Key Topic #6: Legislation, Regulations, and Voluntary Measures

Learning Objectives

1. **Identify** common BMPs used to reduce NPS pollution in urban, suburban, and agricultural environments (e.g., rain gardens, cover crops, buffer strips, pervious pavement).
2. **Explain** how selected BMPs reduce pollutant loads or improve stormwater infiltration, using diagrams or real-world examples.
3. **Compare** the costs, benefits, and feasibility of different BMPs in various land use contexts (e.g., a schoolyard vs. a farm vs. a residential street).
4. **Demonstrate** how to plan or assess a BMP using a field checklist, photo documentation, or a site sketch (e.g., rain garden layout or runoff path).
5. **Recommend** appropriate BMPs for a hypothetical site based on land use, soil conditions, and observed pollution risks.

Resource Title	Source	Located on
BMPs used to reduce NPS pollution in urban environment, *excerpts*	*National Management Measures to Control Nonpoint Source Pollution from Urban Areas, US EPA, 2005*	Page 172-184
Agricultural Nonpoint Source Pollution, Hydromodification, *excerpts*	*U.S. EPA, 2005*	Page 185-186
Economics of Water Quality Protection from Nonpoint Sources: Theory and Practice, *Abstract excerpt*	*Ribaudo et al, Resource Economics Division, Economic Research Service, U.S.D.A. Agricultural Economic Report No. 782, 1999*	Page 187
Estimating Benefits and Costs of Stormwater Management: *chart and graphic*	*Environmental Finance Center, Sacramento State, 2019*	Page 188-189
Case Study-Burnsville rain gardens	*Minnesota Stormwater Manual, 2005*	Page 190-193
Case studies for stormwater and rainwater harvest and use/reuse	*Minnesota Stormwater Manual, 2012*	Page 194-200
Home NPS BMPs: Reducing Nonpoint Source Pollution at Home, *summary*	*Rodrigue, Paul, USDA NRCS and U.S. EPA*	Page 201-202
Steps to Help Control NPS Pollution, *excerpts*	*Mississippi Department of Environmental Quality*	Page 203

BMPs used to reduce NPS pollution in urban environment

From "National Management Measures to Control Nonpoint Source Pollution from Urban Areas", United States Environmental Protection Agency, 2005

The *National Water Quality Inventory: 2000 Report to Congress* identified urban runoff as one of the leading sources of water quality impairment in surface waters (USEPA, 2002b). Of the 11 pollution source categories listed in the report, "urban runoff/storm sewers" was ranked as the fourth leading source of impairment in rivers, third in lakes, and second in estuaries.

Management practices to control urban runoff can be classified in seven categories. The following practices are described for illustrative purposes only. EPA has found these practices to be representative of the types of practices that can be applied successfully to achieve the new development runoff treatment management measure. As a practical matter, EPA anticipates thatthe management measure can be achieved by applying one or more management practices appropriate to the source(s), location, and climate. Thus, practices that by themselves do not achieve 80 percent TSS removal can be combined with other practices to achieve 80 percent removal (such that x + y + z = 80 percent). This is the "treatment train" approach, in which several types of practices are used together and integrated into a comprehensive runoff management system (WMI, 1997b). The seven categories include:

— Infiltration practices;
— Vegetated open channel practices;
— Filtering practices;
— Detention ponds or vaults;
— Retention ponds;
— Wetlands; and
— Other practices such as water quality inlets.

Infiltration Practices

These practices capture and temporarily store runoff before allowing it to infiltrate into the soil over several days. Design variants include:
— Infiltration basins;
— Infiltration trenches; and
— Pervious or porous pavements.
To prevent premature clogging, these practices must not receive drainage from a construction activity or site. Infiltration practices can be placed in service after the construction activity is complete or the site is stabilized.

Infiltration basins

Infiltration basins (Figure 5.1) are impoundments created by excavation or creation of berms or small dams. They are typically flat-bottomed with no outlet and are designed to temporarily store runoff generated from adjacent drainage areas (from 2 to 50 acres, depending on local conditions). Runoff gradually infiltrates through the bed and sides of the basin, ideally within 72 hours, to maintain aerobic conditions and ensure that the basin is ready to receive runoff from the next storm. Infiltration basins are often used as an off-line system for treating the first flush of

runoff flows or the peak discharges of the two-year storm.

The key to successful operation is keeping the soils on the floor and side slopes of the basin unclogged to maintain the rate of percolation. This is usually much easier said than done. For example, Schueler (1992) reported infiltration basin failure rates ranging from 60 to 100 percent in the mid-Atlantic region. To help keep sediment out of the basin, incoming runoff should be pretreated using vegetated filter strips, a settling forebay, or other techniques. Grasses or other vegetation should also be planted and maintained in the basin. If soil pores become clogged, the basin bottom should be roughened or replaced to restore percolation rates.

Infiltration trenches

Infiltration trenches (Figure 5.2) are shallow (2- to 10-feet deep) excavated ditches with relatively permeable soils that have been backfilled with stone to form an underground reservoir. The trench surface can be covered with a grating or can consist of stone, gabion, sand, or a grasscovered
area with a surface inlet. Runoff diverted into the trench gradually infiltrates into the subsoil and, eventually, into the ground water. Trenches can be used on small, individual sites or for multi-site runoff treatment. Pretreatment controls such as vegetated filter strips should be incorporated into the design to remove sediment and reduce clogging of soil pores. More expensive than pond systems in terms of cost per volume of runoff treated, infiltration trenches are best-suited for drainage areas of less than 5 to 10 acres, or where ponds cannot be used. Variations in the design of infiltration trenches include dry wells, which are pits designed to control small volumes of runoff (such as rooftop runoff) and exfiltration trenches. A typical dry well design includes a perforated pipe 3 to 4 feet in diameter that is installed vertically in deposits of gravely/sandy soil. Rock is then backfilled around the base of the well. An exfiltration trench is an infiltration trench that stores runoff water in a perforated or slotted pipe and percolates it out into a surrounding gravel envelope and filter fabric. Dry wells and other infiltration practices that involve subsurface drainage may be regulated by EPA's Underground Injection Control Program. See the EPA's Underground Injection Control Program Web site at http://www.epa.gov/safewater/uic.html for more information.

Pervious or porous pavements

Pervious pavement has the approximate strength characteristics of traditional pavement but allows rainfall and runoff to percolate through it. The key to the design of these pavements is the elimination of most of the fine aggregate found in conventional paving materials. There are two types of pervious pavement, porous asphalt and pervious concrete (WMI, 1997b). Porous asphalt has coarse aggregate held together in the asphalt with sufficient interconnected voids to yield high permeability. Pervious concrete, in contrast, is a discontinuous mixture of Portland cement, coarse aggregate, admixtures, and water that also yields interconnected voids for the passage of air and water. Underlying the pervious pavement are a filter layer, a stone reservoir, and a filter fabric. Stored runoff gradually drains out of the stone reservoir into the subsoil. Figure 5.3 shows several types of porous pavement. More information about pervious pavement can be found at http://www.gcpa.org/pervious_concrete_pavement.htm (Georgia Concrete & Products Association, 2003).

