation, drinking, washing, bathing, cooling, and flushing. Commonly referred to as “reuse.”

Cistern: A tank that stores water.

Source area: Surface area from which water is harvested (e.g., rooftop, roadway, green space).

Collection efficiency: Harvested water volume as a percent of the total rainfall on the source area during a certain period of time.

Disinfection: Reduction of viable micro-organisms to a level that is deemed suitable for the intended use.

Dry running protection: System for protecting a water pump against running when no water is present.

First flush device: A device that diverts runoff generated during the beginning of a rainfall event, which carries higher levels of debris and contaminants from collection surfaces, from entry into storage components. Only suited for warm weather applications. Extreme caution should be observed in cold climates.

Green Roof: a rooftop treatment practice where a thin planting media is established on roof surfaces and then planted with hardy, low–growing vegetation

Harvested water: Water that is collected from impermeable surfaces, such as rooftops and parking lots, and stored for future use.

Make-up water supply: Municipal water or other reliable water source that is used to supply water for beneficial use in the event that harvested water is not available.

Non-potable water: Water that does not meet drinking water standards.

Overflow Siphon: Functions as a trap to keep out vermin and also to evacuate floating pollen and debris in the tank during rain events.

Potable water: Water that meets drinking water standards.

Pre-storage treatment: Best management practices that are used upstream of the storage unit.

Pretreatment: Treatment of harvested stormwater prior to entering the storage unit; typically processes that remove trash, gross solids, and particulate matter.

Post-storage treatment: Practices that are used to remove fine particulates, dissolved pollutants and microorganisms from harvested rainwater.

Rainwater: A form of stormwater that is collected directly from roof surfaces which can have lower levels of pollutants than other sources of stormwater.

Recycled Water: Water which, as a result of treatment of waste, is suitable for direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource (Current California Water Code 13050-13051)

Reuse: Use of stormwater, greywater, or blackwater to meet water demands, including but not limited to: irrigation, drinking, washing, cooling, and flushing.

Runoff: The portion of rainfall or snowmelt not infiltrated, evaporated, or transpired that drains or flows over the land and becomes surface flow.

Stormwater: Rainfall or snowmelt that runs off surfaces.

Sub-surface irrigation: Water that is applied below ground level for plants and is not directly exposed to above ground surface and/or air.

Surface irrigation: Water that is applied above ground level for plants and is directly exposed to the above ground surface and/or air.

System pressure: Pressure needed to deliver water to the designated fixtures.

Treatment: Treatment of harvested stormwater after storage but prior to distribution; typically processes that remove dissolved pollutants and bacteria.

Wastewater: Used or spent water containing pollutants or solids and discharged from homes, commercial establishments, farms, or industries.

Water harvesting: The process of capturing and retaining water for beneficial uses at a different time or place than when or where the water was generated.

Water yield: The volume of harvested water over a certain period of time.

# Overview of Water Harvesting and Use

The objective of this section is to provide guidance on the design, construction, and maintenance of stormwater harvesting and use systems for management of stormwater by cities, engineers, and other stormwater managers. Stormwater harvesting and use is part of a larger concept of ‘reuse’, the practice of collecting stormwater, greywater, or blackwater to meet water demands, including but not limited to: irrigation, drinking, washing, cooling, and flushing. The focus of this section will be on the harvesting and use of stormwater, but the harvesting and use of stormwater can be combined with the harvesting and use of greywater and blackwater, for which other regulations and guidelines apply. In Minnesota, please contact the Minnesota Department of Health for questions related to harvest and use of greywater or blackwater.

A **stormwater harvesting and use system** is a constructed system that captures and retains stormwater for beneficial use at a different time or place than when or where the stormwater was generated. A stormwater harvesting and use system potentially has five components (Figure 1):

* **collection system** (which could include the catchment area and stormwater infrastructure such as curb, gutters, and stormsewers),
* **storage unit** (such as a cistern or pond)
* **treatment system: pre- and post-storage** (that removes solids, pollutants and microorganisms, including any necessary control systems), if needed, and the
* **distribution system** (such as pumps, pipes, and control systems).

