City of Grand Rapids

Good Housekeeping

And Pollution Prevention

Best Management Practices Manual

For Structural and Operational Stormwater Controls

Prepared by:

GVMC

Department of Environmental Programs

In Cooperation with:

The MS4 Permitted Communities

Of The Lower Grand River Watershed

Contents

Introduction

Background

As the owner and operator of a municipal separate storm sewer system (MS4), the City of Grand Rapids, must implement stormwater pollution prevention on their properties as well as within their MS4. The State of Michigan regulates the City of Grand Rapids, through a National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit program identifies six minimum control measures that operators of regulated small MS4s must incorporate into stormwater management programs. These measures are expected to result in significant reductions of pollutants discharged into receiving waterbodies. This manual identifies the Best Management Practices (BMPs) implemented by the City of Grand Rapids to address pollution prevention and good housekeeping.

This manual is intended to provide the staff at the City of Grand Rapids and regulators with information necessary to ensure uniform and correct implementation of procedures and maintenance related to structural and operational stormwater controls at municipally owned and operated facilities. A complete inventory of these facilities is provided in Appendix 6 of the Stormwater Management plan. The procedures in this will be reviewed annually for effectiveness and accuracy. In the event that a new facility or structural control is added it will be reviewed and added to the inventory within 30 days. Relevant portions of this manual will also be provided to contractors working on behalf of the City of Grand Rapids to ensure they are complying with the approved procedures, inspections, and maintenance intervals.

Manual Organization

The manual is divided into two sections: Structural BMPs and Operational BMPs.

Structural BMPs identify devices that are constructed to protect, treat, convey, control or infiltrate stormwater. Each BMP includes a brief description, a sample design, and inspection and maintenance guidance including a tracking tool. Specific inspection and maintenance intervals are identified in the SWMP. The estimated number of stormwater structural controls is identified in the facility inventory included in Appendix 6.

Operational BMPs are activities that have the potential to impact stormwater quality such as cutting lawns, applying fertilizer, and washing vehicles. Operational BMPs provide guidelines for conducting these activities in a manner that prevents stormwater pollution. Each operational BMP identifies a procedure, and any maintenance, if applicable.

Partners

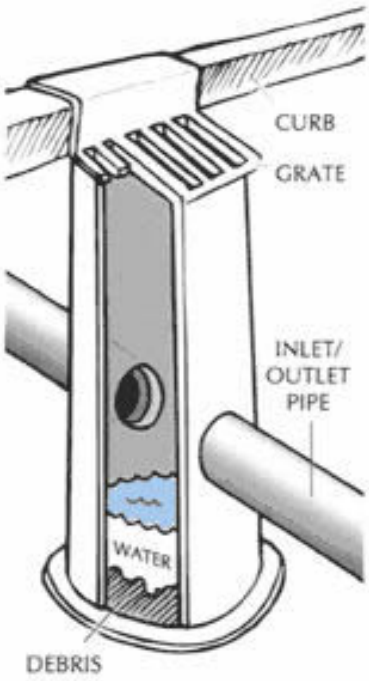
This manual was prepared as a cooperative effort by the MS4 permitted members of the Lower Grand River Watershed identified below and the Department of Environmental Programs at the Grand Valley Metropolitan Council. Individual procedures and tracking tools have been customized to meet the needs of each community.

Kent County	**Ottawa County**
Cascade Charter Township	City of Ferrysburg
City of East Grand Rapids	City of Grand Haven
City of Grand Rapids	City of Hudsonville
City of Grandville	Georgetown Charter Township
City of Kentwood	Grand Valley State University
City of Rockford	Ottawa County Water Resource Commissioner
City of Walker	Ottawa County Road Commission
City of Wyoming	Village of Spring Lake
Forest Hills Public Schools	
Grand Rapids Charter Township	
Kent County Drain Commissioner	
Kent County Road Commission	
Plainfield Charter Township	
Village of Sparta	

Structural Control BMPs

Catch Basins

A catch basin is an underground concrete structure typically fitted with a slotted grate to collect stormwater runoff and route it through underground pipes. Catch basins can also be used as a junction in a pipe system and may have a solid lid (commonly called a manhole).



Catch basins typically provide a storage volume (sump) below the outlet pipe to allow sediment and debris to settle out of the stormwater runoff. Some catch basins are also fitted with a spill control device (inverted elbow on outlet pipe) intended to contain large quantities of grease or oils. Stormwater manholes are not designed to allow for the removal of sediment but, nonetheless, are important components of the stormwater conveyance system.

A catch basin may be an enclosed space where harmful chemicals and vapors can accumulate. Therefore, if the inspection and maintenance requires entering a catch basin, it should only be conducted by an individual trained and certified to work in hazardous confined spaces.

All water and sediment in the sump is pumped out using a vactor truck. The vactor truck disposes of the waste in its tank at the stormwater vactor unloading station at the wastewater treatment plant. Liquid waste drains to the wastewater plant for treatment and solids are dried and sent to a landfill for disposal in accordance with Part 211 of Act 451 of 1994 (Natural Resources and Environment Protection Act).

Cleaning and inspection is tracked in CityWorks. If structural repair is required, a CityWorks work order is prepared.

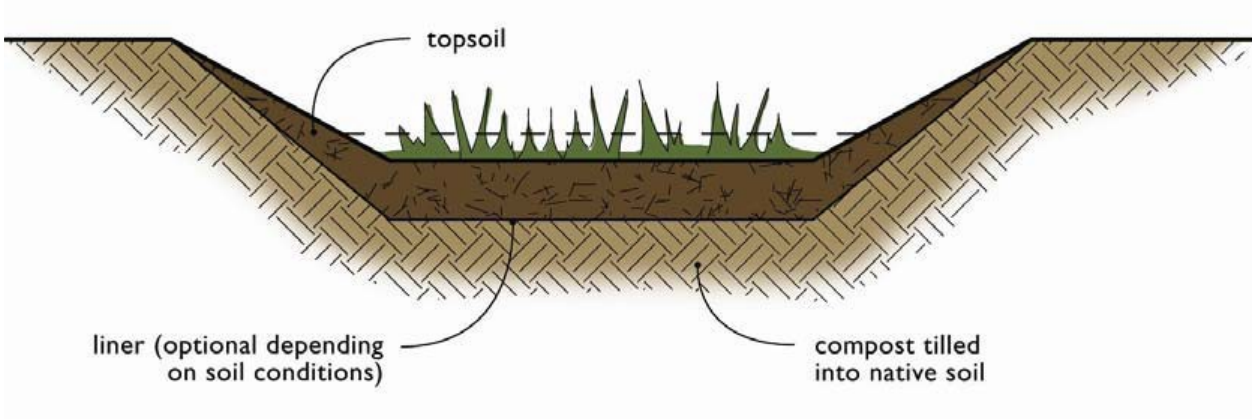
Catch Basins			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Results Expected When Maintenance Is Performed Or Not Needed**
General	Trash and Debris	Trash or debris is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin.	No trash or debris located immediately in front of catch basin or on grate opening.
	Sediment	Sediment (in the basin) impedes the functionality of the catch basin.	No sediment in the catch basin.
	Structure Damage to Frame and/or Top Slab	Top slab has large holes or cracks; trash or debris material is running into basin.	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab or not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has significantly separated or cracked or any evidence of soil particles entering catch basin through cracks.	Pipe is re-grouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 50% of the basin opening.	No vegetation blocking opening to basin.
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants, or other pollutants (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate Opening Unsafe	Grate with opening wider than design standard.	Grate opening meets design standards.
	Grate Damaged or Missing	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

Vegetated Swales

A vegetated swale (also called a biofiltration swale) uses grass or other dense vegetation to filter sediment and oily materials out of stormwater. Vegetated swales usually look like flat-bottomed channels with grass growing in them. This method of stormwater management uses vegetation in conjunction with slow and shallow-depth flow for runoff treatment. As runoff passes through the vegetation pollutants are removed through the combined effects of filtration, infiltration, and settling. These effects are aided by the reduction of the velocity of stormwater as it passes through the swale. Vegetated swales can replace traditional curb and gutter systems.

Vegetated swales provide stormwater quality control (treatment) but do not provide stormwater quantity control (detention/retention). Swales are stormwater treatment devices that must be properly maintained to sustain pollutant removal capacity.