(https://stormwater.pca.state.mn.us/index.php?title=File:Picture_of_porous_asphalt_1.jpg)

Modular pavement consists of individual blocks made of pervious material such as sand, gravel, or sod interspersed with strong structural material such as concrete. The blocks are typically placed on a sand or gravel base and designed to provide a load-bearing surface that is adequate to support personal vehicles, while allowing infiltration of surface water into the underlying soils. They usually are used in low-volume traffic areas such as overflow parking lots and lightly used access roads. An alternative to pervious and modular pavement for parking areas is a geotextile material installed as a framework to provide structural strength. Filled with sand and sodded, it provides a completely grassed parking area. More information about concrete pavers can be found at http://www.concretenetwork.com/concrete/porous_concrete_pavers/ (Concretenetwork.com, 2003).

(https://stormwater.pca.state.mn.us/index.php?title=File:Univ_of_MN_PICP_Photograph.jpg)

Vegetated Open Channel Practices

Vegetated open channels are explicitly designed to capture and treat runoff through infiltration, filtration, or temporary storage.

A vegetated swale is an infiltration practice that usually functions as a runoff conveyance channel and a filtration practice. It is lined with grass or another erosion-resistant plant species that serves to reduce flow velocity and allow runoff to infiltrate into ground water. The vegetation or turf also prevents erosion, filters sediment, and provides some nutrient uptake benefits. These practices are also known as biofiltration swales. Check dams are often used to reduce flow velocity. When used, sediment that collects behind check dams should be removed regularly.

Two types of channels are typically used in residential landscapes:

— *Grass channels*. These have dense vegetation, a wide bottom, and gentle slopes (Figure 5.4). Usually they are intended to detain flows for 10 to 20 minutes, allowing sediments to filter out.

— *Dry swales*. As with grass channels, runoff flows into the channel and is subsequently filtered by surface vegetation (Figure 5.5). From there, runoff moves downward through a bed of sandy loam soil and is collected by an underdrain pipe system. The treated water is delivered to a receiving water or another structural control. Dry swales are used in large-lot, single-family developments and on campus-type office or industrial sites. They are applicable in all areas where dense vegetative cover can be maintained. Because of a limited ability to control runoff from large storms, they are often combined with other structural practices. They should not be used in areas where flow rates exceed 1.5 feet per second unless additional erosion control measures, such as turf reinforcement mats, are used.


(Photo of a dry swale. Courtesy of Limnotech.)

Filtering Practices

Filtering practices capture and temporarily store runoff and pass it through a filter bed of sand, organic matter, soil, or other media. Filtered runoff may be collected and returned to the conveyance system, or allowed to exfiltrate into the soil. Design variants include:

— Surface sand filter;
— Underground sand filter;
— Organic filter;
— Pocket sand filter; and
— Bioretention areas.

Filtration basins and sand filters

Filtration basins are impoundments lined with a filter medium such as sand or gravel. Runoff drains through the filter medium and through perforated pipes into the subsoil. Detention time is typically four to six hours. Sediment-trapping structures are often used to prevent premature clogging of the filter medium (NVPDC, 1980; Schueler et al., 1992).

Sand filters are usually two-chambered practices: the first is a settling chamber and the second is a filter bed filled with sand or another filtering medium. As runoff flows into the first chamber, large particles settle out and finer particles and other pollutants are removed as runoff flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and multi-chambered treatment train (Robertson et al., 1995). All of these filtering practices operate on the same basic principle. Modifications to the traditional surface sand filter

were made primarily to fit sand filters into more challenging site designs (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).

Media filtration units

Similar to wastewater treatment technology, passive filtration units can be used to capture pollutants from runoff. Media filtration practices commonly use trenches filled with sand or peat. Other media, including types of crushed rock and composted leaves, can also be used. A basin collects the runoff and gradually routes discharge through cartridges filled with filter media. An emergency bypass prevents system flooding during large rainstorms. According to the Unified Sewerage Agency of Washington County in Oregon (WEF, 1998), composted leaf media trap particulates, adsorb organic chemicals, and remove 90 percent of solids, 85 percent of oil and grease, and 82 to 98 percent of heavy metals through cation exchange from leaf decomposition. Similar types of systems with various filter media are available commercially.

Bioretention systems

Bioretention systems are suitable to treat runoff on sites where
there is adequate soil infiltration capacity and where the runoff volumes that are not infiltrated do not present a safety or flooding hazard. Typical applications for bioretention include parking areas with or without curbs, traffic islands, and swales or depressed areas that receive runoff from impervious areas.

Bioretention system designs are very flexible, can be adapted to a wide range of commercial, industrial, and residential settings, and can be linked in series or combined with structural devices to provide the necessary level of treatment depending on expected runoff volumes and pollutant loading. A common technique is to use bioretention areas to pre-treat sheet flow before it is channelized or collected in an inlet structure.

Bioretention practices are commonly called rain gardens.

Bioretention is a terrestrial-based (up-land as opposed to wetland) water quality and water quantity control process. Bioretention employs a simplistic, site-integrated design that provides opportunity for runoff infiltration, filtration, storage, and water uptake by vegetation.

Bioretention areas are suitable stormwater treatment practices for all land uses, as long as the contributing drainage area is appropriate for the size of the facility. Common bioretention opportunities include landscaping islands, cul-de-sacs, parking lot margins, commercial setbacks, open space, rooftop drainage and street-scapes (i.e., between the curb and sidewalk). Bioretention, when designed with an underdrain and liner, is also a good design option for treating stormwater hotspots (PSHs). Bioretention is extremely versatile because of its ability to be incorporated into landscaped areas. The versatility of the practice also allows for bioretention areas to be frequently employed as stormwater retrofits.


(https://stormwater.pca.state.mn.us/index.php?title=Bioretention)

Detention and Retention Practices

Detention ponds and vaults
These practices temporarily detain runoff to ensure that the post development peak discharge rate is equal to the predevelopment rate for the desired design storm (e.g. two-, 10-, or 25-year).

These practices may also be used to provide temporary extended detention to protect downstream channels from erosion (e.g., 24-hour extended detention for a one-year storm). Extended detention (ED) ponds are an example of this type of facility. ED ponds temporarily detain a portion of urban runoff for up to 24 hours after a storm, using a fixed orifice to regulate outflow at a specified rate and allowing solids and associated pollutants time to settle out. ED ponds are normally dry between storm events and do not have any permanent standing water. These basins are typically composed of two stages: an upper stage, which remains dry except after larger storms, and a lower stage, which is designed for typical storms. Enhanced ED ponds are equipped with plunge pools or forebays near the inlet, a micropool at the outlet, and an adjustable reverse-sloped pipe as the ED control device (NVPDC, 1980; Schueler et al., 1992). Most ED ponds use a riser with an anti-vortex trash rack on top to control large floating solids.


(https://stormwater.pca.state.mn.us/index.php?title=File:Picture_of_a_dry_pond_1.jpg)

Detention tanks and vaults are underground structures used to control peak runoff flows. They are usually constructed out of concrete (vaults) or corrugated metal pipe (tanks). Underground detention can also be achieved by retrofitting the over-capacity storm drain pipes with baffles. The baffles allow water to be stored in the pipes so it can be released at a slower rate. Pretreatment structures such as water quality inlets and sand filters can be used to treat runoff and remove trash and debris.

These systems are primarily applicable where space is limited and there are no other practical alternatives. Concrete vaults are relatively expensive and are often used to control small flows where system replacement costs are high. Corrugated metal pipe systems are less expensive and are often used to control larger volumes of runoff in parking lots, adjacent to rights-of-way, and in medians. These systems should be located where maintenance can be conducted with minimal disturbance.

Underground detention structures provide runoff quantity control but do not provide significant water quality control without modifications. Corrugated metal pipe systems can work in conjunction with infiltration to provide additional runoff treatment. This is accomplished by adding perforations to the pipe to allow it to store the water until it can be released into the soil (FHWA, no date).