The specific components of a stormwater harvesting and use system vary by the **harvested stormwater source** (rooftops, low density development, traffic areas, etc.) and the **beneficial use of stormwater** (irrigation, flushing, washing, bathing, cooling, drinking, etc.). Commonly in stormwater harvest and use, rainwater is differentiated from stormwater and is defined as stormwater runoff collected directly from roof surfaces which can have lower levels of pollutants and it often requires less treatment than other forms of stormwater. However, rainwater is still stormwater and depending on the use, may require treatment prior to use. See Table 1 below for a summary matrix of harvested water sources and beneficial uses. (Call out box?) The components, design, construction, and operation & maintenance of a water harvesting and use system are described in more detail in the Design Guidance, Construction Sequence, and Operation & Maintenance sections.

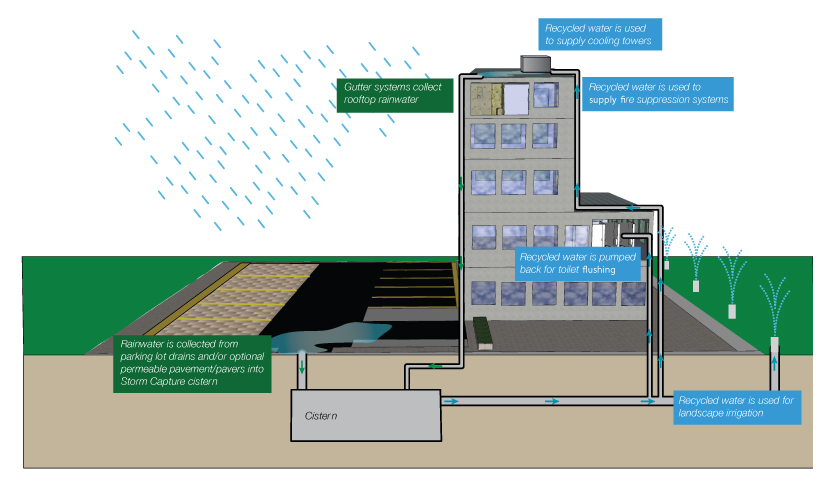
The source area of harvested stormwater largely determines the quality of the stormwater supply in a stormwater harvest and use system. As precipitation accumulates and flows over surfaces it collects pollutants and microbial contaminants . The type of and quantity of pollution in stormwater depends on the composition of the surfaces over which stormwater runoff flows and the activities within the drainage area that generate pollution. (Call out box?) Water quality considerations of harvested water are described in more detail in the Water Quality Considerations section.

The quantity of runoff that can be harvested is dependent on the depth and intensity of precipitation as well as the capacity of the source area to shed or retain water. (Call out box?) Quantification of runoff that can be harvested from a site is described in more detail in the Calculators section.

The beneficial use of stormwater determines the volume and treatment criteria needed. Common beneficial uses of stormwater are described in this memo under the section ‘Beneficial Use of Stormwater Key Considerations.’ (Call out box?) Methods for estimating beneficial use water volume demand are outlined in the Design Guidance and Calculators section. (Call out box?) Water quality criteria for different beneficial uses of stormwater are discussed in more detail in the Water Quality Considerations section.

A central consideration in any stormwater harvesting and use system is matching the water quality of harvested stormwater with the water quality requirements of the beneficial use of stormwater. Water quality requirements for beneficial uses of stormwater are often context-specific and required treatment will vary depending on source water quality. Water quality requirements for beneficial uses of stormwater are based on the risks posed to human health (i.e., health criteria) and/or to the environment. For some uses, industry-specific standards may also apply. The difference between the water quality of the harvested stormwater and the water quality requirements of the beneficial use of stormwater must be addressed by incorporating appropriate treatment components into the stormwater harvesting and use system. The water quality requirements of common beneficial uses of stormwater and the level of treatment needed for various types of harvested stormwater to meet these requirements are summarized in Table 1. These concerns are taken up in greater detail in the Water Quality Considerations section.

