Chapter 5: Beneficial Technologies Not Analyzed

5.1 Introduction

Thirty-one technologies were identified as having positive impacts to water quality, but the available data was not sufficient to evaluate them using the Production Theory, as described in Chapter 2, *Technology/Indicator Analysis*. These technologies were considered in the alternatives analysis and in the Recommended Plan; however, further analysis will be required to determine the effectiveness of these technologies.

A technology may have very positive impacts on water quality, but not fit with production theory analysis due to the following factors:

- The available cost data is not be precise enough (this is usually not the production theory issue). An example is a technology that has not been used or studied to a great extent and thus little data are available on costs of construction and/or operation.
- The available efficiency of the technology in terms of units of application per unit of water quality improvement is not available, or is available in very limited data sources, not available in a useable form, or is in a form that is too subjective. An example is a technology where costs are available, but data are imprecise or inconclusive with regard to what the technology accomplishes in terms of water quality improvement.

The technologies included in this chapter are organized by primary indicator as shown in Table 5-1.

TABLE 5-1
OUTLINE OF CHAPTER 5 TECHNOLOGIES

Section	Primary Indicator	Subsection / Technologies	
5.2	Volume	5.2.1	Contract Terms – Milwaukee Metropolitan Sewerage District (MMSD) contract with United Water Services (UWS)
		5.2.2	French Drains / Dry Wells
		5.2.3	Infiltration Sumps
		5.2.4	Real Time Control for Storage/Treatment
5.3	Total Suspended Solids (TSS)	5.3.1	Agricultural Practices - Base Slope Storage
		5.3.2	Channel Stabilization
		5.3.3	Compost Amendments for Erosion Control
		5.3.4	Conservation Cover
		5.3.5	Construction Erosion Controls - Filter Fabric, Straw, Sedimentation Trap
		5.3.6	Contour Farming
		5.3.7	Drop Structure Removal
		5.3.8	Filter Strip
		5.3.9	Grade Stabilization Structure
		5.3.10	Grassed Swale
		5.3.11	Grassed Waterway
		5.3.12	Mulching
		5.3.13	Prescribed Grazing
		5.3.14	Residue Management
		5.3.15	Revegetation Measures - New Development
		5.3.16	Runoff Diversion to Reduce Nonpoint Pollution
		5.3.17	Streambank and Shoreline Restoration
		5.3.18	Strip Cropping
		5.3.19	Windbreak Establishment
5.4	Nutrients (Phosphorus / Nitrogen)	5.4.1	Golf Course Fertilizer Management
		5.4.2	Lawn Management
		5.4.3	Nutrient Management
		5.4.4	Prescribed Burning
5.5	Other Indicators	5.5.1	Pesticide/Herbicide Management
		5.5.2	Public Education Programs
		5.5.3	Stream Day-Lighting
		5.5.4	Wastewater Treatment Plant Outfall Diffuser

5.2 Primary Indicator: Volume

For the purposes of this *State of the Art Report* (SOAR) analysis, the volume indicator refers to the reduction of separate sewer overflows (SSOs) and combined sewer overflows (CSOs). The technologies that could be used to reduce the volume indicator that were not analyzed using the production theory are described in this section.

5.2.1 Contract Terms – Milwaukee Metropolitan Sewerage District Contract with United Water Services

In 1998, MMSD signed a 10-year operation and maintenance (O&M) contract with UWS. Under this contract, UWS operates and maintains the MMSD's wastewater conveyance and treatment system. The contract requires compliance with the terms of the MMSD's Wisconsin Pollutant Discharge Elimination System (WPDES) permit and requires an additional level of pollutant removal beyond that required in the permit. In addition, the contract provides financial incentives for additional pollutant removal.

Since this is an existing contract, the O&M contract provisions were screened out from further analysis in this report. These provisions are being evaluated as a part of an active MMSD project to formulate the contract provisions for the next operations procurement in 2008.

5.2.2 French Drains / Dry Wells

A French drain, also known as a dry well, is an underground shaft or hole that is designed to store and infiltrate stormwater. The French drain may be an open chamber or may be filled with aggregate. French drains are used to reduce the amount of water that is discharged from a site and are commonly used for unpolluted roof runoff. French drains can only be used to infiltrate clean stormwater runoff and are not considered appropriate where high pollutant loadings are expected due to the potential for groundwater contamination. French drains provide for groundwater recharge from surface stormwater runoff. Soils must be permeable to allow for adequate infiltration. Maintenance includes regular inspection and repair.(1)

5.2.3 Infiltration Sumps

Stormwater infiltration sumps are below-ground structures used to collect stormwater runoff and pass it into the surrounding soil. Infiltration sumps are best suited in areas where the underlying soils are moderately to highly permeable, and the groundwater table is deep below the ground surface. They are generally more appropriate for residential areas that are less than 50% impervious.

Infiltration sumps collect runoff in a standard stormwater inlet structure at the ground surface and route it to a manhole structure and an attached sump chamber. As the manhole chamber fills, flow reaches an overflow point and begins to fill the second chamber. Perforations in the second chamber allow the water to infiltrate into the soil. A typical 4-foot diameter, 30-foot deep sump can serve about 1.5 acres. Sump maintenance includes cleaning every two to three years.