Retention ponds

These practices use a permanent pool, extended detention basin, or shallow marsh to remove pollutants and can include:

— Micropool extended detention ponds;
— Wet ponds;
— Wet extended detention ponds; and
— Multiple pond systems.

Ponds are basins designed to maintain a permanent pool of water and temporarily store runoff (ED wet pond), which is released at a controlled rate. Ponds allow particulates to settle and can provide biological uptake of pollutants such as nitrogen or phosphorus. Enhanced designs include a forebay to trap incoming sediment where it can easily be removed.

(https://stormwater.pca.state.mn.us/index.php?title=File:Picture_of_a_wet_pond_2.jpg)

Constructed wetlands

Constructed wetlands are engineered systems designed to treat runoff. They are typically designed to provide some of the functions of natural wetlands, e.g., wildlife habitat, in addition to controlling runoff volumes and pollutant loadings. There are many variations of constructed wetlands, such as shallow wetlands, extended detention wetlands, pond/wetland systems, and small isolated "pocket" wetlands. Constructed wetlands may contain some or all of the following elements: shallow vegetated areas, permanent pools, sediment forebays, transition areas, and weirs. Designs are intended to slow flow through the wetlands and provide maximum contact with wetland vegetation.

Other Practices

Other practices used to control urban runoff have not been studied as extensively as those above

but have been used with varying degrees of success. They include:
— Water quality inlets;
— Hydrodynamic devices;
— "Baffle boxes;"
— Catch basin inserts;
— Vegetated filter strips;
— Street surface storage;
— On-lot storage; and
— Microbial disinfection.

In some cases, these practices are used for pretreatment or are part of an overall runoff management system, which is sometimes referred to as a "treatment train." For example, water quality inlets, catch basin inserts, and vegetated filter strips installed upslope of a wet pond or filtration practice will help remove a portion of the pollutants present in runoff before it enters the pond or filtration practice. These other practices in the treatment train improve runoff quality and can help extend the longevity of the filtration practice and wet pond.

Pollution Prevention

Implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities:
— The improper storage, use, and disposal of household chemicals, including automobile fluids, pesticides, paints, solvents, etc.;
— Lawn and garden activities, including the improper application and disposal of lawn and garden care products, and the disposal of leaves and yard trimmings;
— Turf management on golf courses, parks, and recreational areas;
— Commercial activities, including parking lots and gas stations;
— Improper disposal of pet wastes; and
— Activities that generate trash.

The four main avenues for household chemicals to become problem pollutants are through leaks and spills, improper use, improper storage, and improper disposal.
(1) *Leaks and spills*. Chemicals leaking from improperly maintained automobiles and lawn equipment or faulty containers can accumulate on roads, driveways, and lawns and be carried by runoff to receiving water bodies.
(2) *Improper use*. Failure to follow label instructions properly may result in over-application of fertilizers or pesticides and can lead to chemical accumulation in the soil and grass. These chemicals can leach to ground water or be carried by runoff to surface waters.
(3) *Improper storage*. Improper storage of chemicals can lead to spills that can contaminate runoff and ground water or result in dangerous chemical reactions.
(4) *Improper disposal*. It is a common practice for citizens to pour unwanted chemicals, such as detergents, cleansers, or automotive fluids, onto their lawns or driveways or directly down storm drains. Contrary to popular belief, most storm sewers do not connect to wastewater treatment plants—chemicals disposed of this way could be discharged directly to receiving water bodies. Additionally, when chemicals are poured down drains connected to a

wastewater treatment plant or septic system, they could interfere with treatment systems by killing the bacteria that metabolize pollutants, causing water discharged from the plants to be contaminated. Ground water is also at risk because runoff can carry these chemicals through the soil to the water table. Product labels describe requirements for proper disposal and should be followed carefully.

(5) *Outdoor car washing*. This activity can result in high loads of nutrients, metals, and hydrocarbons being carried to receiving waters during dry weather conditions when the wash water flows into the storm drain system. According to surveys, 50 to 75 percent of households wash their own cars and 60 percent of those households wash their cars at least once a month (Schueler and Swann, 2000b).

Failing septic systems

Approximately one in four American households relies on a septic system to dispose of their wastewater. Septic systems have a failure rate of 5 to 35 percent, depending on soil conditions and other factors. When septic systems fail, the untreated or partially treated wastewater discharges to surface and ground waters. A survey conducted in the Chesapeake Bay watershed found that the average age of septic systems in the area was about 27 years, which is seven years beyond the design life of an unmaintained system. About half the owners indicated that they had not inspected or cleaned out their system in the previous three years. (Schueler and Swann, 2000b).

Lawn and garden activities

Lawn care practices are often targeted by watershed managers as contributors of pesticides and nutrients to runoff. A nationwide study by the U.S. Geological Survey (USGS) in 1999 found a high incidence of insecticides and herbicides in urban streams. Insecticides commonly used in homes, gardens, and commercial areas were found more frequently and in higher concentrations in urban streams than in agricultural streams. These concentrations often exceeded guidelines for the protection of aquatic life. Herbicides, such as those used for weed control, were found in 99 percent of sampled streams, but rarely at levels that exceeded guidelines.

Maintaining a healthy lawn might require fertilizers, pesticides, and heavy watering in some areas. Overuse of fertilizers, pesticides, and water can lead to excessive growth, increased pest problems, and environmental damage. In terms of fertilizer inputs, nutrients typically are applied to lawns at about the same rates as for row crops.

Commercial activities

Runoff from commercial land uses, such as shopping centers, office parks, and parking lots or garages may contain high hydrocarbon loadings and metal concentrations that are twice those found in the average urban area. These loadings can be attributed to heavy traffic volumes and large areas of impervious surface on which automotive-related pollutants concentrate. Other commercial uses, such as vehicle maintenance, liquids storage, and equipment storage and maintenance, can also introduce pollutants to runoff.

Lawn, Garden, and Landscape Activities

Lawns are a significant feature of urban landscapes. This large area of managed landscape has

the potential to contribute to urban runoff pollution due to over-fertilization, overwatering, overapplication
of pesticides, and direct disposal of lawn clippings, leaves, and trimmings. Also,
erosion from bare patches of poorly managed lawns contributes sediment to watercourses, and disposal of lawn clippings in landfills can reduce the capacity of these facilities to handle other types of waste. Public education for citizens and municipal crews with respect to pest tolerance and proper handling of fertilizers, pesticides, water, and yard waste can greatly reduce the potential for adverse impacts to waters receiving runoff from lawns. Municipalities and watershed managers should develop an outreach campaign that targets citizens, lawn care businesses, landscapers, and municipal crews. Materials should highlight the following steps to help citizens and lawn care professionals maintain healthy, attractive lawns with less maintenance and fewer chemical inputs:

— Lawn conversion
— Soil building
— Grass selection
— Mowing and thatch management
— Minimal fertilization
— Weed control and tolerance
— Pest management
— Sensible irrigation

Lawn conversion

Grasses are very water-hungry and labor-intensive landscaping plants when compared to ground cover, flowers, shrubs, and trees. Therefore, to reduce the maintenance requirements of a lawn and address problem areas where turf is difficult to grow, property owners could identify areas where turf grass can be replaced with other types of plantings.