Typical pollutants that are removed by vegetated swales include sediment, nutrients, trash, metals, bacteria, and oils and greases.



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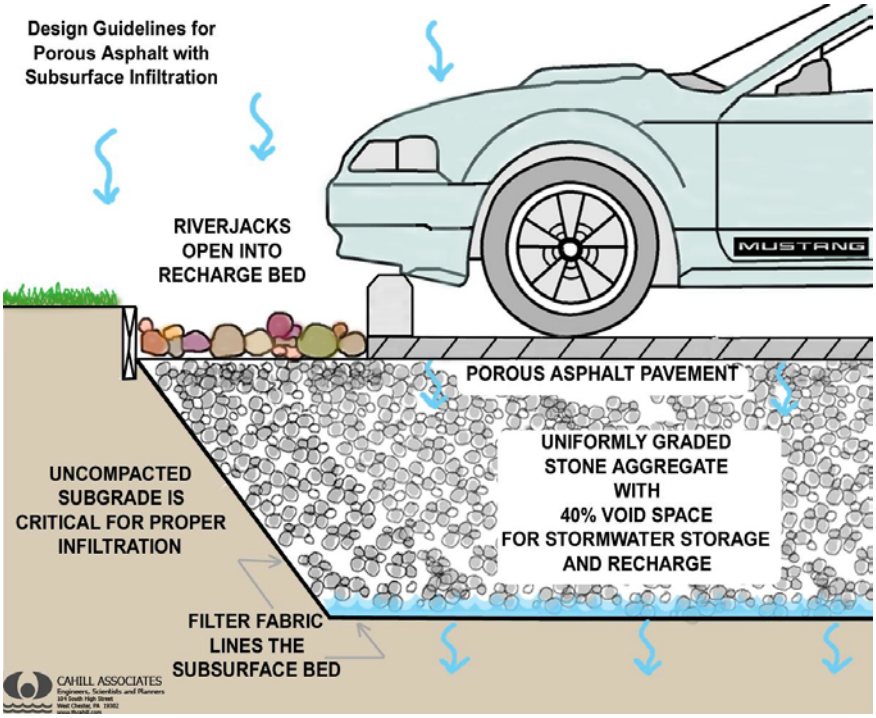
Typical Vegetated Swale			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or re-seed into loosened, fertile soil.
	Vegetation	When the grass becomes excessively tall (greater than 12-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	Erosion/ Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, over seed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

Porous Pavement

Porous pavement is an infiltration technique that combines stormwater infiltration, storage, and structural pavement consisting of a permeable surface underlain by a storage reservoir. Stormwater drains through the surface course where it is temporarily held in the voids of the stone bed and then slowly infiltrates into the underlying, uncompacted soil. Pervious pavement is well suited for parking logs, walking paths, sidewalks, playgrounds, plazas tennis courts and other similar uses. The storage reservoir typically consists of a stone bed of uniformly graded, clean and washed coarse aggregate with a void space of approximately 40%. A layer of nonwoven geotextile filter fabric typically separates the aggregate from the underlying soil.



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Porous Pavement			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
General	Pavement Clogged	Pavement is not draining properly	Vacuum lot regularly to prevent clogging Additional vacuuming may be required in the event that water is not draining
	Underdrain Clogged	Pavement is not draining properly	Clear the blockage from the underdrain to achieve positive drainage
	Damaged Pavement Surface	Potholes or settling in pavement	For areas of 50 sq. ft. or less patch the affected area. For larger areas review needed repairs with a design engineer.

Pump Stations

Pump stations can be designed to remove stormwater from areas that cannot be drained by gravity and are not good candidates for stormwater infiltration either because of prohibitive onsite conditions or inadequate space to address the necessary volume. They are typically sized to accommodate a specified design storm and may or may not include additional storage depending upon the area needs and drainage characteristics. The release rate of the pump station is determined by the outlet capacity and conditions. Pump stations are classified as confined spaces and per MIOSHA requirements, anyone entering a "confined space" must be equipped with the proper safety equipment and training. Regular inspections are critical to identify the need for debris and sediment removal, and to confirm proper mechanical function.

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Secondary Containment

Secondary containment is a second barrier or an outer wall of a double enclosure which will contain any leak or spill from a storage container. Secondary containment helps protect the surface water, groundwater, and soils and reduce worker exposure to regulated substances. This enclosure is usually needed wherever regulated substances are being handled and stored in tanks, totes, drums, small pails, or other containers. The MDEQ has prepared a comprehensive guidance document on secondary containment requirements in the State of Michigan. It is available at: http://www.michigan.gov/documents/deq/deq-whm-hwp-Undrstnd-SC-Rqrmnts_248135_7.pdf. Tanks with secondary containment need to be inspected regularly for damage, corrosion and leaks.

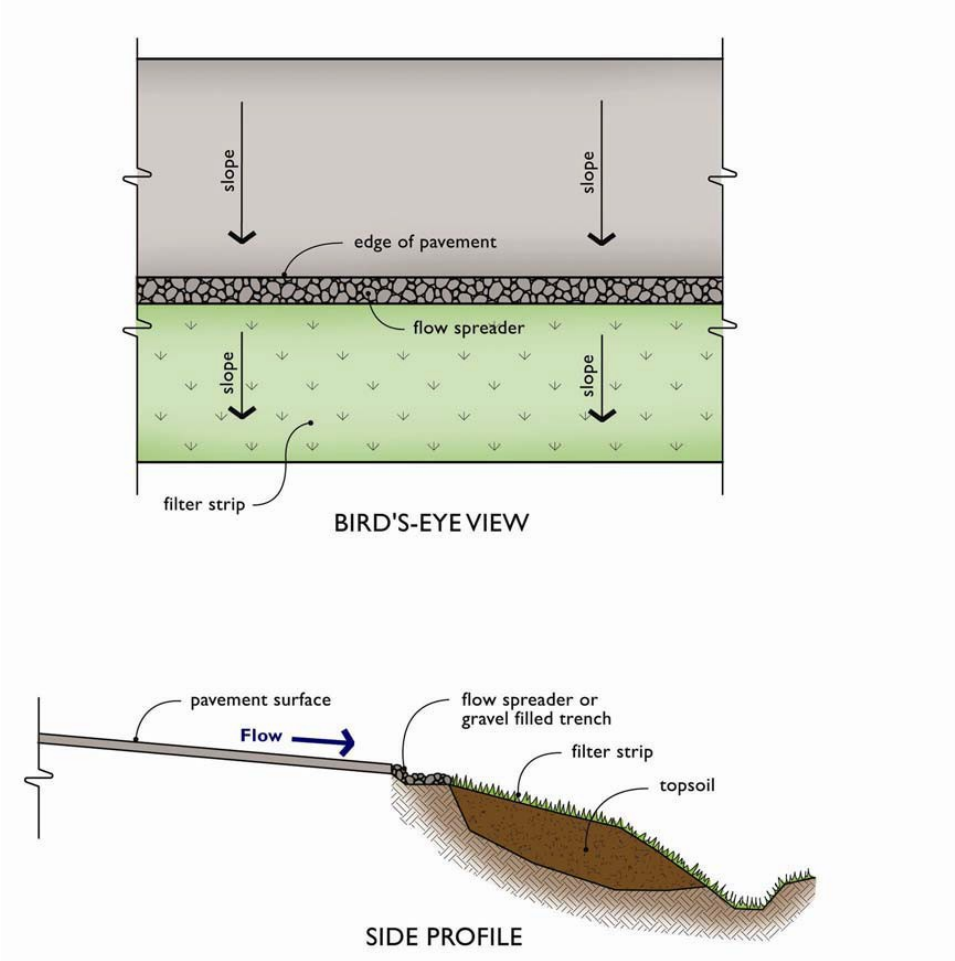
Secondary containment is only situated at our public works facility for the emulsion (tar for street cracks) tank. Given that the emulsion hardens with exposure to air,

Secondary Containment			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
General	Leaks or drips	Evidence of tank contents within the secondary containment reservoir or outside the tank	Observe the tank to determine the origin of the leak and repair it. If drips are occurring when materials are added or removed review and revise procedure as necessary.
	Corrosion	Evidence of tank contents within the secondary containment reservoir or outside the tank	Conduct a comprehensive tank inspection to determine the cause of the corrosion and repair or replace the tank.
	Structural Damage	Evidence of tank contents within the secondary containment reservoir or outside the tank	Conduct a comprehensive tank inspection to determine the cause of the damage and repair or replace the tank. If damage occurred when materials were added or removed review and revise procedure as necessary.