Finally, the specific components of a water harvesting and use system determine the costs, environmental concerns and long term maintenance of a system. These topics are discussed in more detail in the Costs, Environmental Concerns, and Operation and Maintenance sections.



**Storage Unit:**

Cistern or pond

**Distribution System:**

Pumps and pipes needed to distribute harvested water to the indoor or outdoor uses

**Treatment System:**

Such as filtration or disinfection

**Collection System:**

Stormwater is collected from rooftops and nearby catchment area

Figure 1. Example Stormwater Harvesting and Use System Schematic.

The first should include a rainwater harvesting system with the minimum standards in Standard 63 (prefiltration, SI, OS, FF drawn into system) sediment filtration for outdoor use and sediment, carbon and disinfection (typ UV, Ozone or Cl inject) and backup water supply for indoor. I would also recommend that the rainwater system show overflow to a secondary bmp such as infiltration system. The second would be a ground capture system and should at a mimimum include information in ARCSA/ASPE standard 78. These figures should represent what is currently allowable under code in MN and can be adapted as codes change for greywater and stormwater. If requested, Stark can provide schematics and approvals from RMS to use or to be changed by EOR. These do not need to be vendor specific, but there are typical standards and they differ because of source water for rainwater and stormwater capture. See Virginia manual for good details on in tank components and overflow to secondary draw down.

Table 1. Water harvesting and use system matrix

The color coding represents the ‘average’ or typical health criteria level for each beneficial use of stormwater (based on guidance from Metropolitan Council, 2011). The level of effort needed to achieve the health criteria level is illustrated by the number of circles. Just stormwater harvest and use is described in detail in this section. Please contact the Department of Health and Department of Labor and Industry for questions related to harvest and use of wastewater. .

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Beneficial Uses | | Harvested Water | | | |
| Stormwater from rooftops only (rainwater) | Stormwater |  |  |
| High quality Low quality | | | |
| Outdoor | Sanitary sewer flushing | ⭘ | ⚫ |  |  |
|  |  |  |  |  |
| Irrigation – low exposure risk | (⚫) | ⚫(⚫) |  |  |
| Irrigation – high exposure risk | ⚫(⚫) | ⚫⚫(⚫) |  |  |
| Vehicle/building washing | ⚫(⚫) | ⚫(⚫) |  |  |
| Fire fighting | (⚫) | ⚫(⚫) |  |  |
| Water features (uncontrolled access) | ⚫⚫ | ⚫⚫ |  |  |
| Street cleaning/ dust control | ⚫(⚫) | ⚫(⚫) |  |  |
|  | ⚫(⚫) | ⚫(⚫) |  |  |
| Indoor | Fire suppression | ⚫⚫ | ⚫⚫ |  |  |
| Cooling | ⚫(⚫) | ⚫(⚫⚫) |  |  |
| Process /Boiler Water | ⚫(⚫) | ⚫(⚫⚫) |  |  |
| Flushing | ⚫(⚫) | ⚫⚫(⚫) |  |  |
| Washing | ⚫⚫ | ⚫⚫(⚫) |  |  |
| Drinking water | ⚫⚫⚫⚫ | ⚫⚫⚫⚫ |  |  |

***Key:***

§*Health Criteria Level for use category. Based State on State of California, Water Recycling Criteria, 2000 (Met Council, 2011). The ‘average’ or typical level is shown. In practice health criteria will be context specific.*

⚫= 1 Limited human exposure at point of use and limited exposure to pathogens upstream of point of use.

⚫= 2 Limited human contact and controlled access at point of use.

⚫= 3 Uncontrolled access at point of use.