EXISTING DEVELOPMENT

The purpose of this management measure is to protect or improve surface water quality by developing and implementing watershed management programs that pursue the following objectives:

— Reduce surface water runoff pollution loadings from areas where development has already occurred.
— Reduce the volume and peak runoff rates of surface water runoff to reduce runoff flow, increase infiltration, and minimize habitat degradation and sediment loadings from erosion of streambanks and other natural conveyance systems.
— Preserve, enhance, or establish buffers that provide water quality benefits along water bodies and their tributaries.

Maintaining water quality becomes increasingly difficult as urbanization occurs and areas of impervious surface increase. Increased peak runoff volumes from impervious surfaces result in alteration of stream channels, natural drainageways, and riparian habitat. This alteration, in turn, results in elimination or reduction of predevelopment aquatic flora and fauna and degradation of

predevelopment water quality. Other effects include increased bank cutting, streambed scouring, embedded cobbles, siltation, increases in instream water temperature, decreases in dissolved oxygen, and changes to the natural structure and flow of the stream or river.

Agricultural Nonpoint Source Pollution

The primary agricultural NPS pollutants are nutrients, sediment, animal wastes, salts, and pesticides. Agricultural activities also have the potential to directly impact the habitat of aquatic species through physical disturbances caused by livestock or equipment. Although agricultural NPS pollution is a serious problem nationally, a great deal has been accomplished over the past several decades in terms of sediment and nutrient reduction from privately-owned agricultural lands. Much has been learned in the recent past about more effective ways to prevent and reduce NPS pollution from agricultural activities.

NRCS maintains a National Handbook of Conservation Practices (USDA–NRCS, 1977), updated continuously, which details nationally accepted management practices. These practices can be viewed at the USDA-NRCS web site at https://www.nrcs.usda.gov/resources/guides-and-instructions/field-office-technical-guides. In addition to the NRCS standards, many States use locally determined management practices that are not reflected in the NRCS handbook.

WATER QUALITY ANDFORESTRY ACTIVITIES

The effects of forestry activities on surface waters are of concern to EPA and state and local authorities because healthy, clean waters are important for aquatic life, drinking water, and recreational use. Surface waters and their ecology can be affected by inputs of sediment, nutrients, and chemicals, and by alterations to stream flow that can result from forestry activities. The purpose of implementing management measures and best management practices (BMPs) to protect surface waters during and after forestry activities is to protect important ecological conditions and characteristics of the surface waters in roaded and logged forested areas.

Management Measures

- Road System Planning
- STREAMSIDE MANAGEMENT AREAS
- REVEGETATION OF DISTURBED AREAS
- FOREST CHEMICAL MANAGEMENT

Hydromodification

USEPA (1993) defines hydromodification as the "alteration of the hydrologic characteristics of coastal and non-coastal waters, which in turn could cause degradation of water resources." Examples of hydromodification in streams include dredging, straightening, and, in some cases, complete stream relocation. Other examples include construction in or along streams, construction and operation of dams and impoundments, channelization in streams, dredging, and land reclamation activities. Hydromodification can also include activities in streams that are being done to maintain the stream's integrity such as removing snags.[2] Some indirect forms of hydromodification, such as erosion along streambanks or shorelines, are caused by the introduction or maintenance of structures in or adjacent to a waterbody and other activities, including many upland activities, that change the natural physical properties of the waterbody. EPA has grouped hydromodification activities into three categories: (1) channelization and channel modification, (2) dams, and (3) streambank and shoreline erosion.

Hydromodification is one of the leading sources of impairment in our nation's waters. According

to the *National Water Quality Inventory: 2000 Report to Congress* (USEPA, 2002a), there are almost 3.7 million miles of rivers and streams[4] in the United States. Approximately 280,000 miles of assessed rivers and streams in the United States are impaired for one or more designated uses, which include aquatic life support, fish consumption, primary and contact recreation, drinking water supply, and agriculture. Many of the pollutants causing impairment are delivered to surface and ground waters from diffuse sources, such as agricultural runoff, urban runoff, hydrologic modification, and atmospheric deposition of contaminants. The leading causes of beneficial use impairment (partially or not supporting one or more uses) are nutrients, sediment, pathogens (bacteria), metals, pesticides, oxygen-depleting materials, and habitat alterations (USEPA, 2002a).

Economics of Water Quality Protection From Nonpoint Sources: Theory and Practice

(Economic Research ServiceU.S. DEPARTMENT OF AGRICULTURE)

Water quality is a major environmental issue. Pollution from nonpoint sources is the single largest remaining source of water quality impairments in the United States. Agriculture is a major source of several nonpoint-source pollutants, including nutrients, sediment, pesticides, and salts. Agricultural nonpoint pollution reduction policies can be designed to induce producers to change their production practices in ways that improve the environmental and related economic consequences of production. The information necessary to design economically efficient pollution control policies is almost always lacking. Instead, policies can be designed to achieve specific environmental or other similarly-related goals at least cost, given transaction costs and any other political, legal, or informational constraints that may exist.

Estimating Benefits and Costs of Stormwater Management

Chart and Graphic from:
https://www.efc.csus.edu/reports/efc-cost-project-part-1.pdf

Table 6: Some potential benefits for stormwater management as described in Stormwater Resource Plans through CA State Water Resources Control Board guidelines.

Benefit Category	Benefits	Non-Monetary Metric
Water quality	Prevent or reduce pollutant discharges	Load of total suspended solids (TSS) reduced
	Prevent or reduce hydromodification	Volume of runoff reduced
Water supply	Augment water supply	Volume captured and infiltrated into groundwater basins
	Reduce water demands	Volume captured that results in reduced demand on other sources
Flood management	Prevent or reduce localized flooding	Peak flow reduction for design storm
	Prevent or reduce regional flooding	Size of area with flood mitigation
Climate change adaptation and resilience	Support water supply reliability	Additional volume of water available for supply
	Address increased precipitation volumes and intensities	Rate of peak flow reduced for the identified design storm
	Provide infrastructure redundancy	Volume of new redundant capacity
	Provide infrastructure longevity	Months or years of expected additional component life
Environmental	Protect or restore habitat	Size of area of wetland, riparian zone, or habitat
	Support biodiversity	Number of additional habitat acres for sensitive species
	Improve instream flow rates	Rate of instream flowrate improved
	Improve instream flow temperatures	Water temperature (°F or °C) improved or percent canopy cover increased
	Reduce urban heat island effects	Reduced air surface temperatures
	Reduce greenhouse gas emissions and air pollutants	Mass of greenhouse gas emissions sequestered or reduced
Community	Support permit compliance	Achieved permit needs with regulator
	Create jobs	Number of new jobs
	Provide recreational opportunities	Size of space created/enhanced
	Improve mental and physical health	Quantified improvement in community health, such as reduced hospital visits
	Provide educational opportunities	Number of outreach materials provided, events conducted, or participants
	Increase property values	Dollar value increase in property values
	Improve aesthetics	Size of public space created
	Improve community involvement	Number of hours volunteered or participants