Vegetated Buffer Strips

A buffer strip (also known as a filter strip or vegetated filter strip) is a linear strip of grass that removes sediment and oils from stormwater by filtering it. Stormwater is treated as it runs across the filter. Usually, filter strips are placed along the edge of linear paved areas such as parking lots and roads and where a flow spreader is installed to ensure that water flows eventually across the strop in sheet flow. Where designed filter strips are installed, road shoulders should only be graded to maintain level flow off the road.

Typical pollutants that are removed by vegetated swales include sediment, nutrients, trash, metals, bacteria, and oils and greases.



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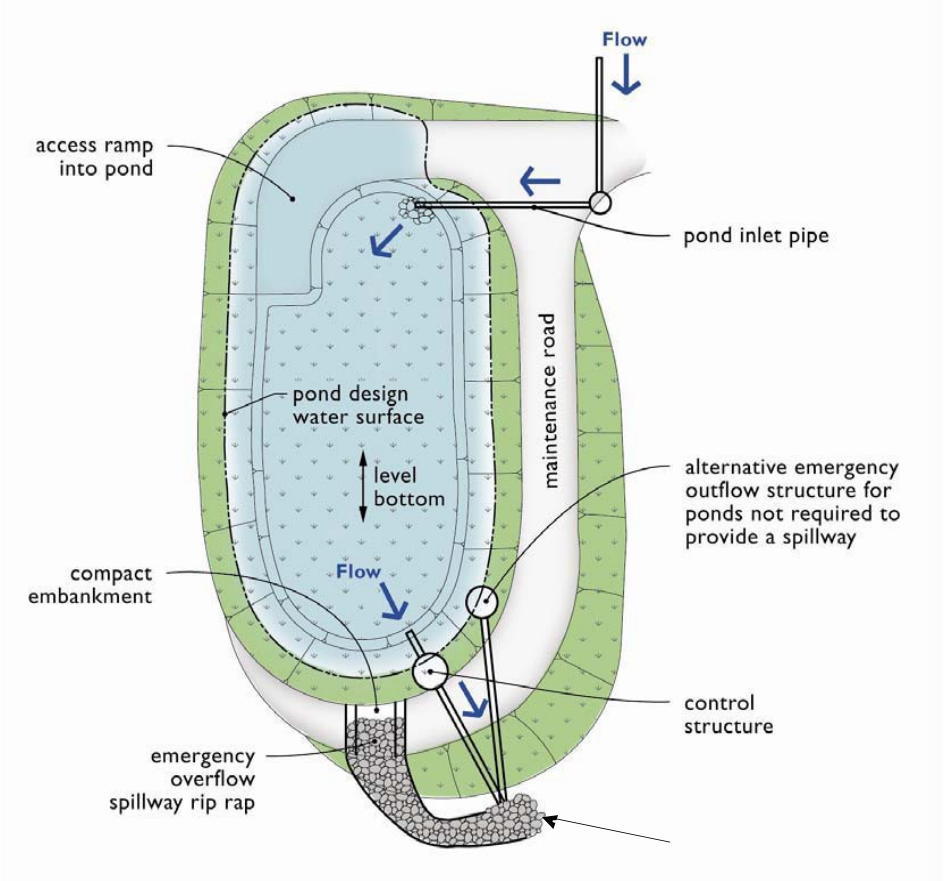
Buffer Strip			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
	Vegetation	When the grass becomes excessively tall (greater than 12-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and debris from filter.
	Erosion/ Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re- graded and re-seeded. For smaller bare areas, over seed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter	Level the spreader and clean so that flows are spread evenly over entire filter width.

Detention Ponds

A stormwater detention pond is an open basin built by excavating below existing ground or by constructing above- ground berms (embankments). The detention pond temporarily stores stormwater runoff during rain events and slowly releases it through an outlet (control structure). The primary purpose of detention ponds is to reduce stormwater runoff peaks. Detention ponds are typically designed to completely drain within 24 hours after the completion of a storm event. Styles vary greatly from well manicured to natural appearing. Generally, more natural-appearing vegetation is preferred for reduced maintenance and enhanced wildlife habitat. Some facilities are designed to appear as natural water bodies or are in park-like areas.



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Detention Pond			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
General	Trash and Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can in a 10 foot wide by 100 foot long area). In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate with the Clean Water Plant)	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired.
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove. If dead, diseased, or dying trees are identified that inhibit functionality, remove.	Trees do not hinder maintenance activities.
Side Slopes of Pond	Erosion	Eroded damage where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms, the City Engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment exceeding maintenance specifications or affecting inletting or out-letting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.

Detention Pond (Continued)			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
Pond Berms (Dikes)	Settlements	Any part of berm which has settled signifigantly lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. Consult with the City Engineer to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway and Berms Over 4 Feet in Height.	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. The City Engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend the City Engineer be called to inspect and evaluate condition and recommend repair of condition.)	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway	Rock Missing	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out-flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	Eroded damage where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms, the City Engineer should be consulted to resolve source of erosion.

Bioretention & Rain Gardens,

Bioretention areas are designed and constructed to capture, store and infiltrate stormwater runoff into the surrounding, permeable soils over a period of several days. They can be designed with or without underdrains and depending on the soil conditions and the proposed drainage area. Pretreatment for sediment removal is required to prevent clogging. Bioretention designs include rain gardens which are depressions designed with, highly permeable soils and specialized, native vegetation to capture and treat stormwater runoff form impervious areas including rooftops, streets and parking lots.

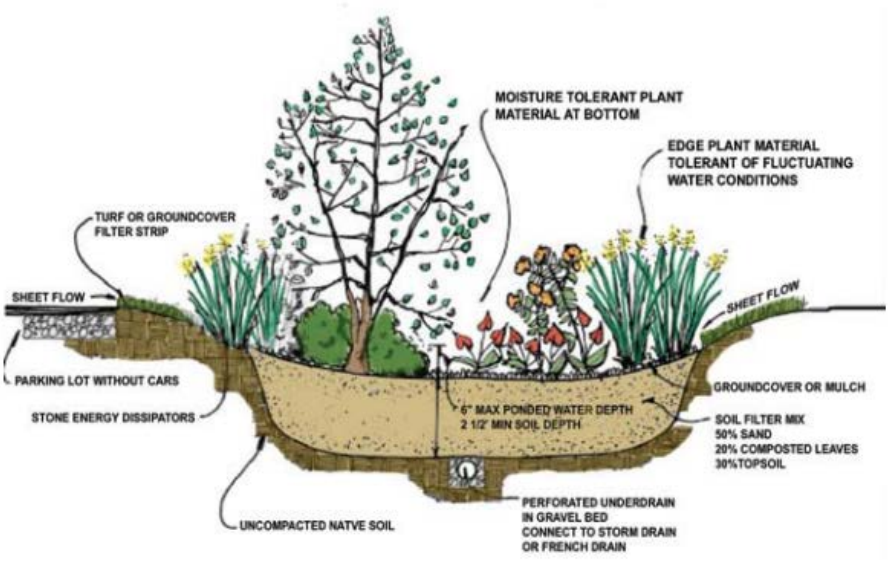
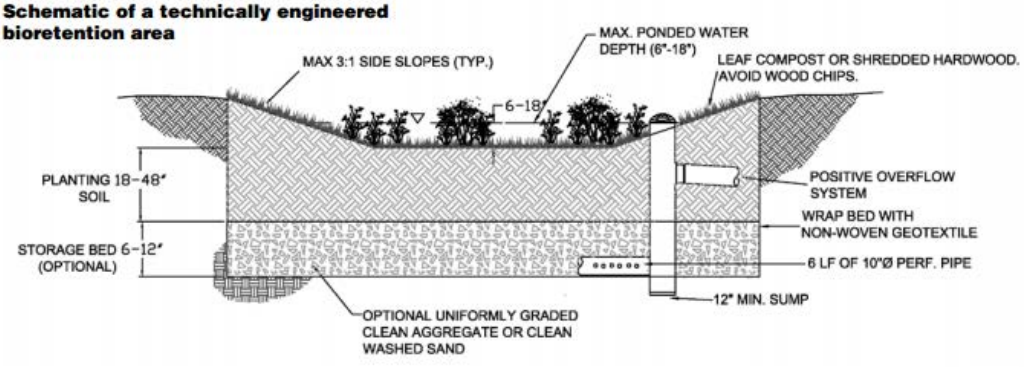