The potential for groundwater contamination needs to be considered prior to the installation of an infiltration sump. All applicable regulations in Wis. Admin. Code Natural Resources (NR) 815 (Injection Wells) and Commerce (Comm) 83 (Private Onsite Wastewater Treatment Systems) must be followed.(2)

5.2.4 Real Time Control for Storage/Treatment

Real-time control employs weather forecasting and measured system information to maximize the use of storage and treatment facilities in order to reduce overflows. Real-time control of the MMSD's conveyance and treatment system has been effective in improving water quality, particularly during periods of wet weather. One approach is to maximize the storage of wastewater in the conveyance system to minimize overflows to waterways. Many strategies for real-time control have been studied by MMSD's Real-Time Control project. For this reason, there was no further consideration in SOAR. The system modeling used for the 2020 Facilities Plan (2020 FP) conveyance model includes modeled strategies that were developed in the Real-Time Control project. As new strategies are developed and refined, the 2020 FP conveyance model is updated.(3)

5.3 Primary Indicator: Total Suspended Solids

The total suspended solids (TSS) indicator relates to the reduction of sediment and other suspended solids contained in stormwater runoff that will ultimately reach a receiving water. Technologies that effectively reduce the total suspended solids indicator typically prevent or reduce erosion, promote sedimentation or capture sediment through filtering practices.

The technologies that could be used to reduce the TSS indicator that were not analyzed using the production theory are described in this section.

5.3.1 Agricultural Practices - Base Slope Storage

Base slope storage is the construction of storage cells at the base of farm fields to collect stormwater runoff from the fields. Like wet detention basins, base slope storage cells provide removal of sediments and some nutrients. Maintenance includes an annual inspection to identify damage, measure sediment accumulation, and examine the inlet and outlets. Debris should be removed from inlet and outlets and side slope vegetation should be maintained on a monthly basis. Sediment should be removed when the available storage volume has been reduced or when the pond becomes eutrophic.

5.3.2 Channel Stabilization

Channel stabilization is used to prevent erosion and reduce total suspended solids in receiving waters. Channel stabilization measures may include the following:

- Alter the channel bed elevation or slope
- Add channel elements such as riprap to maintain the channel bed elevation
- Modify sediment transport or deposition characteristics of the channel
- Manage surface water and groundwater levels in floodplains, riparian areas, and wetlands

Channel stabilization should be used in areas where damaging aggradation or degradation is occurring that cannot be controlled using upland or bank stabilization measures. When implementing channel stabilization measures, consideration must be given to existing channel structures, natural and manmade tributaries and outfalls, floodplain elevation, channel water level, habitat, and safety.(4)

5.3.3 Compost Amendments for Erosion Control

Amending urban soils with compost involves incorporating stable, humus-like organic material produced by the biological and biochemical decomposition of materials such as leaves and yard trimmings, food scraps, food processing residuals, manure and /or other agricultural residuals, forest residual and bark, and soiled or non-recyclable paper. The addition of compost amendments to soil can increase water infiltration and retention and reduce the potential for soil erosion. Compost amendments are typically used on urban soils that have become highly compacted and have low organic matter and nutrients.

Compost can also be applied directly to bare soils for erosion protection. A 1-½ to 3-inch layer of compost has been found to control erosion by enhancing plant growth and retaining moisture and slowing runoff. Constructing compost berms at the top and bottom of a slope will slow velocity and provide sediment settling and filtering. Maintenance includes placement of additional compost materials as initial compost deteriorates.(5,6,7)

5.3.4 Conservation Cover

Conservation cover is the practice of establishing and maintaining vegetative cover on retired agricultural lands to prevent or reduce erosion, improve water quality, and create or enhance wildlife habitat. The vegetative cover may include grasses and legume, trees, or a mixture of vegetation. The long-term objectives of the land and targeted wildlife species should be considered during vegetation selection. Permanent vegetative cover should be established within one year of conversion from agricultural use. Maintenance includes regular inspection and repair of erosion areas, replacement of plants, periodic mowing, and weed control.(8)

5.3.5 Construction Erosion Controls - Filter Fabric, Straw, Sedimentation Trap

When sites are prepared for construction, vegetation and topsoil are typically removed, exposing large areas of bare ground that are highly susceptible to erosion. Construction site erosion controls include the use of filter fabric, straw, and sedimentation traps to reduce erosion and capture sediment contained in stormwater runoff.

Filter fabric can be used as fencing to capture silt in stormwater runoff (silt fencing) or for inlet protection. The fabric allows water to pass through but captures sediment. Silt fences also slow the runoff velocity. Straw can be used to cover cleared areas to protect the bare soils from erosion. Straw bales can be used to construct barriers to filter and slow runoff. Sedimentation traps are pond-like structures designed to retain runoff from small disturbed areas allowing sediment to settle out before the water is discharged.