⚫= Drinking water standards

⚫= not currently practiced regionally/not recommended (NAS, 2015; EPA, 2012)

*Expected level of effort needed to meet water quality criteria (relative scale)*

⭘ = no treatment needed

⚫= minimal (pretreatment)

⚫⚫= medium (pretreatment + disinfection OR pretreatment + treatment)

⚫⚫⚫= high (pretreatment + treatment + disinfection)

⚫⚫⚫⚫= drinking water standards

() = parenthesis indicate a level of treatment that may be required depending on context.

# Beneficial Use of Stormwater Key Considerations

Beneficial uses of stormwater include any use of water to meet individual or societal water needs, including but not limited to: irrigation, drinking, washing, bathing, cooling, and flushing. Beneficial uses of stormwater pose different levels of human health risk based on whether public access is “restricted” or “unrestricted”. A use is restricted if public access can be controlled, such as irrigation of golf courses, cemeteries, and highway medians. A use is unrestricted if public access cannot be controlled, such as irrigation of parks, toilet flushing, firefighting, or water feature uses. Unrestricted beneficial uses of stormwater have more stringent water quality regulations that limit public health risk and exposure to pollutants and microorganisms than restricted beneficial uses of stormwater (Alan Plummer Associates, 2010; NRMMC *et al*., 2009; USEPA, 2004). Other ways to classify beneficial uses of stormwater include water quality criteria (potable/non-potable use); setting (indoor/outdoor, urban/rural, residential/municipal/commercial/industrial, etc.), and scale of implementation (private, neighborhood, regional, etc.).

Key considerations for choosing a beneficial use of stormwater include the demand characteristics (seasonal, constant, intermittent, etc.) which influence the design of the makeup supply; exposure level (no contact, limited contact, unrestricted contact) which influence treatment system design; and the scale of implementation (some applications are better suited to multi-residential or commercial settings). In addition, storage availability and distance between the water source and the beneficial use of stormwater can affect cost and therefore adoption rates, but not inherently affect the technical feasibility.

Key considerations for specific beneficial uses of stormwater which are represented in the reference literature are discussed categorically in the text that follows. In-depth discussion of considerations for beneficial uses of stormwater can be found in: *Using Graywater and Stormwater to Enhance Local Water Supplies: An Assessment of Risks, Costs, and Benefits* (NCDENR, 2014) and *2012 Guideline for Water Reuse* (USEPA, 2012; see Chapter 2).

## Outdoor Uses

Outdoor uses include irrigation, water features, sanitary sewer flushing, street cleaning/dust control, vehicle/building washing, firefighting, recharge, and ornamental and recreational wetlands. Plumbing codes and requirements for outdoor systems may be less restrictive than those for indoor use; however, in any system, appropriate measures must be taken to prevent contamination of drinking water supply and minimize health risk exposure.

### Irrigation

Irrigation is the most common use of harvested water and therefore examples and case studies are more plentiful for this use. In some communities, especially more recently developed suburban areas, the demand for irrigation on the community’s water system can increase significantly during the summer months, at times doubling, tripling, or more the base water demand. Harvested water collected in a community could be used to meet their irrigation water demands, or could be transported via water trucks to meet off-site irrigation needs, such as ultra-urban, downtown settings.

Estimating demand for irrigation water can require complex calculations that take into account not only the size of the irrigation plot, but also the type of plantings and seasonal climatic factors (evapotranspiration, plant water use coefficients, precipitation, humidity, etc.). Given the practicality of harvesting water for irrigation, a wide variety of tools have been developed for estimating irrigation demand. Water demand will be greater for irrigation systems which are susceptible to evaporation losses (sprinkler, spray).

Water quality criteria for irrigation vary depending on the risk of exposure at the point of use (restricted vs. unrestricted public access), the type of crop (food crops vs. non-food crops), and, if applicable, the point of sale of food crops (fresh produce vs. processed food). Water used in animal operations for watering or cleaning may require additional treatment. Additional considerations include maintenance of equipment (potential clogging of spray nozzles) and risk of exposure for wildlife. Stormwater harvested in cold climates can have elevated chloride levels from winter applications of road salts, potentially affecting vegetation growth.