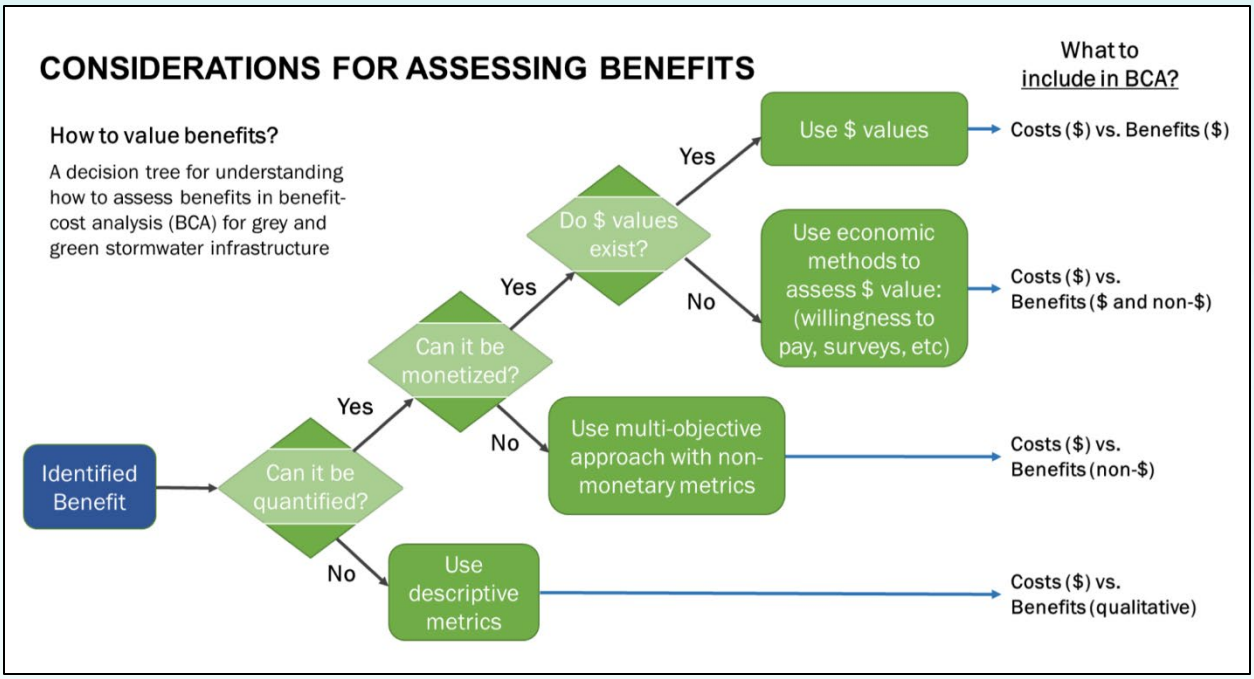


Figure 7: A decision tree for applying methods to assess benefits in benefit-cost analysis

Case Study:

Burnsville rain gardens - retrofitting for water quality

Over the past decades, Burnsville's Crystal Lake had seen a marked decrease in water clarity, due in part to algae bloom resulting from increased phosphorus entering the lake. Water quality typically decreased from spring to late summer, which impacted recreational use of the lake.

Contents

Photo showing one of the rain gardens installed as part of the Burnsville rain garden project.

Project summary

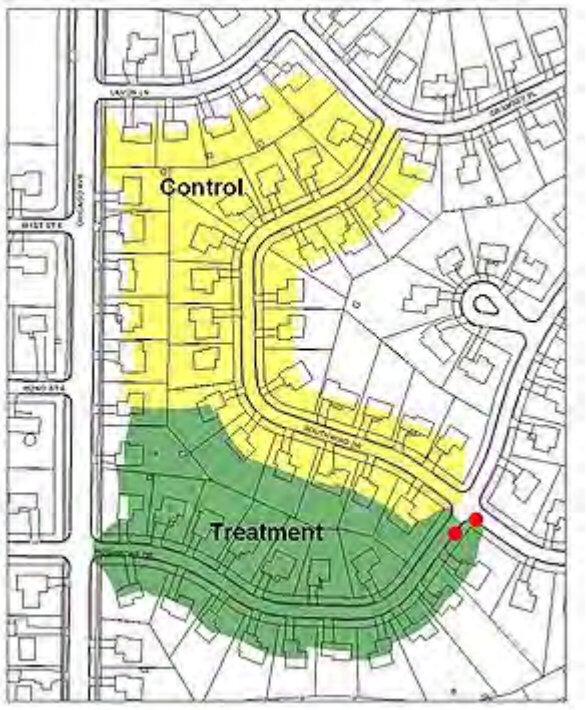
- Location: Burnsville
- Landscape setting: suburban residential
- Drainage area: 5.3 acres, 25 houses (17 with rain gardens)
- Project timeline: 2001 to 2006
- Project cost: $147,000
- Project contact: Barr Engineering (https://www.barr.com/)

Background

Recognizing that incoming stormwater from surrounding residential neighborhoods was an important factor in lake health, the City of Burnsville sought an alternative treatment method to reduce that runoff. However, curb and gutter was already in place in the 20-year-old neighborhoods near the lake, and there was insufficient room for traditional stormwater ponds.

Rain gardens—shallow, vegetated depressions that capture runoff and allow it to soak into the ground—emerged as the best solution. In addition to suiting the space and budget constraints in this fully built residential area, rain gardens offer visual amenity that tend to increase residents' commitment to help implement and maintain them.

With the help of two grants—$30,000 from the city and $117,000 from the Metropolitan Council—Burnsville was not only able to design and build the gardens, but to implement a study to gauge their effectiveness. A paired watershed study—monitoring one 5.3 acre neighborhood with 17 rain gardens and a similar, no-rain-garden neighborhood nearby—allowed the city and its partners to see how the BMPs performed during actual storm events.



Schematic illustrating the location of control and treatment watersheds. Control watersheds, shaded yellow, contained no rain gardens, while the treatment area, shaded green, contained rain gardens.

Implementation

To get baseline data, gauges were installed in each neighborhood to measure runoff for two summers prior to rain garden installation.

Since the greatest concentration of pollutants is washed off impervious surfaces during the first inch of precipitation, rain gardens are designed to accommodate that “first flush” from a given watershed. The Burnsville gardens were designed to accommodate 0.9 inches and drain rapidly, within 24 to 48 hours. Rain gardens can be planted with many types of vegetation, including native perennials and shrubs or cultivated varieties. The Burnsville participants were given the choice of three basic garden styles: native wildflower, cultivated perennials and/or shrubs.

Following evaluations of soil and topography, city staff and consultants sought to educate area residents about efforts to improve Crystal Lake water clarity and how rain gardens fit into the picture. The Rushmore Drive neighborhood, characterized by gentle topography and sandy soils, was selected, with hopes of getting at least 30 percent of the 25 residents to participate. As it happened, 85 percent of households signed on, resulting in 17 gardens—13 in front yards, 4 in back. All but one selected a scheme using low-maintenance cultivated perennials and shrubs, which tend to look neater than an all-native garden.

Grading plans, created by engineer Kurt Leuthold, in consultation with landscape architect Fred Rozumalski, incorporated stone retaining walls and gradual slopes from street to basin. During the design phase, Gopher One marked underground utilities so they could be accurately surveyed. The project engineer stresses the importance of this step to help minimize pre-construction surprises and changes.

The landscape architect met with homeowners and drew up planting plans that considered individual resident preferences. Each garden is separated from the street and curb cut by a mow strip, which serves two purposes: to lend a neat, intentional edge to the garden and to trap sediment traveling with the rainwater. The planting designs emphasize showy groupings of tidy-looking plants, which enhance the appearance of the front yards. Construction began in fall 2003. In order to avoid hitting utilities and to ensure proper flow, precise grading of the gardens was critical, as was close adherence to soil specifications and avoiding compaction. Native sandy topsoil was stockpiled and mixed with compost, then installed at a depth of 12 inches following grading. To ensure quality, the city relied on the engineering consultant to do extensive construction observation, and Gopher One marked utilities two additional times—before sod stripping and soil removal and also prior to grading.