Regular maintenance of construction erosion controls is necessary for continued effectiveness. Maintenance activities include inspections, removal of accumulated sediment, replacement of filter fabric or straw, re-securing fencing or straw bales, and replacement of broken stakes.(9)

5.3.6 Contour Farming

Contour farming is the practice of planting crop rows nearly level across a slope following the contours of the land. The crop rows create a series of small dams that slow water flow and increase infiltration. Contour farming is most effective on slopes between 2-10% and may not be well suited for rolling topography. The crop row line grades should not exceed 2% except near a drainage way. Contouring can reduce soil erosion by as much as 50% compared to up and down hill farming.(10) Farming on the contour will reduce fuel consumption for equipment. Steeper or longer slopes may require strip cropping described in Section 5.3.18.

Construction of stabilized drainage ways, such as a grassed waterway, may be necessary to prevent erosion in concentrated runoff areas.(11,12,13)

5.3.7 Drop Structure Removal

Drop structures are typically installed to disrupt the natural flow of a stream in order to stabilize a channel bottom in an area with a steep gradient. The water flows over the drop structure to a stable plunge pool at a lower elevation. Removing a watercourse drop structure will allow the stream to return to a more natural condition, and can improve habitat conditions. The dissolved oxygen (DO) may decrease slightly as a result of the removal, but TSS and other pollutants would be minimally affected. Erosion potential, sediment transport, and stream flow characteristics should be carefully evaluated during design for a drop structure removal.

5.3.8 Filter Strip

A filter strip is an area of vegetation located between cropland, grazing land, or other un-stabilized area and an environmentally sensitive area. The purpose of the filter strip is to capture sediment and other pollutants and reduce or eliminate the pollutant loading to the protected area. Filter strips can be used to protect and stabilize the riparian zone and reduce flood water velocity. They should not be used in areas where high levels of pollutants are expected, such as animal feed lots, or in areas of concentrated flows. Filter strips constructed for removal of dissolved nitrogen should include at least 50% deep-rooted vegetation. The slope of the land, soil type, vegetation type, and habitat improvement should be considered when establishing filter strips. Filter strip widths typically range from 20 to 120 feet. The filter strip should be protected from livestock and from herbicide application on adjacent crop land. Maintenance includes regular inspection and repair, and occasional mowing.(14)

5.3.9 Grade Stabilization Structure

A grade stabilization structure is built across a natural or manmade channel to stabilize the channel grade, reduce gully erosion, or improve water quality by collecting and storing runoff. A grade stabilization structure can be used where stormwater runoff, due to high flow velocity, is causing erosion or an unstable channel base. The stabilization structure should have a controlled spillway with a stable outfall. Adequate erosion control practices should be installed upstream of the structure to prevent sedimentation. The grade control structure can be designed to pond water. Ponded water can improve habitat for fish and wildlife, improve aesthetics, and be used as an emergency water supply.

Downstream gradient, fluvial geomorphic conditions, upstream stabilization, and existing fish and wildlife habitat should be considered in the design of a grade stabilization structure. Maintenance includes regular inspection and, as necessary, sediment removal, concrete or erosion repair, and removal of debris from the outlet.(15,16,17)

5.3.10 Grassed Swale

A grassed swale is a broad, shallow, earthen channel vegetated with erosion resistant and flood tolerant grasses used to convey stormwater runoff. Stormwater is treated through settling, filtering by the vegetation, filtering through subsoils, and/or infiltration into the underlying soils. Water quality can be further improved by using an engineered subsoil to increase soil filtration.

Grassed swales can be used in many situations, but may not be suitable for ultra urban areas due to limited pervious area and other space restrictions. Grassed swales should not be installed over sanitary sewer laterals due to the increased potential for infiltration into the sewer system. The flow rate in the swale is a critical design element because a slow flow rate is necessary for filtration and settling to occur. Grassed swales have been found to provide low to moderate removal of soluble phosphorus and nitrogen and moderate to high removal of particulate pollutants. The drainage area to a grassed swale should be small to ensure that the flow rate remains slow and non-erosive. Design considerations should include existing soil conditions, topography, and depth to groundwater.

Maintenance of grassed swales includes regular inspection, repair of erosion, removal of debris, replacement of vegetation, and mowing.(18,19)

The analysis of existing grassed swales in terms of total suspended solids (TSS) removal will need to be addressed by communities and the WDNR as a part of NR 151 compliance. Communities permitted under Wis. Admin. Code NR 216 (Storm Water Discharge Permits) must reduce total suspended solids loading 20% by March 2008 and 40% by 2013. Existing swales may account for a portion of the TSS reduction within the communities, depending upon the swale design and condition.

5.3.11 Grassed Waterway

A grassed waterway is a natural or constructed channel that is vegetated. The channel is typically shaped or graded to carry surface water at a non-erosive velocity to a stable outlet. Grassed waterways can be used to convey runoff from terraces, diversions, or other areas where stormwater runoff becomes concentrated. The vegetation and slowed velocity of the runoff reduces the potential for erosion and provides filtering.