### Water Features

Water demand for water features (such as decorative fountains, pools or water walls) may be constant (indoor) or seasonal (outdoor). Many water features have high water demand due to evaporative losses. Harvested water may require disinfection for use in water features depending on risk of exposure/ingestion at point of use.

### Sanitary Sewer Flushing

Health criteria for sanitary sewer flushing are less stringent than most beneficial uses of stormwater due to low risk of exposure. Demand for sewer flushing is likely intermittent, but requires large volumes of water per application. Sewer flushing may be a suitable use for water harvested in stormwater impoundments, but pretreatment may be required to prevent sediment from being deposited in sewers. If flushing storm sewers, additional considerations regarding the water quality of a downstream lake or stream (with respect to its ability to meet state water quality standards) may increase treatment requirements.

### Street Cleaning and Dust Control

Street cleaning and dust control uses may be intermittent in many cases but possibly regular (daily or weekly washing). Special fittings may be required to fill water tanks as most trucks are fitted for compatibility with fire hydrants. Pretreatment is needed to prevent clogging of spray nozzles and disinfection may be required due to risk exposure.

### Vehicle/Building Washing

Vehicle and equipment washing are common uses of water and there are several examples of using harvested water for vehicle washing in the U.S. (NAS, 2015; US EPA, 2012). Demand for outdoor washing may be seasonal in cold climates. Water harvested for washing may require disinfection due to risk of exposure. Salinity and hardness of harvested stormwater may be a concern for equipment washing.

### Firefighting

Harvested rainwater and stormwater that are pretreated is generally suitable for fire suppression, but disinfection may be required if merited by exposure risks (NAS, 2015). Harvested water can be used to fill onboard water tanks. On a larger scale, because firefighting is an emergency use of water, demand for this use will not be predictable; however, wet ponds may provide suitable emergency supply for fire suppression. Use for fire suppression will require a large storage volume on site that is compatible with International Fire Codes (IFC).

## Indoor Uses

Adherence to plumbing codes impose additional water quality criteria and require a higher level of treatment for indoor uses than similar outdoor uses. Indoor uses are more likely to require a constant supply of water and therefore requires a back up water supply. In cold climates, a secondary supply will most likely be needed during winter months. Indoor uses provide an opportunity to maximize the cycling of water on site since greywater from beneficial uses of stormwater supplied with harvested water can be captured for additional beneficial use.

### Flushing

Toilet and urinal flushing has a relatively constant demand throughout the year and account for approximately 24% of household water use (NAS, 2015), however toilet type (e.g., low flush) may affect demand. Use of non-potable water for toilet flushing or other indoor uses requires that the municipal water supply be protected. Water quality criteria are more restrictive due to plumbing code and unrestricted access at point of use. Currently this use is practiced most commonly in multi-residential or commercial setting, due to treatment and plumbing requirements (NAS, 2015). Beneficial use for toilet flushing may contribute to sustainable building certifications such as US Green Building Council (USGBC) and the State of Minnesota’s B3 Guidelines.

### Fire Suppression

Considerations for fire suppression sprinkler systems are similar to those for firefighting. Systems must be compatible with IFC and indoor plumbing codes.

### Washing

Indoor washing applications include laundry (residential, industrial, institutional, etc.), washing of equipment, or other cleaning practices. Laundry accounts for about 22% of household water use in the U.S. (USEPA, 2008). Using harvested water for laundry may reduce household consumption of potable water significantly.

### Cooling

Harvested water can be used for cooling water or cooling water makeup supply. Harvested water with high levels of salinity or hardness can cause scaling and should be avoided, whereas rainwater is naturally soft and low salt rainwater is preferred in these applications. Industry specific standards may apply. This use application may be suitable for implementation at a variety of scales.

### Process and Boiler Water

The considerations for process and boiler water are similar to those for cooling water. Industry specific criteria will likely apply and health criteria for process water are dependent on the particular application.