Photos illustrating a private residence before and after installation of a rain garden. Notice the curb cut from the street into the rain garden.

Small construction companies were more responsive to the request for bids on this relatively small project (the grading budget was $50,000); city staff indicated that in the future they would not solicit bids from large companies for a project of this scale.

Instead of having planting completed by the contractor, the Burnsville project utilized resident-volunteers to plant their own gardens, with the help of the landscape architect and city staff. This not only helped keep the budget down, but gave homeowners a hands-on investment in their gardens, and familiarized them with the plants.

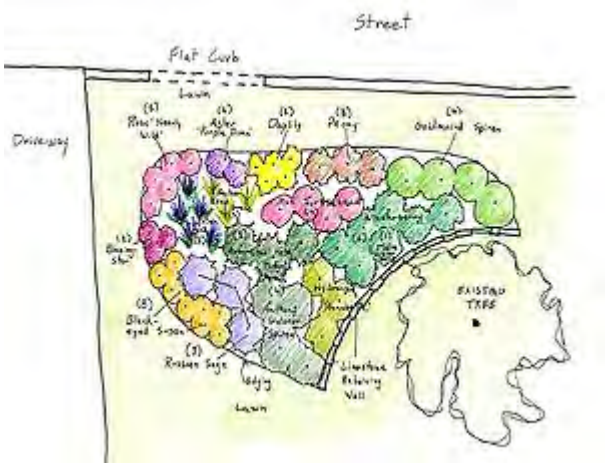
In order to let plants become established before being inundated, curb cuts were not made until spring 2004. It is important to design curb cuts sufficiently wide so stormwater actually reaches the gardens; a too-narrow cut can allow water to wash on by. At Burnsville, the typical curb opening was 6 feet, with 2 feet tapering sections on each side.

Costs

Cost per garden was approximately $7500, with about $500 of this going toward plants.

Results

Resident reviews have been favorable (an important factor in ongoing success of the gardens), and the monitoring data indicates excellent results.



Schematic showing the design for a rain garden. Note the placement of plants within different locations in the rain garden.

2004 monitoring data showed that the rain gardens achieved an 80 percent reduction in runoff volume in 49 rain events. Most basins drained dry within 3 to 4 hours. During winter, some ice build-up was evident, but as the melt infiltrated, ice collapsed and disappeared with no adverse effects.

Future actions

Photo illustrating a completed rain garden.

The Dakota County Soil and Water Conservation District conducted runoff audits on each lot in the study neighborhood to provide homeowners with additional suggestions on reducing runoff from their properties, such as redirecting downspouts, installing rain barrels to capture roof runoff and aerating lawns to enhance infiltration.

Another effort to benefit Crystal Lake, a single infiltration basin in West Buck Hill Park, was installed in fall 2004. It accepts runoff from a 25-acre sub-watershed.

The Burnsville rain garden project area and control neighborhood are being monitored through 2005. While the success of the project recommends installing more rain gardens elsewhere in the city, the project coordinator has departed, so it is unclear whether additional gardens will be built in the near future.

Links

- Barr report (http://www.ci.burnsville.mn.us/DocumentCenter/Home/View/449)
- Fact sheet (http://www.burnsville.org/DocumentCenter/Home/View/450)
- City of Burnsville (http://www.burnsville.org/index.aspx?NID=594)
- [1] (http://www.landandwater.com/features/vol48no5/vol48no5_2.html)

Case studies for stormwater and rainwater harvest and use/reuse

Green Infrastructure: Stormwater and rainwater harvest and use systems can improve or maintain watershed hydrology, reduce pollutant loading to receiving waters, increase water conservation, reduce stress on existing infrastructure, and reduce energy consumption

Cottage Grove City Hall

- **Location:** Cottage Grove, MN
- **Owner:** City of Cottage Grove
- **Designer**: Wold Architects (City Hall), SkyHarvester (reuse system)
- **Year of Completion**: 2012
- **Total Drainage Area**: 0.9 acres of rooftop
- **Total Construction Cost**: $120,000
- **Pretreatment/Methods of Filtration**: Rainwater filter (screen to remove large particles leaves, debris, and sediment), Fine filter (filter fine particles, down to 5 microns), UV Treatment (provides microbial disinfection)
- **Documented Maintenance Practices**: Replacement of filter media and UV bulbs as needed, general winterization of irrigation system
- **Pollutant Removal**: Runoff volume control approximately 1.8 acre-feet (570,000 gallons) per year. MIDS calculator estimates pollutant reductions of approximately 1.5 pounds of phosphorus (0.85 pounds particulate phosphorus and 0.70 pounds dissolved phosphorus), and 282 pounds total suspended solids per year.
- **Is the site publicly accessible**: Yes, an interpretive sign is on the rear patio of City Hall for public viewing.
- **Special Design Features**: Rainwater Harvester Control Panel to regulate operation of systems, Irrigate planting beds on 7-acre site, education signage about system

In 2012 the City of Cottage Grove completed construction of the new City Hall and Public Safety complex, designed by Wold Architects. The building is situated in a growing part of the community, directly adjacent to Cottage Grove Ravine Regional Park, a natural resource and recreation amenity area which features unique habitat and a beloved fishing lake. In an effort to reduce water use and impacts on stormwater runoff, the building design incorporates a stormwater harvester system. The harvester reuses stormwater collected from the building's roof for irrigation of the green space around the building and the Veterans Memorial fountain located at the building entrance. This system collects runoff from the 0.9 acre roof and stores it in an underground storage tank. From the storage tank, the water is filtered and treated with ultraviolet light then pumped through the irrigation system for use on the 7-acre City Hall grounds, and at the fountain. The purpose of the system is to provide the dual benefits of reducing the use of groundwater for landscape irrigation and minimizing stormwater runoff to Ravine Lake.

Click on an image for enlarged view.

Photo of Cottage Grove City Hall building. Image courtesy Emmons and Olivier Resources.

Photo of signage at Cottage Grove harvest and use system. Image courtesy Emmons and Olivier Resources.

Photo of tank for harvest and use system. Image courtesy City of Cottage Grove.

Photo of tank for harvest and use system. Image courtesy City of Cottage Grove.

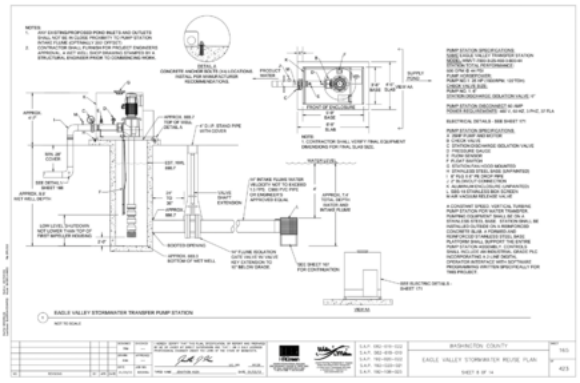
Eagle Valley and Prestwick Golf Club, Woodbury

- **Location**: Woodbury, MN
- **Owner**: City of Woodbury/Prestwick Golf Club Inc
- **Designer**: HR Green, Water in Motion
- **Year of Completion**: 2014
- **Design Features**:
  - Eagle Valley - large storage pond and babbling brook landscape feature for holding and moving stormwater runoff and reuse
  - Prestwick – creation of one large storage pond from two smaller ponds for holding and moving stormwater runoff for irrigation reuse
- **Total Drainage Area**: 430 acres (Eagle Valley), 130 acres (Prestwick)
- **Total Construction Cost**: $700,000.00 (funding from South Washington Watershed District/Clean Water Fund)
- **Pretreatment**: screen filter on intake pump
- **Documented Maintenance Practices**: winterize irrigation system each year, clean pump screen if it gets clogged (has not been needed during first three years of operation)
- **Pollutant Removal**: 99 lbs phosphorus per year, and 9.6 Acre/ft per event volume reduction
- **Is the site publicly accessible**: Yes

Plan for the harvest system showing storage and transport components. Image courtesy Emmons and Olivier Resources, HR Green and Water in Motion.