Grassed waterways should be considered in areas where additional conveyance capacity and erosion control are needed. Drainage areas to the grassed waterway should be stabilized to prevent sediment deposition to the waterway. Soil erodibility, slope, runoff velocity, channel depth, vegetation selection, and habitat should be considered during the design of the grassed waterway. Additional measures, such as filter fences, temporary diversion, mulch anchoring, or a nurse crop may be necessary until the vegetation is established. Irrigation may be necessary to establish vegetation or during drought conditions. Routine maintenance includes regular inspection and repair of damaged vegetation or erosion, periodic mowing, and weed control.(20)

5.3.12 Mulching

Mulching is the practice of applying a protective layer of materials on exposed soils to modify soil temperature and moisture, control weeds, and reduce erosion. Organic mulches include grass clippings, bark, straw and other plant materials. Organic mulches will decompose and add organic matter to soils to improve soil retention and nutrient content. A mulch depth of two to four inches is usually considered sufficient. Inorganic mulches include stone, plastics, and geotextiles. Inorganic mulches do not provide any soil improvement benefits.(21,22)

5.3.13 Prescribed Grazing

Prescribed grazing is a land management practice that promotes livestock grazing in small pastures for a limited time to benefit the quantity and quality of vegetation, improve water quality, and improve the health of the livestock. The livestock is moved to a recovered pasture after a designated amount of time. Prescribed grazing reduces farmer costs by allowing grazing instead of machine harvesting. Livestock health improves because the animals are kept in the pasture instead of in a confined area. Water quality is improved because overgrazing and machine harvesting are avoided. Prescribed grazing produces healthy pastures, which increases infiltration and filtration. As a result, the amount of sediment, nutrients, and fecal matter that could be discharged in stormwater runoff is reduced.

This practice is considered appropriate for all agricultural lands. The pasture size, livestock type, water supply, crop yield, and livestock travel paths should all be considered when establishing a prescribed grazing program. Additional fencing may be necessary to keep livestock from waterways or riparian areas. It may be necessary to make operational adjustments, such as changing the length of grazing or rest time, changing the pasture size, moving watering lines, or moving access lanes. Maintenance includes regular evaluation of pasture growth to determine if supplemental harvesting, supplemental feeding, or additional seeding may be necessary.(23,24,25,26)

5.3.14 Residue Management

Residue management is an agricultural practice that involves changing tillage and planting operations to leave an amount of crop residue on the soil. The residue prevents erosion and reduces runoff velocities from fields. Residue management keeps soil, nutrients, and chemicals from washing away with the stormwater runoff. There are three crop management systems common in Wisconsin that help to maintain residue:

1) Mulch-till, which uses chisel plows or disks to till the entire field and provides moderate erosion control
2) Zone-till, which uses coulters to till a five to seven-inch strip for planting and/or injecting starter fertilizer and provides excellent erosion control
3) No-till which leaves the soil and crop residue undisturbed except for the crop row where the seed is placed in the ground which provides maximum erosion control (27)

5.3.15 Revegetation Measures - New Development

Revegetation measures for new development should include vegetation that does not require significant use of fertilizers, herbicides, or pesticides. The landscaping plan should be developed using native plants to reduce overall landscape maintenance, such as mowing grass and chemical applications. Newly created traditional lawn areas typically receive intensive chemical applications to help in establishment of the turf grass. Eliminating this type of lawn and the corresponding chemical applications will reduce the potential for nutrient and other pollutant contamination in stormwater runoff. Use of native plants in place of turf grass can also result in a reduction of runoff volume and rate.(28)

5.3.16 Runoff Diversion to Reduce Nonpoint Pollution

Diverting stormwater runoff around potential pollutant sources prevents exposure of the source to stormwater and eliminates the potential for the stormwater to become contaminated. Methods of diversion include gutters, drains, sewers, dikes, berms, swales, and graded pavement. Stormwater diversions can be used at industrial, agricultural, and construction sites to minimize the contact of stormwater runoff with sources that could impart pollutants, such as chemical or manure storage areas.

Diversions can also be constructed to collect stormwater runoff from contaminated areas to provide treatment. For example, runoff from a feed lot can be diverted and collected for treatment of nutrients and fecal coliforms. Runoff from an airport can be diverted for treatment of de-icers.

Proper erosion control measures should be incorporated into the diversion design to prevent erosion in areas with concentrated flows. Diversions should be sized properly to prevent overflow and flooding. Regular maintenance should include removal of debris.(29)

5.3.17 Streambank and Shoreline Restoration

Streambank and shoreline restoration practices repair eroded or failed areas along streambanks or shorelines. The restoration may be done to protect private or public property or infrastructure or to reduce land loss and sediment loadings. Restoration practices are either vegetative or structural and include the following:

- Live stakings (live cuttings of trees tamped into the ground that sprout readily)
- Live fascines (bundles of dormant branch cuttings bound together and placed in shallow trenches)
- Brush layers (cuttings tied together in shallow trenches arranged horizontally on the bank face and partially buried)
- Brush mattresses (interwoven cuttings laid side by side on the face of a bank which sprout to establish numerous plants)
- Joint plantings (live stakes tamped into open spaces betweens rocks on a stream slope)
- Live cribwalls (hollow, box-like interlocking arrangements of untreated logs filled above the stream baseflow level with soil and live branch cuttings)
- Conventional bank armoring with rock or rubble

Bank protection measures may include:

- Rootwad or boulder revetments (logs with root mass attached or boulders placed in and on streambanks)
- Lunkers (constructed cells which are imbedded into the toe of a streambank to provide covered fish habitat and shelter as well as to prevent streambank erosion).