### Drinking Water

Household water demand for drinking and cooking is fairly constant, but these uses make up a relatively small portion of household use (< 5%; USEPA, 2008). The level of treatment required to meet drinking water criteria and public acceptance are key considerations of drinking water uses. Using treated rainwater for drinking water supplies is practiced in various parts of the U.S. including Virginia, Texas, Georgia, but to a much lesser degree in Minnesota. Public acceptance of harvest and use for potable supply may be greater in cases where potable water is commonly used, but not necessarily required (e.g., laundry and flushing), than in cases where potable water is required (e.g., drinking).

# Water Harvesting and Use Benefits

The potential benefits of water harvesting and use for stormwater management are largely tied to the impacts of urbanization. Urbanization can dramatically alter the hydrology and water quality of a watershed or smaller catchment. Increased impervious surface area and other changes in land cover associated with urbanization tend to decrease the attenuation of water on landscapes. This results in increased runoff volumes and peak stream flows following storm events; and decreased groundwater recharge and stream baseflows in the watershed. Furthermore, the quality of stormwater runoff can be degraded when runoff flows over developed or managed surfaces collecting pollutants and pathogens that may cause health risks to plants, animals and humans. By retaining and/or treating stormwater on-site through harvesting and use, the impacts of urbanization on hydrology and water quality can be reduced.

As the human population and urbanization grow, there is also a need to reduce potable water demand (Hatt *et al*., 2006). Although this goal is most commonly associated with harvest and use programs in arid environments where the availability of freshwater is limited, the cost savings associated with reducing potable water consumption can be a compelling goal even in water rich environments. The harvest and use of stormwater may also reduce stress on existing water and stormwater infrastructure providing cost savings on repair and maintenance or even mitigating the need for expansion of facilities. Additional benefits of water harvesting and use include education opportunities and onsite environmental benefits.

Potential benefits of water harvesting and use systems are summarized in Table 2.

Table 2. Potential benefits of water harvesting and use in urban areas

| **Potential benefits of water harvesting and use in urban areas** |
| --- |
| **Reduce impacts of urbanization on watershed hydrology** |
| Reduce runoff volume from the site |
| Reduce peak stream flows following storm events |
| Reduce flooding in downstream waters |
| Increase groundwater recharge |
| **Reduce impacts of urbanization on water quality** |
| Reduce pollutant loads to downstream receiving waters |
| **Increase water conservation** |
| Conserve potable water for essential uses |
| Provide alternative to potable water during time of peak demand |
| Reduce or limit withdrawals from ground or surface water supply |
| Maintain reliable water supply in the event of municipal service disruption |
| **Reduce stress on existing/need for additional infrastructure** |
| Reduce the size of stormwater BMPs needed to achieve regulatory requirements |
| Increase the efficiency or extend the life of stormwater BMPs/infrastructure |
| Reduce stress on municipal water supply systems during peak usage |
| Reduce stress on/cost of water supply and treatment infrastructure |
| Reduce community expenditure on expansion of infrastructure |
| **Energy, education, environment, and economics** |
| Provide educational opportunities/increase public awareness |
| Attain sustainable design certification/recognition |
| Reduce consumption of potable water for individual cost savings |
| Reduce the energy footprint of water, wastewater, and stormwater infrastructure |
| Take advantage of rainwater quality (low mineral content, no chlorine and ability to reduce or eliminate the use of water softeners) |
| Reduce on-site erosion control and flooding |

# Water Harvesting: Use of Codes and Standards

Current codes and standards for water harvesting and use systems are described below:

### Plumbing Codes:

The new 2015 Minnesota Plumbing Code, Minnesota Rules, Chapter 4714, took effect **Jan. 23, 2016**. The code includes the design and installation of harvesting rainwater from building roof tops in Chapter 17, Nonpotable Rainwater Catchment Systems. Nonpotable rainwater catchment systems are acceptable for use to supply water to water closets, urinals, trap primers for floor drains, industrial processes, water features, vehicle washing facilities, and cooling tower makeup water provided the design, treatment, minimum water quality standards, and operational requirements are in accordance with Chapter 17 of the code. Designs must be approved by a qualified Minnesota registered professional engineer.