Figure 7.6
Schematic of a technically engineered bioretention area



Source: Prince George's County Bioretention Manual with modifications by Cahill Associates, 2004

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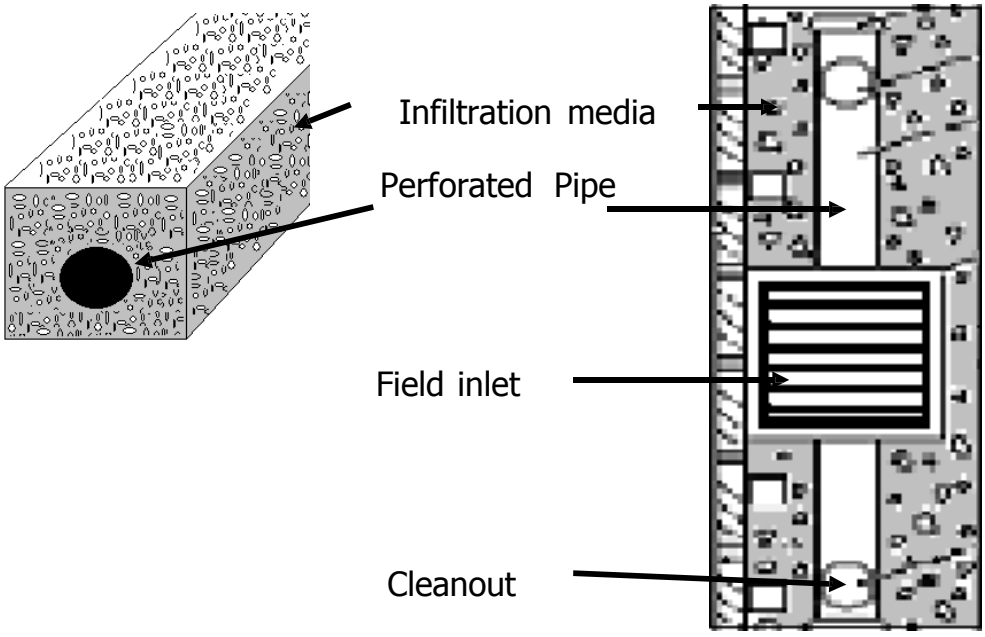
Bioretention			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
General	Sediment Accumulation	Sediment depth exceeds 2 inches.	Remove sediment deposits while minimizing disturbance to vegetated areas. If depositions persist review the site conditions to determine the source and if pretreatment is necessary. Area should infiltrate water according to the design standard.
	Poor Vegetation Coverage	Plantings are insufficient to stabilize the bioretention area	Determine why plant growth is poor and correct that condition. Re-plant according to the planting design and provide additional water if necessary to allow the vegetation to reestablish.
	Vegetation	When the grass becomes excessively tall (greater than 12-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Underdrain	Underdrain inlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated	Remove trash and debris
	Erosion/Scouring	Bank slumping or rills forming due to erosion. Eroded or scoured bottom in linear devices due to flow channelization, or higher flows.	Slopes should be restored stabilized using appropriate erosion control measures. Channelized erosion or scouring may require the installation of turf reinforcement map if conditions warrant.

Infiltration Basins and Trenches

Infiltration basins are shallow surface impoundments that temporarily store, capture and infiltration runoff over a period of several days on a level and uncompacted surface. A stormwater infiltration trench is a closed basin built by excavating below existing ground. Infiltration trenches temporarily store stormwater runoff during rain events. Infiltration trenches do not discharge to a downstream conveyance system or nearby surface water. Instead, infiltration trenches rely on the ability of the site's soils to infiltrate the stormwater into the ground.



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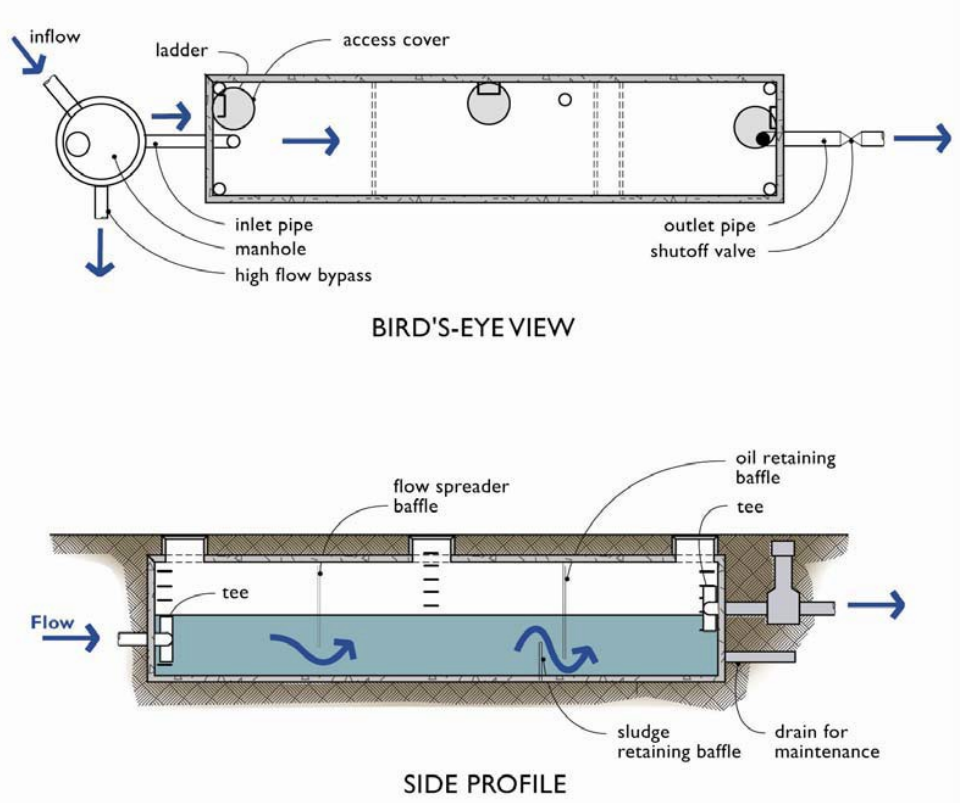
Infiltration Basins & Trenches			
Drainage System Feature	**Potential Defect**	**Conditions When Maintenance Is Needed**	**Maintenance And Expected Results**
General	Sediment Accumulation	Sediment depth exceeds 2 inches.	Remove sediment deposits while minimizing disturbance to vegetated areas. If depositions persist review the site conditions to determine the source and if pretreatment is necessary. Area should infiltrate water according to the design standard.
	Poor Vegetation Coverage	Plantings are insufficient to stabilize the infiltration area	Determine why plant growth is poor and correct that condition. Re-plant according to the planting design and provide additional water if necessary to allow the vegetation to reestablish.
	Vegetation	When the grass becomes excessively tall (greater than 12-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Underdrain	Underdrain inlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris
	Erosion/Scouring	Eroded or scoured bottom in linear devices due to flow channelization, or higher flows.	Slopes should be restored stabilized using appropriate erosion control measures. Channelized erosion or scouring may require the installation of turf reinforcement mat if conditions warrant.
	Stone washouts	Areas covered with stone or other hard-scaping have exposed soils or substrate showing through	Replace missing material to design condition so that no underlying substrate is exposed.

Oil / Water or Grit Separator

Oil / Water or Grit Separator

An oil/water separator is an underground vault that treats stormwater by mechanically separating oil from water. The oil rises to the surface and floats on the water and sediment settles to the bottom. Oil/water separators are typically utilized in locations where high oil concentrations in the stormwater runoff are anticipated (e.g. service and fuel stations). Oil/water separators are most commonly used as the first pre-treatment facility in a series of stormwater management facilities.

Grit separators are similarly designed. By slowing the water flow down as it passes through the device, solids (grit) settle out by gravity to the bottom of separator. Grit separators are used in locations where there are high sand or solids concentrations, such as vehicle wash areas or vactor/street sweeping washout areas.