Vegetative practices are generally considered to have more positive environmental effects, including improving habitat and filtering runoff.(30,31)

5.3.18 Strip Cropping

Strip cropping is the planting of crops between strips of meadow or small grain and row crops. The small grain or hay strips slow runoff water and provide an opportunity for infiltration and filtering of stormwater runoff. The strips should be about the same width, generally ranging from 25 to 75 feet for slopes greater than 10%. A grass border is typically maintained for farming equipment to turn. This practice is typically used in conjunction with crop rotations, which provide nutrient benefits.

Construction of stabilized drainage ways, such as a grassed waterway, may be necessary to prevent erosion in concentrated runoff areas.(32,33,34)

5.3.19 Windbreak Establishment

A windbreak is a row of trees and shrubs that protect areas from wind and provide improved habitat for wildlife. Windbreaks may serve many purposes including reducing soil erosion from wind, protecting plants from wind damage; managing snow deposition; providing shelter for structures, livestock and recreational areas; enhancing wildlife habitat; providing noise and visual screening; delineating property boundaries; enhancing aesthetics; and increasing carbon sequestration.

An established windbreak slows wind on the downwind side of the windbreak for a distance of ten times the height of the trees.(35) Species of plants should be selected based on existing soil conditions, climate, site conditions, and primary wind break purposes. Other items to consider when planning a windbreak are existing overhead and underground structures, surrounding land use, shading of roadways, and safety.(36,37,38)

5.4 Primary Indicator: Nutrients - Phosphorus and Nitrogen

The nutrients indicator relates to the reduction of nitrogen (N) and phosphorus (P) contained in stormwater runoff that will ultimately reach a receiving water. Technologies that effectively reduce the nutrient indicator typically involve better management and application of fertilizers. Technologies that could be used to reduce the nutrient indicator that were not analyzed using the production theory are described in this section.

5.4.1 Golf Course Fertilizer Management

Golf course fertilizer management involves reducing the amount of fertilizers applied to minimize stormwater runoff contamination while still maintaining healthy turf grass. The primary nutrients in turf grass fertilizers are nitrogen, phosphorus, and potassium. The potential for stormwater contamination from fertilizers increases in newly seeded areas, on steep slopes, and when the application is timed poorly. The objective of a fertilizer management plan is to supply the minimum amount of nutrients needed at the proper times and in the proper amount to maintain healthy vegetation. Fertilizer management should address nutrient needs by type of vegetation, soil conditions, and use. Weather and irrigation conditions should be considered prior to fertilizer applications to avoid washing off fertilizers. Use of slow-release nitrogen or more frequent light applications of water soluble nitrogen reduces the potential for leaching. A fertilizer free buffer around all surface waters should also be incorporated into fertilizer management.(39,40)

Wis. Admin. Code NR 151.13(1)3 and 151.14 require all urban properties that exceed five acres of pervious surface where fertilizers are applied to have an active fertilizer management program.

5.4.2 Lawn Management

Lawn management reduces the amount of fertilizers and pesticides applied to lawns to minimize stormwater runoff contamination. Soils should be regularly tested and fertilizer rates adjusted accordingly to prevent over fertilization. Additional lawn management techniques include maintaining a turf height of at least three inches to prevent erosion, improve filtration, reduce irrigation needs, and assist with weed control; watering during early morning or evening hours; avoiding runoff from watering; and using native vegetation where possible.(41,42)

5.4.3 Nutrient Management

Nutrient management is managing the amount of nutrients to match crop or vegetation needs. A nutrient management plan is prepared based on crop yield goals, soil tests to determine the available nutrients, crop sequence, and credits for nutrients from legume crops and manure applications. Special concern areas, such as floodplains and steep slope areas are identified in the plan. The plan identifies a recommended application rate, timing, and method for the nutrient applications. The management plan should be reviewed and updated annually.

Nutrient management maximizes the amount of nutrients the crops convert into grain and fiber while reducing the opportunity for nutrients to reach streams, lakes, or groundwater.

Nutrient management can also be applied to residential lawns.(43,44,45)

Wis. Admin. Code NR 151.07 requires all crop producers and livestock producers that apply manure or other nutrients directly or through contract to agricultural fields to apply nutrients in conformance with a nutrient management plan. Wis. Admin. Code NR 151 contains the state's runoff management regulations.

5.4.4 Prescribed Burning

Prescribed burning is the intentional ignition of fires in a designated area. The purpose of prescribed burning is to control undesirable vegetation and plant disease, reduce wildfire potential, improve wildlife habitat, and improve plant production. Prescribed burning is considered an efficient and economical tool that reduces the amount of pesticides needed to control invasive plants. Fires burn off dead vegetation and stimulate new plant growth by allowing sunlight to encourage germination. Nutrients are returned to the soil as a result of the fire.