Project Background

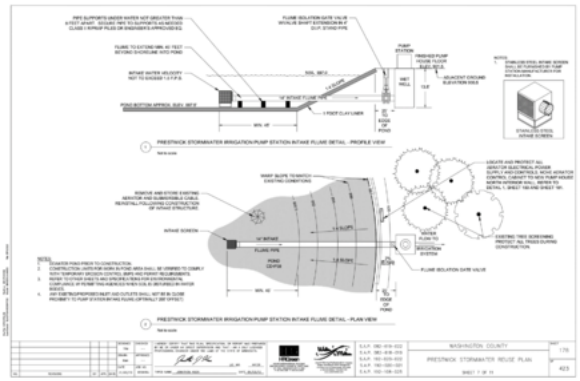
In 2014, the City of Woodbury, with funding from the South Washington Watershed District, constructed stormwater reuse for irrigation systems at Eagle Valley and Prestwick golf clubs. Each system collects runoff from a large drainage area containing roads, housing developments, and a golf course and stores it in a centralized pond. A pump then draws water from the pond for use in golf course irrigation. The total cost of both projects was $700,000.00. The catalyst for the projects was the planned reconstruction of CSAH 19 (Woodbury Drive), changing it from a rural 2-lane road to an urban 4-lane road. The goals for the project were to have no measurable downstream stormwater impacts from the road reconstruction project, and to help achieve Colby Lake's target TMDL standard to reduce phosphorus (TP) inputs by 30 lbs per year.



Eagle Valley Stormwater Transfer Pump Station detail. Image courtesy HR Green and Water in Motion.

Eagle Valley Golf Course

Prior to the reuse for irrigation project Eagle Valley Golf Course pumped 30 million gallons of well water annually to irrigate approximately 60 acres of golf course turf and landscaping. This project collects stormwater runoff from a 430 acre drainage area covering the golf course, surrounding neighborhoods, and Woodbury Drive into a storage pond on the course. The drainage area is 33.8% impervious. The reuse system can pump approximately 22.5 million gallons of stormwater for irrigation from the pond annually. The remainder of irrigation water that is needed will be supplied by the existing well. Stored water can also be routed through a babbling brook landscape feature on the golf course. The P8 modeled water quality benefits of the project at Eagle Valley were reductions in TP to Colby Lake of 56 lbs per year, and a volume reduction of 6.1 acre/ft per event.



Irrigation pump station intake flume detail. Image courtesy HR Green and Water in Motion.

Prestwick Golf Club

Prestwick golf club regularly irrigates up to 75 acres of turf and landscaping. Previously, course managers pumped 35 million gallons of water annually from a course well to accomplish this. The stormwater reuse system which was installed in 2014 can now supply approximately 17.5 million gallons of water from the storage pond annually. The 130 acre drainage area for the pond is 27% impervious. The remainder of irrigation water that is needed will be supplied by the existing well. The P8 modeled water quality benefits of the project at Prestwick were reductions in TP of 43 lbs per year, and a volume reduction of 3.5 acre/ft per event.

Conclusion

The City of Woodbury far exceeded their goals for water quality and volume reduction with the implementation of these two reuse projects at Prestwick and Eagle Valley. In total the projects reduce TP loading to local lakes by almost 100 lbs per year, and also reduces volume by 9.6 acre/ft for each event. The goals were 35 lbs of TP per year, and 1.84 acre/feet per event. In addition, both projects combine to reduce pumping from local aquifers by 40 million gallons annually by utilizing surface storage features (ponds) that add beauty and challenge to both golf courses.

Click on an image for enlarged view.

Photo of creek used to move stored water within the irrigation system. Image courtesy Emmons and Olivier Resources.

Photo of storage pond used for irrigation. Image courtesy Emmons and Olivier Resources.

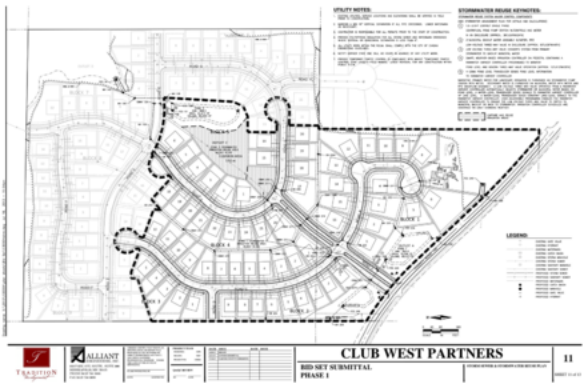
Sign for Eagle Valley Golf Course, with storage pond in the background. Image courtesy Emmons and Olivier Resources.

Photo of pump box for harvest and use system. Image courtesy City of Woodbury.

Photo of pump for harvest and use system. Image courtesy City of Woodbury.

Carver County Club West Development

- **Location**: Harvest Estates, Chaska, MN
- **Project Owner**: Club West Partners LLC
- **Project Designer**: Alliant Engineering
- **Year of Completion**: 2015
- **Design Features**:
  - Gallons used for irrigation annually: Permitted for 22.2 million gallons
  - Use for water: Irrigation of Lawn in Park, Boulevard Plantings and Flower Beds
  - Rainwater Harvester Control Panel: Regulates operation of irrigation systems
- **Total Drainage Area**:
  - Pond 1 = 28 acres
  - Pond 3 = 25 acres
- **Drainage Area Surface Type**: Residential (roads, driveways, turf, etc.)
- **Pond Size**:
  - Pond 1 = 18,600 sq ft
  - Pond 3 = 22,413 sq ft Irrigated area
  - Pond 1: 30,807 square feet



Carver County Club West storm sewer reuse plan. Image courtesy Alliant Engineering.

    - Pond 3: 42,267 square feet
- **Cost Savings Per Year**: $3,000 on irrigation water (compared to City potable water rates)
- **Pretreatment**: NURP pond and screen filter in intake pump
- **Methods of Filtration**: Filter Screens
- **Documented Maintenance Practices**: winterize irrigation system each year, clean clogged pump screen (annual startups and blow outs)
- **Pollutant Removal**: 4.37 lb TP and 1,503 lb TSS per year
- **Is the site publicly accessible**? Yes - Park and boulevards are central features to the neighborhood. With the systems in close proximity to the neighborhood and park entrances, awareness of the system is heightened.

Rainwater harvest components. Images courtesy Alliant Engineering.

Club West Partners, the developer of Harvest Estates, worked with the Carver County Watershed Management Organization (CCWMO) to implement a stormwater harvest and use system that would meet stormwater, TP, and TSS reduction requirements (90% TSS and TP reduction, per CCWMO rules) for that subwatershed. Designed by Alliant Engineering, the harvest and use project utilizes stormwater runoff draining from a new development, Harvest Estates, for irrigation of common areas within the development. The site is located in southwest Chaska, MN, in close proximity to the Minnesota River, where population growth trends continue to encroach on undeveloped areas of the watershed. This project is one of five sites in Carver County where stormwater is being used to irrigate green space in order to mitigate the impacts of population growth on groundwater withdrawals.