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Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Maintenance and Expected Results
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality (i.e. obvious oil or other contaminants present)	Effluent discharge from vault should be clear without thick visible sheen.
	Floatable Material and Sediment Accumulation	Accumulated floatable material and bottom sediment exceeds 25% of the total capacity.	No sediment deposits on vault bottom that would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached.	Frame is sitting flush on the riser rings or top slab and firmly attached.
		Maintenance person judges that structure is unsound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Inlet and/or Outlet Tee	Tee is missing or turned sideways, such that the entering or exiting water is not dispersed.	Tee is securely in place and functioning properly.

References:

Agencies Association (BASSMA) http://www.basmaa.org/

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Association (BASMAA) http://www.basmaa.org/

Best Management Practice Guide for Retail Gasoline Outlets, California Stormwater Quality Task Force. 1997.

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DTSC Doc. No. 621 http://www.stormwatercenter.net/

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Greater Lansing Regional Committee **Good Housekeeping and Pollution Prevention Manual for**

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Operational BMPs

Operational BMPs

Municipal operations and maintenance activities have the potential to negatively impact stormwater quality. Operational BMPs refer to the common practices and procedures listed in the table below, that can prevent the discharge of polluting materials to the MS4 or surface waters. The following operational BMPs have been developed and are being implemented to ensure compliance with operation and maintenance requirements and to effectively minimizing pollutant runoff to the maximum extent practicable from municipal operations.

Types of Properties	O&M Procedure	Page
WW	Slope, Shoreline, Stabilization	152
Pk, PW	Street Sweeping	165
F, L, M, Pk, R, V, WD, WW	Trees, Shrubs and Ground Covers	167
PW	Winter Road Management	180
Pk	Golf Course Manual	185
Pk, PW	Road Salt Storage	210

The City has reviewed and customized these procedures during the 2012-2013 permit cycle.

Property Types Legend:

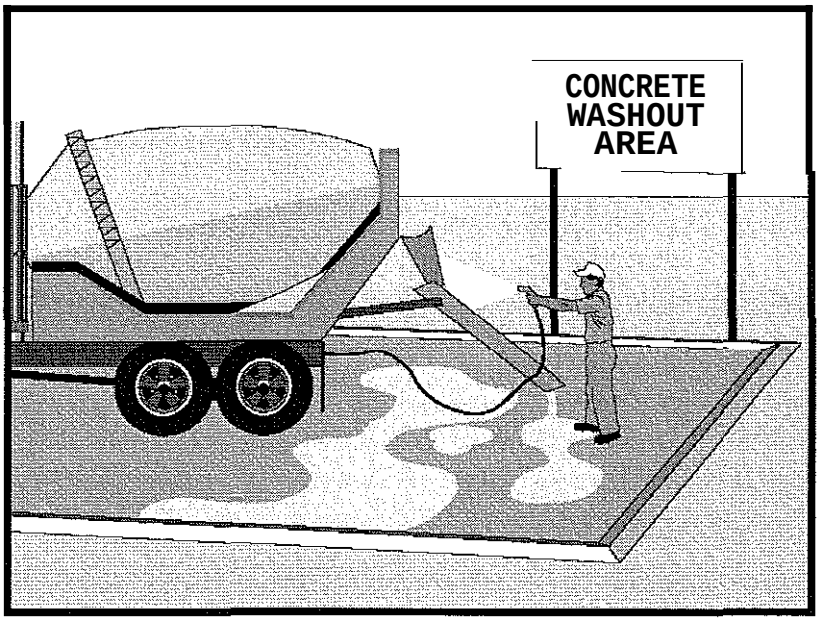
A - Administration	F - Fire	M - Maintenance Grg	PW - Public Works
V – Vacant/Open Land	WW - Wastewater	C - Cemetery	G – Garage/Storage
Pk – Parking/Parks	R – Residential	W – Water Cond/Tmt	D – Unregulated Landfill/Dump
L – Library	Po - Police	WD – Waste Disposal Area	

Operational BMPs	**Potential Pollutants**									
	Sediment	Nutrients	Trash	Metals	Bacteria	Oil & Grease	Organics	Pesticides	Oxygen Demanding Substances	Salt
Concrete Waste Management	x								x	
Dumpster Management	x	x	x	x	x	x	x	x	x	
Erosion and Sediment Control	x				x					
Fueling Areas						x				
Garbage Storage	x	x	x	x	x	x	x	x	x	
Material Covering	x	x	x	x		x	x	x	x	x
Outdoor Storage Areas	x	x	x	x		x	x	x	x	x
Outdoor Storage, Raw Materials	x	x	x	x		x			x	

Operational BMPs	**Potential Pollutants**									
	Sediment	Nutrients	Trash	Metals	Bacteria	Oil & Grease	Organics	Pesticides	Oxygen Demanding Substances	Salt
Petroleum and Chemical Disposal			x				x	x	x	
Petroleum and Chemical Handling			x				x	x	x	
Petroleum and Chemical storage bulk			x				x	x	x	
Salt Application										x
Sand and Salt Storage	x				x					x
Solid Waste Management	x	x	x	x	x	x	x	x	x	
Spill Cleanup	x	x	x	x	x	x	x	x	x	x
Spill Prevention Control and Cleanup	x	x	x	x	x	x	x	x	x	x
Dust Control	x									
Equipment Storage and Maintenance Areas	x		x	x		x				
Fertilizer Management		x						x		X
Lawn Maintenance		x						x	x	x

Operational BMPs	**Potential Pollutants**									
	Sediment	Nutrients	Trash	Metals	Bacteria	Oil & Grease	Organics	Pesticides	Oxygen Demanding Substances	Salt
Organic Debris Disposal	x							x		
Pesticide Management									x	x
Stream Bank Stabilization	x				x					
Soil Management	x				x					
Slope, Shoreline, Stabilization	x				x					
Street Sweeping	x			x	x	x				
Trees, Shrubs and Ground Covers	x	x	x		x			x		
Winter Road Management	x				x					x
Golf Course Manual		x					x	x		
Road Salt Storage										x

Concrete Waste Management WM-8



Objectives

EC	Erosion Control	
SE	Sediment Control	
TC	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stormwater Management Control	
WM	Waste Management and Materials Pollution Control	☒

Legend:
☒ **Primary Objective**
☑ **Secondary Objective**

Targeted Constituents

Sediment	☑
Nutrients	
Trash	
Metals	☑
Bacteria	
Oil and Grease	
Organics	

Potential Alternatives

None

Description and Purpose

Prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting washout offsite, performing onsite washout in a designated area, and training employee and subcontractors.

Suitable Applications

Concrete waste management procedures and practices are implemented on construction projects where:

- Concrete is used as a construction material or where concrete dust and debris result from demolition activities
- Slurries containing portland cement concrete (PCC) or asphalt concrete (AC) are generated, such as from saw cutting, coring, grinding, grooving, and hydro-concrete demolition
- Concrete trucks and other concrete-coated equipment are washed onsite
- Mortar-mixing stations exist
- See also NS-8, Vehicle and Equipment Cleaning

Limitations

- Offsite washout of concrete wastes may not always be possible.

Implementation

The following steps will help reduce stormwater pollution from concrete wastes:

- Discuss the concrete management techniques described in this BMP (such as handling of concrete waste and washout) with the ready-mix concrete supplier before any deliveries are made.
- Incorporate requirements for concrete waste management into material supplier and subcontractor agreements.
- Store dry and wet materials under cover, away from drainage areas.
- Avoid mixing excess amounts of fresh concrete.
- Perform washout of concrete trucks offsite or in designated areas only.
- Do not wash out concrete trucks into storm drains, open ditches, streets, or streams.
- Do not allow excess concrete to be dumped onsite, except in designated areas.
- For onsite washout:

  Locate washout area at least 50 feet from storm drains, open ditches, or water bodies. Do not allow runoff from this area by constructing a temporary pit or bermed area large enough for liquid and solid waste.

  Wash out wastes into the temporary pit where the concrete can set, be broken up, and then disposed properly.

- Avoid creating runoff by draining water to a bermed or level area when washing concrete to remove fine particles and expose the aggregate.
- Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile or dispose in the trash.

Education

- Educate employees, subcontractors, and suppliers on the concrete waste management techniques described herein.
- Arrange for contractor's superintendent or representative to oversee and enforce concrete waste management procedures.