The Chicago Park District indicates that there are fewer air emissions produced from an annual burn than from frequently mowing.(46)

The time of year, objective (broad management or specific species), weather conditions, smoke impacts, and fire breaks should be evaluated prior to prescribing a burn. Burns should be conducted by properly trained personnel with sufficient fire suppression equipment.(47,48,49)

5.5 Other Primary Indicators

This section describes technologies that reduce toxic chemicals or a combination of indicators found in stormwater runoff.

5.5.1 Pesticide/Herbicide Management

Pesticide and herbicide management involves using effective and safe application measures to reduce contamination of surface and groundwater. Pesticide/herbicide management includes the evaluation of current and historical pest and weed problems, crop history, soil conditions, and physical site conditions to develop an integrated pest management strategy. The management strategy may include pest-resistant plants, cultural controls, soil amendments, beneficial insects, natural enemies, barriers, physical treatments, behavioral disruptants, and biological and conventional pesticides. The goal of pesticide and herbicide management is to use safe and effective formulations to maximize the benefits of the control in the fewest applications or lowest rates of application. In order to reduce the potential for rainfall-induced runoff loses, application should not occur before expected rainfall events. Management measures should be regularly evaluated and updated as crop rotations, pest problems, and type of pesticides/herbicides available for use change. Application equipment should be regularly calibrated and inspected.(50,51)

5.5.2 Public Education Programs

Public education and outreach is one of six measures an operator of a Phase II regulated small municipal separate storm sewer system (MS4) is required to include in its stormwater management program to meet the requirements of its U.S. Environmental Protection Agency (USEPA) National Pollutant Discharge Elimination System (NPDES) stormwater permit. The Phase I NPDES stormwater program was promulgated in 1990. The Phase II Stormwater rule, published December 1999, extends coverage of the NPDES program to certain small (serving a population less than 100,000) MS4s.

Public education programs are designed to inform and educate the community in an attempt to gain support and improve compliance with new and existing programs. Municipal operators are required to implement a public education program that distributes educational materials describing the impacts of stormwater discharges on local water bodies and outlining the measures to reduce stormwater contamination. Appropriate best management practices and measurable goals should be included in the program.

The USEPA suggests three main actions that are important for successful implementation of a public education program:

1) Forming partnerships with other governmental and non-governmental organizations
2) Using existing educational materials and strategies
3) Reaching diverse audiences

Education programs may focus on a single behavior or on a general concept. The most effective watershed education programs focus on key pollutants or behaviors, carefully target their audiences, and survey residents to understand their attitudes before designing education campaigns.(52,53)

5.5.3 Stream Day-Lighting

Stream day-lighting exposes a covered section of a watercourse to the environment. Past practices have often enclosed streams in pipes, culverts, or other underground covered conveyances. Day-lighting can be implemented in an existing channel or designed as part of a new channel. Day-lighting has many benefits, including relieving bottlenecks and flooding due to undersized conveyances, reducing runoff velocities, improving water quality, creating aquatic and riparian habitat, providing recreational areas, increasing property value, and creating urban green space. Space constraints, construction difficulties, and high costs are challenges to stream day-lighting.(54)

Public safety concerns also need to be addressed when day-lighting streams. Many of the streams were enclosed in highly developed areas to reduce the risk of overland flooding or to allow the area above the stream to be utilized. Without the proper planning and design, day-lighting could potentially expose stream reaches that are dangerous during high flow events in these highly developed areas. Fast-flowing, flooded streams have many inherent dangers including the risk of drowning. These concerns must be addressed in the channel design of any stream day-lighting project.

5.5.4 Wastewater Treatment Plant Outfall Diffuser

Outfall diffusers incorporate multiple openings at the outfall of a wastewater treatment plant discharge pipe, as opposed to a single opening, to discharge effluent to the receiving water. This creates a larger area where the effluent mixes with the receiving water, called the zone of initial dilution. A larger zone of initial dilution reduces the acute toxicity of any remaining pollutants in the effluent and can improve the water quality near the outfall. Diffusers can be particularly effective in minimizing the localized effects of oxygen-demanding pollutants, ammonia, and metals. Water quality modeling can be used to predict potential benefits of various effluent diffuser designs. This type of modeling is useful in a preliminary design or design effort, which is beyond the scope of this analysis.

References

(1) New Jersey Department of Environmental Protection, *New Jersey Stormwater Best Management Practices Manual Chapter 9.3 Standard for Dry Wells* (February 2004) [Internet]; available from http://www.state.nj.us/dep/stormwater/tier_A/pdf/NJ_SWBMP_9.3%20print.pdf

(2) Milwaukee Metropolitan Sewerage District, *Fact Sheet Infiltration Sumps* [Internet]; available from http://www.mmsd.com/wqi/docs/factsheet_infiltration_sumps.pdf

(3) Milwaukee Metropolitan Sewerage District, *Real Time Control Strategy Improvement Plan* (DRAFT - September 2005)

(4) Natural Resources Conservation Service, *Channel Stabilization Code 584 Conservation Practice Standard* (July 2003)