At Harvest Estates, stormwater is collected into three stormwater ponds. Two intake pumps draw the stormwater from two of the three ponds to irrigate a central park and boulevard at the entrance of the development. By incorporating the harvest and use system into the construction of the new development, overall stormwater runoff impacts are partially mitigated and use of potable water for irrigation is reduced. Up to 22.2 million gallons of harvested stormwater can be used to irrigate the park and boulevards. The project goal is to harvest and use up to 12,500 cubic feet of stormwater per week, or equivalent to a depth of ½”of stormwater over the surface area of the new impervious paving in the development (18.8 acres total). The harvest and use system uses a 1.5-2.0 HP centrifugal stormwater pump, which is then transferred and managed through irrigation controller pedestals that allow for the efficient harvest and use of stormwater. The system reduces the need to pump irrigation water from conventional sources, with a bypass switch for municipal water only in cases of decreased rainfall. Harvested stormwater pumped from the two ponds goes through a filter system to remove sediment prior to irrigation uses. The modeled water quality benefits of the project are TP reductions up to 4.37 lb per year and TSS reductions up to 1,503 lb per year. To date, roughly 1.5 million gallons of stormwater have irrigated the site through the harvest and use system, with an overall cost savings of $3,000 each year due to the decreased use of potable water.

Click on an image for enlarged view.

Photo of Carver County site. Image courtesy DR Horton Homes.

Photo of irrigated area. Image courtesy Emmons and Olivier Resources.

Photo of irrigated area. Image courtesy City of Cottage Grove.

Mississippi Watershed Management Organization (MWMO)

Cistern located at Mississippi Watershed Management Organization. Photo by MWMO Staff. To enlarge, click on image.

Name of Project: Mississippi Watershed Management Organization (MWMO)
Type of Reuse System: Cistern
Overview: The cistern, located at the MWMO, utilizes rooftop runoff from the main office area roof to water trees in a trench system.
Location: Mississippi Watershed Management Organization, 2522 Marshall Street NE, Minneapolis 55418
Owners: Mississippi Watershed Management Organization
Contractors: Meisinger Construction-general contractor for facility construction
Operators: Mississippi Watershed Management Organization
Cost (*additional plumbing would be needed if plumbed into the building to be used as grey water*):

- Concrete Slab - $5,200
- Cistern (including piping) – $23,700
- Rain Leader- $8,400

Type and size of system: 4,000 gallon capacity CorGal Water Tank, volume annual dependent on rainfall, filled by roof runoff only
Year of Completion: 2012
Drivers/Stormwater Goals: To water trees, reduce stormwater runoff that reaches the river, infiltrate rainwater. Future use as grey water in facility.

Funding sources: Public – MWMO funding
Monitoring: Total Suspended Solids, VSS, bacteria, once every 3 months
Web links: http://mwmo.org/
Lessons Learned: Design flaws – the plumbing was not correct and all the water drained out, the rain leader diverter operation was not intuitive. Additionally plumbing code hindered process of connecting to facility to be used as grey water. Staff opted to do this at a later time once plumbing codes were updated and other projects set precedence.
For more information contact:

Doug Snyder, Mississippi Watershed Management Organization Executive Director
E-mail: Dnsyder@mwmo.org
Phone: 612-746-4971

Cistern located at Mississippi Watershed Management Organization. Photo by MWMO Staff. To enlarge,click on image.

Home NPS BMPs: Reducing Nonpoint Source Pollution at Home

Nonpoint source (NPS) pollution is the leading cause of water quality problems in the U.S.. It's caused by pollutants carried by rainfall or irrigation runoff, which can come from various sources like agricultural runoff, urban streets, and construction sites.

Homeowners can significantly contribute to preventing NPS pollution by implementing Best Management Practices (BMPs) around their homes.

Here are some key NPS BMPs homeowners can use:

1. Managing Runoff:
    - Direct downspouts: Divert roof runoff onto grassed areas or into rain barrels instead of paved surfaces or storm sewers.
    - Install rain gardens or permeable pavement: These features help infiltrate stormwater into the ground, reducing runoff and promoting groundwater recharge.
    - Reduce impervious surfaces: Limit concrete and asphalt walkways and driveways. Consider using alternatives like gravel, stone, or permeable pavers.
    - Plant trees and native vegetation: Trees and native plants help slow down runoff, absorb excess water, and filter pollutants.

2. Smart Lawn and Garden Care:
    - Fertilize and apply pesticides sparingly: Use these chemicals only when necessary and follow recommended application rates. Avoid applying them before rain events.
    - Choose drought-resistant and native plants: These plants require less water, fertilizer, and pesticides, reducing environmental impact.
    - Compost yard waste: Recycling grass clippings and leaves through composting reduces fertilizer needs and keeps waste out of storm drains.
    - Mow properly: Follow recommended mowing heights and avoid excessive watering.
    - Control soil erosion: Plant ground cover and stabilize erosion-prone areas to prevent soil runoff.

3. Responsible Waste Management:
    - Dispose of hazardous materials properly: Never pour oil, antifreeze, paint, or other household chemicals down storm drains or into the trash. Utilize local hazardous waste collection programs.
    - Clean up spills: Absorb spills of fluids like oil and grease with absorbent material and dispose of it properly.
    - Manage pet waste: Promptly clean up pet waste to prevent it from washing into storm drains and contaminating waterways.
    - Maintain septic systems: If you have a septic system, have it inspected and pumped regularly to ensure proper function and prevent pollution.

4. Vehicle Care:
    - Wash cars on pervious surfaces: Use a commercial car wash or wash your car on a lawn to prevent soapy water from entering storm drains.

- Address leaks promptly: Repair any leaks from your vehicle to prevent fluids from entering the storm drain system.
- Recycle used automotive fluids: Dispose of used oil and other fluids at designated recycling stations.

By implementing these simple BMPs, homeowners can make a significant difference in protecting water quality and reducing NPS pollution.

Steps to help control NPS pollution

Summarized from: https://www.mdeq.ms.gov/water/surface-water/nonpoint-source-pollution-program/steps-tohelp-control-nps-pollution/

• Collect litter and animal waste before they wash into storm drains.

• Apply fertilizer at the recommended rate when heavy rain isn't likely to wash it away.

• Recycle grass clippings and leaves by mulching or composting. If you can't compost, collect and dispose of yard waste according to local provisions. Do not put in storm drain.

• If you change your own oil, take the used oil to a recycling station. Check with your local service stations for such facilities. Never dump oil into a storm drain.

• Home septic tanks should be located, constructed and installed according to regulations. Maintenance and prompt correction of problems are important.

• Direct roof runoff onto a grassed area. Roof drains should not be connected to a sanitary or storm sewer system.

• Watch for soil erosion around your home. Seed, install sod or plant ground cover to protect the site.

• Use porous surfaces such as flagstone, gravel, stone, and interlocking pavers rather than concrete and asphalt.

• If you're concerned about the effects of runoff leaving a nearby construction site, contact the local governing body responsible for erosion and sediment control in your area.

• Be active! Join a civic or environmental group and participate in stream cleanup activities. Give talks, man booths, join the Adopt-A-Stream Program… spread the word.

You couldn't live long without clean water. Nothing can. Do your part to protect our waters.