Concrete Slurry Wastes

- FCC and AC waste should not be allowed to enter storm drains or watercourses.
- FCC and AC waste should be collected and disposed of or placed in a temporary concrete washout facility.
- A sign should be installed adjacent to each temporary concrete washout facility to inform concrete equipment operators to utilize the proper facilities.

- Below grade concrete washout facilities are typical. Above grade facilities are used if excavation is not practical.

- A foreman or construction supervisor should monitor onsite concrete working tasks, such as saw cutting, coring, grinding and grooving to ensure proper methods are implemented.

- Saw-cut FCC slurry should not be allowed to enter storm drains or watercourses. Residue from grinding operations should be picked up by means of a vacuum attachment to the grinding machine. Saw cutting residue should not be allowed to flow across the pavement and should not be left on the surface of the pavement. See also NS-3, Paving and Grinding Operations; and WM-10, Liquid Waste Management.

- Slurry residue should be vacuumed and disposed in a temporary pit (as described in OnSite Temporary Concrete Washout Facility, Concrete Transit Truck Washout Procedures, below) and allowed to dry. Dispose of dry slurry residue in accordance with WM-5, Solid Waste Management.

Onsite Temporary Concrete Washout Facility, Transit Truck Washout Procedures

- Temporary concrete washout facilities should be located a minimum of 50 ft from storm drain inlets, open drainage facilities, and watercourses. Each facility should be located away from construction traffic or access areas to prevent disturbance or tracking.

- A sign should be installed adjacent to each washout facility to inform concrete equipment operators to utilize the proper facilities.

- Temporary concrete washout facilities should be constructed above grade or below grade at the option of the contractor. Temporary concrete washout facilities should be constructed and maintained in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.

- Temporary washout facilities should have a temporary pit or bermed areas of sufficient volume to completely contain all liquid and waste concrete materials generated during washout procedures.

- Washout of concrete trucks should be performed in designated areas only.

- Only concrete from mixer truck chutes should be washed into concrete wash out.

- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated washout area or properly disposed of off Site.

- Once concrete wastes are washed into the designated area and allowed to harden, the concrete should be broken up, removed, and disposed of per WM-5, Solid Waste Management. Dispose of hardened concrete on a regular basis.

- Temporary Concrete Washout Facility (Type Above Grade)

  Temporary concrete washout facility (type above grade) should be constructed as shown on the details at the end of this BMP, with a recommended minimum length and

minimum width of 10 ft, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.

Straw bales, wood stakes, and sandbag materials should confo1m to the provisions in SE-9, Straw Bale Barrier.

Plastic lining material should be a minimum of 10 mil in polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.

- Temporary Concrete Washout Facility (Type Below Grade)

  Temporary concrete washout facilities (type below grade) should be constructed as shown on the details at the end of this BMP, with a recommended minimum length and minimum width of 10 ft. The quantity and volume should be sufficient to contain all liquid and concrete waste generated by washout operations.

  Lath and flagging should be commercial type.

  Plastic lining material should be a minimum of 10 mil polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.

Removal of Temporary Concrete Washout Facilities

- When temporary concrete washout facilities are no longer required for the work, the hardened concrete should be removed and disposed of. Materials used to construct temporary concrete washout facilities should be removed from the site of the work and disposed of

- Holes, depressions or other ground disturbance caused by the removal of the temporary concrete washout facilities should be backfilled and repaired.

Costs

All of the above are low cost measures.

Inspection and Maintenance

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.

- Temporary concrete washout facilities should be maintained to provide adequate holdiog capacity with a minimum freeboard of 4 in. for above grade facilities and 12 in. for below grade facilities. Maintaining temporary concrete washout facilities should include removing and disposing of hardened concrete and returning the facilities to a functional condition. Hardened concrete materials should be removed and disposed of.

- Washout facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is 75% full.

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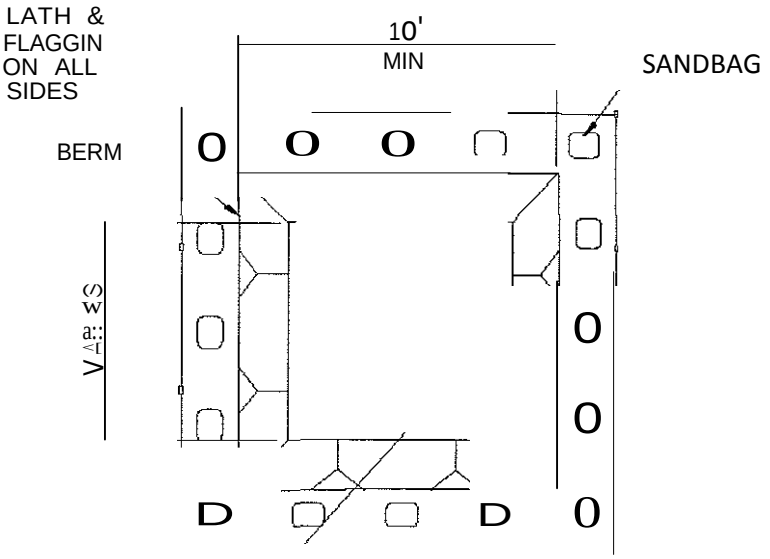
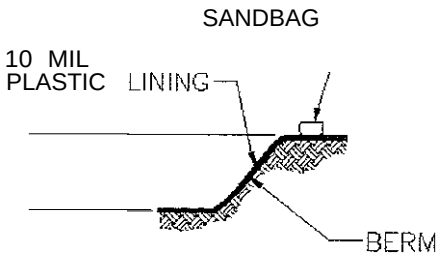
WM-8 Concrete Waste Management



PLAN

NOT TO SCALE

TYPE "BELOW GRADE"

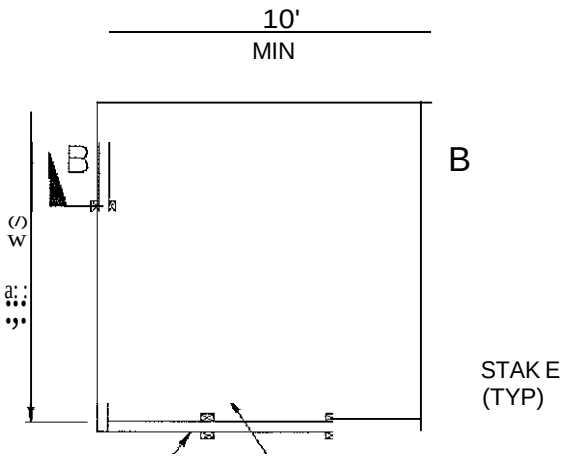


SECTION A-A

NOT TO SCALE

PLASTIC LINING

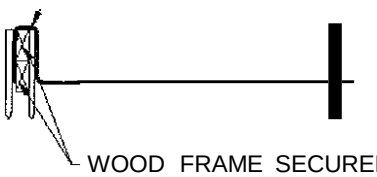
10 MIL



PLAN

NOT TO SCALE

TYPE "ABOVE GRADE"



SECTION B-B

NOT TO SCALE

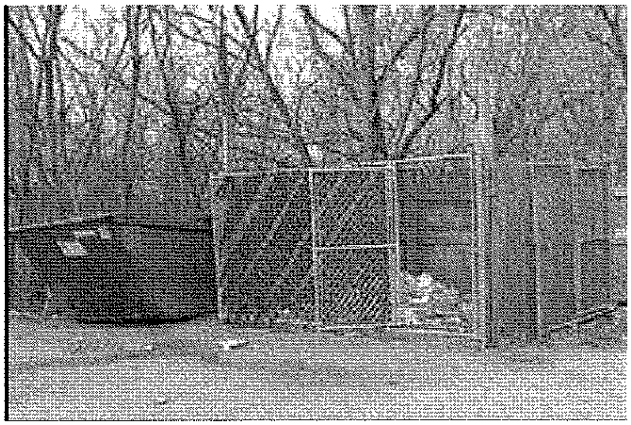
NOTES

1. ACTUAL LAYOUT DETERMINED IN FIELD.
2. THE CONCRETE WASHOUT SIGN SHALL BE INSTALLED WITHIN 30 FT. OF THE TEMPORARY CONCRETE WASHOUT FACILITY.