(5) Milwaukee Metropolitan Sewerage District, *Compost Amendments Fact Sheet*

(6) U.S. Environmental Protection Agency, *Innovative Uses of Compost Erosion Control, Turf Remediation, and Landscaping* (October 1997), [Internet]; available from http://www.epa.gov/epaoswer/non-hw/compost/erosion.pdf

(7) Connecticut Department of Environmental Protection, *Using Compost to Control Soil Erosion, Establish Turf and Amend Planting Backfill: A Research Summary* (July 2001), [Internet]; available from http://dep.state.ct.us/wst/compost/dotcompost.htm

(8) U.S. Department of Agriculture Natural Resources Conservation Services, *Conservation Cover Code 327 Conservation Practice Standard* (February 2004)

(9) Center for Watershed Protection, *Erosion and Sediment Control Fact Sheets* [Internet]; available from http://www.stormwatercenter.net

(10) Conservation Technology Information Center Core 4 Conservation, *Contour Farming* [Internet]; available from http://www2.ctic.purdue.edu/Core4/CT/Choices/Choice15.html

(11) U.S. Department of Agriculture Natural Resource Conservation Service, *Contour Farming Code 330 Conservation Practice Standard* (May 2002)

(12) Conservation Technology Information Center Core 4 Conservation, *Contour Farming* [Internet]; available from http://www2.ctic.purdue.edu/Core4/CT/Choices/Choice15.html

(13) U.S. Department of Agriculture Natural Resources Conservation Service, Contour Farming and Strip Cropping [Internet]; available from http://www.wi.nrcs.usda.gov/programs/solutions/stripcropping.html

(14) U.S. Department of Agriculture Natural Resources Conservation Service, *Filter Strip Code 393 Conservation Practice Standard* (January 2001)

(15) U.S. Department of Agriculture Natural Resources Conservation Service, *Grade Stabilization Structure Code 410 Conservation Practice Standard* (January 2002)

(16) Polk Soil and Water Conservation District, *Grade Stabilization Structure* [Internet]; available from http://polk-swcd.org/Practices%20folder/gradestab.htm

(17) Conservation Technology Information Center Core 4 Conservation, *Grade Control Structure* [Internet]; available from http://www2.ctic.purdue.edu/Core4/CT/Choices/Choice25.html

(18) Virginia Department of Conservation and Recreation, *Minimum Standard 3.13 Grassed Swale* (September 2002) [Internet]; available from http://www.dcr.virginia.gov/sw/docs/swm/Chapter_3-13.pdf

(19) Center for Watershed Protection, *Stormwater Management Fact Sheet: Grassed Channel* [Internet]; available from http://www.stormwaterwatercenter.net

(20) U.S. Department of Agriculture Natural Resources Conservation Service, *Grassed Waterway Code 412 Conservation Practice Standard* (May 2005)

(21) U.S. Department of Agriculture Natural Resources Conservation Service, *Backyard Conservation Tip Sheet Mulching* [Internet]; available from http://www.nrcs.usda.gov/feature/backyard/Mulching.html

(22) Virginia Cooperative Extension, *Mulching for a Healthy Landscape* (Publ. No. 426-724, 2001) [Internet]; available from http://www.ext.vt.edu/pubs/envirohort/426-724/426-724.html

(23) U.S. Department of Agriculture Natural Resources Conservation Service, *Prescribed Grazing (Managed Grazing-Wisconsin) Code 528 Conservation Practice Standard* (December 2005)

(24) Cornell University Department of Crop and Soil Sciences, *Prescribed Grazing Management* [Internet]; available from http://www.css.cornell.edu/forage/pasture/prescgm.html

(25) Polk Soil and Water Conservation District. *Prescribed Grazing* [Internet]; available from http://polk-swcd.org/Practices%20folder/prescribed_grazing.htm

(26) Ozaukee County Land and Water Conservation, "Local Dairy Farm Sold on Prescribed Grazing" in *Ozaukee "Dirt" Ozaukee County Land and Water Conservation News* (Summer 2001) [Internet]; available from http://www.co.ozaukee.wi.us/landconservation/OzaukeeDirt/2001Summer/

(27) U.S. Department of Agriculture Natural Resource Conservation Service and University of Wisconsin Extension, *Residue Management Choices A Guide to Management of Crop Residues in Corn and Soybeans* (March 2000)

(28) Pennsylvania Department of Environmental Protection Bureau of Stormwater Management, "BMP 5.8: Revegetate and Re-Forest Disturbed Areas, Using Native Species," *Pennsylvania Stormwater Management Manual* – DRAFT (2005)

(29) U.S., Environmental Protection Agency, *Storm Water Technology Fact Sheet Flow Diversion* (September 1999) [Internet]; available from http://www.epa.gov/owm/mtb/fl.pdf

(30) U.S. Environmental Protection Agency, "Streambank and Shoreline Erosion Management Measure," in *Polluted Runoff (Nonpoint Source Pollution)* (August 2003) [Internet]; available from http://www.epa.gov/owow/nps/MMGI/Chapter6/ch6-4.html