Rainwater catchment systems use for plumbing applications listed above in combination with lawn irrigation must meet the requirements of Chapter 17.  System components used solely for lawn irrigation, such as irrigation pumps and piping mounted outside of buildings are not subject to the requirements of Chapter 17.   *The conveyance of the rainwater catchment system is still governed by the plumbing code.*

Minimum water quality standards are now described in Chapter 17.

“1702.9.4 Minimum Water Quality. The minimum water quality for rainwater catchment systems shall meet the applicable water quality recommendations in Table 1702.9.4”

|  |  |
| --- | --- |
| **Measure** | **Limit** |
| Turbidity (NTU) | <1 |
| E. coli (MPN/100 mL) | 2.2 |
| Odor | Non-offensive |
| Temperature (degrees Celsius) | MR |
| Color | MR |
| pH | MR |

MR-measure and record only; Treatment: 5 micron or smaller absolute filter; Minimum .5-log inactivation of viruses.

To achieve these water standards, it is highly recommended to sample your source water and design your water treatment system around the baseline data. It is recommended to work with suppliers and manufacturers that are trained or have direct and relevant experience treating rainwater. Most UV manufacturers will include an Ultra Violet Transmittance (UVT) requirement for their UV to reach end use requirements. To achieve less than 1 NTU, a 1 micron absolute pre-filter may be required. If the roof is “dirty” gravel, pervious pavers, green roof or carbon filtration may be required to eliminate odors. Other strategies may include inclusion of aeration in the tank to maintain aerobic conditions. The most cost effective and long run approach is to reduce the amount of organic material entering the tank.

### Water Harvesting and Use Considerations

### Treatment

High levels of pollutant and pathogen treatment, can add cost and can limit the range of practical beneficial uses of stormwater considered in the design of water harvesting and use systems. Partly, for this reason, irrigation has been the most common type of beneficial use application for water harvesting and use systems constructed in Minnesota due to the low levels of treatment required and lack of consistent rules.

### Storage versus supply

The relative availability of harvested water supply, storage size, and water demand is often not balanced in society. For example, in highly urbanized sites, the harvested water supply can sometimes greatly exceed the water demands and storage availability, while in less urbanized sites, water demands and storage availability can sometimes greatly exceed harvested water supply. These limitations can be overcome by centralizing water harvesting and use systems over larger areas to bring together areas with excess harvested water supply with areas of high water demand.

### Cold climates

In cold climates stormwater and rainwater supply are seasonal. Beneficial uses of stormwater which require a constant supply, will need to rely on a secondary supply during several months of the year as required by the plumbing code for indoor uses. Additionally, outdoor systems not designed with freeze protection will require annual maintenance to prevent damage from freeze/thaw cycles.

Systems can be designed for year round supply (see Ontario and Alaska Guidance documents). Two generally accepted approaches are to provide 2 inches of rigid insulation over the entire tank area in a shallow frost protected foundation approach and having all water supply pipes exit the bottom of the tank below frost line or with freeze protected and/or heat traced pipe. In these applications, the prefiltration devices must be chosen that can withstand freeze thaw conditions. If the system is insulated and the conveyance piping is run with consistent slope, there is rarely problems in this application. The overflow of the system can be problematic if the tank and the filter overflow to daylight or a pond. Refer to Ontario guidelines for subsurface overflow strategies.

### Site constraints

Constructing water harvesting and use systems in fully developed areas can be difficult due to space and cost limitations of retrofitting developed sites with the infrastructure needed to collect, store, and distribute harvested water to the beneficial use.

### Public acceptance

Modern society is used to nearly all water supplies being treated to the drinking water level. While this type of treatment for all domestic uses of water may be unnecessary and costly, the public sometimes perceives a high level of risk for using water not treated to drinking water levels. Overcoming this perception of harvested water being ‘dirty’ or ‘dangerous’ will be a large hurdle for this management technique to expand beyond irrigation uses of stormwater.

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