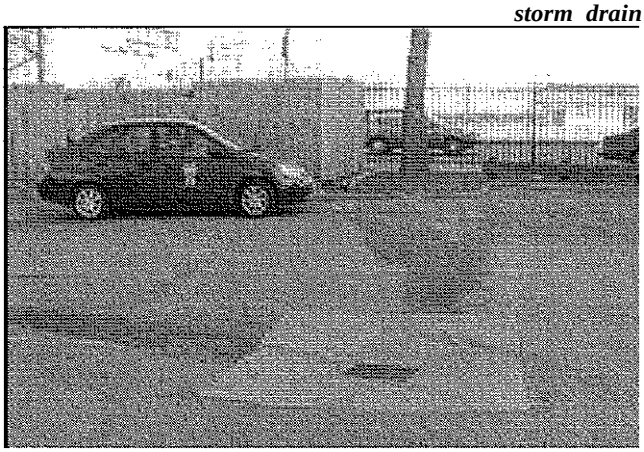
Dumpster Management

How Can Dumpsters Impact Water Quality?

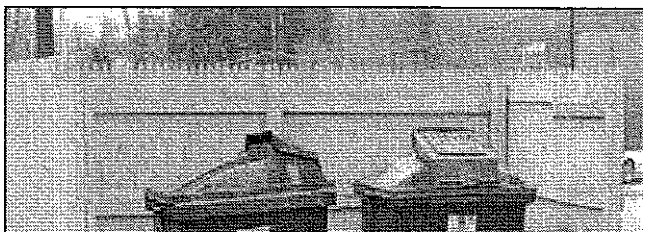
Businesses, construction sites, and municipal operations generate waste as a part of their daily operations, and temporarily store it pending disposal by an independent contractor in dumpsters and other storage containers. Dumpsters can be a significant source of pollution to local streams if not managed properly. Many dumpsters do not have covers, which allows rainfall to mix with the wastes, creating a potent brew affectionately known as "dumpster juice." This, combined with the occasional spill or overflow, makes dumpsters a potential source of trash, oil and grease, metals, bacteria, organic material, nutrients, and sediments to local surface waters. These pollutants can be washed into the storm drain system through runoff and end up in local streams and lakes. Dumpsters with poor management practices are also unsightly, create unpleasant odors and attract rodents.



Typical signs of poor dumpster management: trash accumulation and uncovered du1npster near storm drain



"Dumpster juice" stains reveal that the dumpster runoff /lows to a storm drain inlet.



Leaking oil and grease containers at a restaurant are a source of stormwater pollution

Top Ten Indicators That Your Dumpster Might Be A Pollution Source

1. Runoff from the dumpster flows into the storm drain system. Look for liquid leaking from the container and/or signs of previous leakage, which are often indicated by stains or deposits on the ground or storm drain inlets.
2. The lid is missing or poorly functioning so that it cannot be closed or secured.
3. There is no secondary containment measure to contain spills. (See Fact Sheet on Outdoor Storage)
4. The dumpster waste has a high moisture content. This includes food, yard waste, or other waste material that may leak out of the dumpster.
5. The dumpster is frequently emptied or not emptied frequently enough. Frequently emptied dumpsters usually have more spillage and are uncovered and exposed to rainfall more often. Dumpsters that are overflowing and do not allow the lid to close properly can also expose the waste to rainfall.
6. The waste includes toxic or hazardous materials or other unacceptable substances in the container.
7. There are cracks or dents in the dumpster that may permit leakage from the dumpster or allow rainfall to enter the dumpster.
8. Presence of hydraulic hoses with cracks or leaks (if applicable).
9. There is no routine inspection or maintenance plan for the dumpster.
10. Dumpster does not contain clear signage indicating what kind of waste can be accepted.

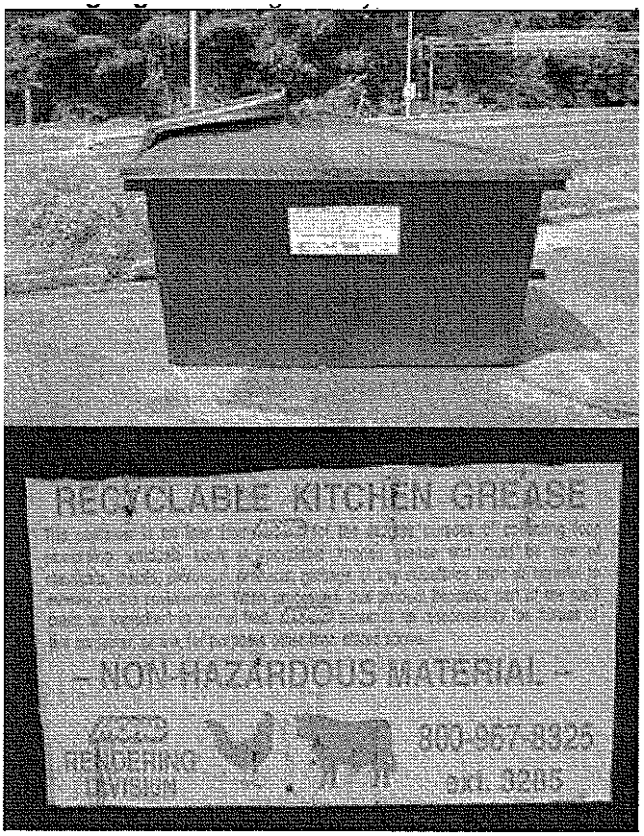
What Types of Dumpsters Are Likely to be a Problem?

- Foodservice businesses
- Vehicle service areas such as fueling stations, repair facilities
- Industrial and municipal facilities that produce high volume and variety of wastes
- Dumpsters with multiple contributors, such as multi-family units, and institutional facilities
- Temporary dumpster locations at construction sites and demolition projects
- Solid waste collection (transfer) areas and waste haulers

Dumpster Management Practices

- Locate dumpsters away from storm drain inlets.
- Routinely train staff on why good dumpster management is important and what their responsibilities are regarding proper disposal techniques. Topics include: what should and should not go into the dumpster, how to close and secure the lid, and how to report dumpster management concerns.

- Clean up trash and litter around the dumpster on a regular basis. Trash attracts more trash.
- Keep it covered. Make sure the lid is closed and secured after depositing waste.
- Prevent spills. Use secondary containment measures to keep spills from entering the storm drain system (see Fact Sheet on Outdoor Storage for more information).
- Inspect dumpster condition regularly to ensure no cracks are present that would allow leakage.
- Provide alternative disposal locations for unacceptable substances. For instance, hazardous waste, oil and grease and other liquids should never be thrown into a dumpster. To encourage proper disposal of these materials, appropriate disposal containers and/or information on alternative disposal locations should be provided.
- Use storage methods appropriate for the type of waste being stored. An oil/grease separator or sump pit should be installed for dumpsters that receive waste with high moisture content, such as oil and grease, yard waste or food.
- Post clear signage indicating what types of waste are acceptable.



Recyclable kitchen grease container with clear signage

How Can I Reduce Illegal Dumping?

Unfortunately, even with proper dumpster management, illegal dumping (i.e. "'midnight dumping") may occur around your dumpster, which may increase the likelihood that your dumpster becomes a pollution source. To minimize illegal dumping in or around your dumpster, consider the following:

- Keep the area clean
- Ensure that the area is well-lit
- Keep the dumpster lid or gate locked after hours (if possible)
- Post signs indicating penalties for illegal dumping and a phone number for reporting incidents

- Keep a record of dumping incidences (time of day, day of week, etc) to determine if a pattern exists
- Report illegal dumping to the proper authorities -

What if I Work with a Disposal Contractor?

Do not assume your contractor is routinely inspecting the dumpster to prevent pollution discharge. Choosing a reliable and well-trained waste disposal contractor is important to prevent storm water contamination.

The solid waste disposal contractor should perform routine maintenance in addition to regularly emptying the dumpster. Report any concerns about the condition of the dumpster or collection process to the service immediately (e.g., dumpster put in wrong location, dented corners, leaks, infrequent dumping, etc.).