(31) Center for Watershed Protection, "Stream Restoration: Bank Protection Practices" in *Stormwater Manager's Resource Center* [Internet]; available from http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Restoration/bank_protection.htm

(32) U.S. Department of Agriculture Natural Resources Conservation Service, *Farmland Conservation Choices A Guide to Environmentally Sound Practices for Wisconsin Farmers* (December 1998)

(33) Conservation Technology Information Center Core 4 Conservation, *Contour Strip-cropping* [Internet]; available from http://www2.ctic.purdue.edu/Core4/CT/Choices/Choice13.html

(34) K.L. Wells, University of Kentucky College of Agriculture Department of Agronomy, *Strip Cropping and Contouring* (AGR-98, August 1983) [Internet]; available from http://www.ca.uky.edu/agc/pubs/agr/agr98/agr98.htm

(35) Conservation Technology Information Center Core 4 Conservation, *Windbreak* [Internet]; available from http://www2.ctic.purdue.edu/Core4/CT/Choices/Choice17.html)

(36) U.S. Department of Agriculture Natural Resources Conservation Service, *Windbreak/Shelterbelt Establishment Code 380 Conservation Practice Standard* (June 2002)

(37) Patricia Boehner et al., University of Nebraska-Lincoln Finch, Sherman, Soil Conservation Service, *Windbreak* Establishment (EC91-1764-B) [Internet]; available from http://ianrpubs.unl.edu/forestry/ec1764.htm

(38) Conservation Technology Information Center Core 4 Conservation, *Windbreak* [Internet]; available from http://www2.ctic.purdue.edu/Core4/CT/Choices/Choice17.html)

(39) Virginia Cooperative Extension, *Nutrient Management for Golf Courses* (2003), 430-399, [Internet]; available from http://www.ext.vt.edu/pubs/turf/430-399/430-399.html

(40) Delaware River Basin Commission, *Water Conservation Guidelines for Golf Courses* (October 2002) [Internet]; available from http://www.state.nj.us/drbc/golfcourses.pdf

(41) Minnesota Pollution Control Agency, *2005 Minnesota Stormwater Manual, Version 1.0,* Chapter 12 - Pollution Prevention Residential Practices, [Internet]; available from http://www.pca.state.mn.us/publications/wq-strm8-14ae.pdf

(42) Center for Watershed Protection, *Pollution Prevention Fact Sheet: Landscaping and Lawn Care* [Internet]; available from http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/LandscapingandLawnCare.htm

(43) Conservation Technology Information Center Core 4 Conservation, *What's a Crop Nutrient Management Plan?* [Internet]; available from http://www2.ctic.purdue.edu/Core4/Nutrient/WhatsaPlan2.html

(44) U.S. Department of Agriculture Natural Resources Conservation Service, *Farmland Conservation Choices A Guide to Environmentally Sound Practices for Wisconsin Farmers* (December 1998)

(45) U.S. Department of Agriculture Natural Resources Conservation Service, *Backyard Conservation Tip Sheet Nutrient Management* [Internet]; available from http://www.nrcs.usda.gov/feature/backyard/NutMgt.html

(46) Chicago Park District, *Balancing Nature with Controlled Burn Management* (March 10, 2006) [Internet]; available at http://www.chicagoparkdistrict.com/index.cfm/fuseaction/news.detail/object_id/a3b9c666-68d8-4e67-b4b4-e3797c693614.cfm

(47) U.S. Department of Agriculture Natural Resources Conservation Service, *Prescribed Burning Code 338 Conservation Practice Standard* (June 2002)

(48) Kenneth F. Higgins et al., *Prescribed Burning Guidelines in the Northern Great Plains*, (U.S. Fish and Wildlife Service, Cooperative Extension Service, South Dakota State University, U.S. Department of Agriculture EC 760, Jamestown, ND, 1989) [Internet]; available at http://www.npwrc.usgs.gov/resource/tools/burning/burning.htm

(49) Chicago Park District, Department of Natural Resources, *Nature Areas Prescribed Burn Management*. (February 2002) [Internet]; available at http://www.chicagoparkdistrict.com/index.cfm/fuseaction/custom.natureOasis01

(50) U.S. Environmental Protection Agency, "Pesticide Management," *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA 840-B-92-002 January 1993) [Internet]; available from http://www.epa.gov/OWOW/NPS/MMGI/Chapter2/ch2-2d.html

(51) Conservation Information Technology Center Core 4 Conservation, *Weed & Pest Management (IPM) Facts* [Internet]; available from http://www2.ctic.Purdue.edu/Core4/ipm/IPMfact.html

(52) U.S. Environmental Protection Agency, *Stormwater Phase II Final Rule Public Education and Outreach Minimum Control Measure* (December 2005)

(53) Center for Watershed Protection. "Program Resources Fact Sheet" in *Stormwater Manager's Resource Center* [Internet]; available from http://www.stormwatercenter.net

(54) Richard Pinkham, Rocky Mountain Institute, *Daylighting New Life for Buried Streams* (September 2000) [Internet]; available from http://www.rmi.org/images/other/Water/W00-32_Daylighting.pdf