For More Information

Dauphin County Refuse and Recycling Opportunities, includes information on recycling locations, composting, newsletters, curbside recycling, household hazardous waste, municipal waste and nontraditional waste (e.g. computers). www.DauphinCounty.org

U.S. Environmental Protection Agency (EPA) Waste Management Website, includes information on recycling, cleanup, waste programs, voluntary partnership programs, pollution prevention and treatment/control opportunities. http://www.epa.gov/epaoswer/osw/index.htm

Paxton Creek Watershed and Education Association
P.O. Box 61674 Harrisburg, PA 17106
www.paxtoncreek.org

Standard Operating Procedure for:

3.5 Erosion and Sediment Control

Purpose of SOP: To protect stormwater from pollution by reducing or eliminating pollutant loading from land disturbing activities.

Always:

- Use erosion control techniques or devices to stabilize disturbed areas. Use effective site planning to avoid sensitive areas.
- Keep land disturbance to a minimum.
- Inspect and maintain erosion control devices. Install erosion control devices properly.
- Install erosion control blankets when seeding drainage ways.

Whenever Possible:

- Protect disturbed areas from stormwater runoff by using stabilizers such as mulch. Limit construction activities during months with higher runoff rates.
- Assign responsibility for maintaining erosion control devices. Reduce the velocity of stormwater runoff.
- Divert clean water away from the disturbed area during construction activities. Protect vegetative buffers or create new ones.
- Stabilize soils by mulching and/or seeding when soils are exposed for more than one week during the dry season, and two days during the rainy season.

Never:

Never divert runoff into a sensitive area.

Fueling Areas SD-30

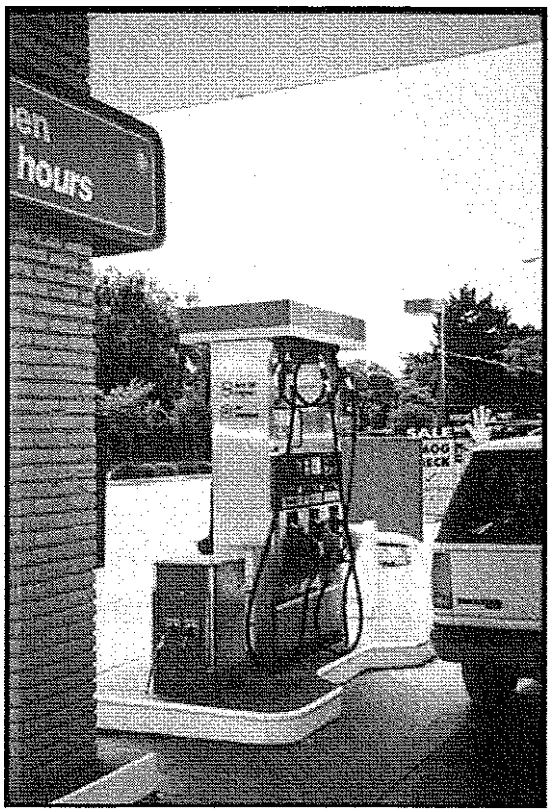


Photo Credit Geoff Brosseau

Design Objectives
Maximize Infiltration
Provide Retention
Slow Runoff
Minimize Impervious Land Coverage
Prohibit Dumping of Improper Materials
☑ Contain Pollutants
☑ Collect and Convey

Description

Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the stormwater conveyance system. Spills at vehicle and equipment fueling areas can be a significant source of pollution because fuels contain toxic materials and heavy metals that are not easily removed by stormwater treatment devices.

Approach

Project plans must be developed for cleaning near fuel dispensers, emergency spill cleanup, containment, and leak prevention.

Suitable Applications

Appropriate applications include commercial industrial and any other areas planned to have fuel dispensing equipment, including retail gasoline outlets, automotive repair shops, and major non-retail dispensing areas.

Design Considerations

Design requirements for fueling areas are governed by Building and Fire Codes and by current local agency ordinances and zoning requirements. Design requirements described in this fact sheet are meant to enhance and be consistent with these code and ordinance requirements.

Designing New Installations

Covering

Fuel dispensing areas should provide an overhanging roof structure or canopy. The cover's minimum dimensions must be equal to or greater than the area within the grade break. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area. The fueling area should drain to the project's treatment control BMP(s) prior to discharging to the stormwater conveyance system. Note - If fueling large equipment or vehicles that would prohibit the use of covers or roofs, the fueling island should be designed to sufficiently accommodate the larger vehicles and equipment and to prevent stormwater run-on and runoff. Grade to direct stormwater to a dead-end sump.

Surfacing

Fuel dispensing areas should be paved with Portland cement concrete (or equivalent smooth impervious surface). The use of asphalt concrete should be prohibited. Use asphalt sealant to protect asphalt paved areas surrounding the fueling area. This provision may be made to sites that have pre-existing asphalt surfaces.

The concrete fuel dispensing area should be extended a minimum of 6.5 ft from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 ft, whichever is less.

Grading/Contouring

Dispensing areas should have an appropriate slope to prevent ponding, and be separated from the rest of the site by a grade break that prevents run-on of urban runoff. (Slope is required to be 2 to 4% in some jurisdictions' stormwater management and mitigation plans.)

Fueling areas should be graded to drain toward a dead-end sump. Runoff from downspouts/roofs should be directed away from fueling areas. Do not locate storm drains in the immediate vicinity of the fueling area.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of "redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

- In the case of an emergency, provide storm drain seals, such as isolation valves, drain plugs, or drain covers, to prevent spills or contaminated stormwater from entering the stormwater conveyance system.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.

Standard Operating Procedure for:

3.22 Garbage Storage

Purpose of SOP: To protect stormwater from contamination by properly storing garbage. Garbage and leachate can be transported by stormwater and enter the storm drain system and receiving waterbodies.

Always:

- Dispose of hazardous materials according to manufacturer's specifications and applicable regulations.
- Cover rubbish bins to keep rubbish and leachate in and wind and rain out.

Whenever Possible:

- Store garbage containers beneath a covered structure or inside to prevent contact with stormwater.
- Install berms, curbing or vegetation strips around storage areas to control water entering/leaving storage areas.
- Locate dumpsters on a flat, concrete surface that does not slope or drain directly into the storm drain system.
- Locate dumpsters and trash cans in convenient, easily observable areas.
- Provide properly-labeled recycling bins to reduce the amount of garbage disposed.
- Inspect garbage bins for leaks regularly, and have repairs made immediately by responsible party.
- Keep bins free of improperly discarded trash.
- Provide training to employees to prevent improper disposal of general trash. Minimize waste by purchasing recyclable products that have minimal packaging. Request/use dumpsters without drain holes.

Never:

- Never place hazardous wastes in a dumpster or trash bin.

BMP INFO SHEET #3

Covering Options: Tarp, Roof, or Awning

One of the most effective actions a person can take to prevent stormwater contamination is keeping potential pollutant generating materials out of the rain. There are numerous options for covering an activity or stored materials. This BMP, combined with the prevention of stormwater runon into the covered area, can be as effective as storing materials or conducting activities indoors.

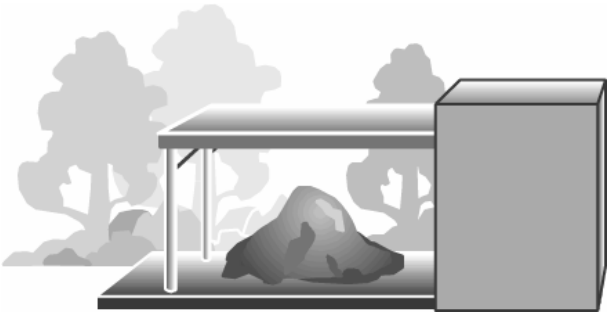
The simplest cover is a tarp or other nonstructural device. Building a permanent structure may require a building permit and must comply with all applicable building and fire codes. These building requirements may in some cases make some of these structures too expensive to be practical. Contact the King County Department of Development and Environmental Services for information on building permits and requirements for a roof structure.

Many activities, such as stockpiling of raw or erodible materials or storage drums, can be effectively covered with a heavy plastic tarp made of impermeable material. Weights such as bricks or sandbags should be used to anchor the cover in place. Care should be taken to ensure that the tarp covers the stored materials completely and that stormwater runon does not penetrate significantly under the cover. If several tarps are used to form a cover, they should be tethered together or overlapped. If necessary, pins or stakes should be used to anchor the tarps to the ground. The tarp/cover will be easier to keep in place and will last longer if some form of wind protection is possible. Attempts should be made to located stockpiles in areas where winds are minimal.

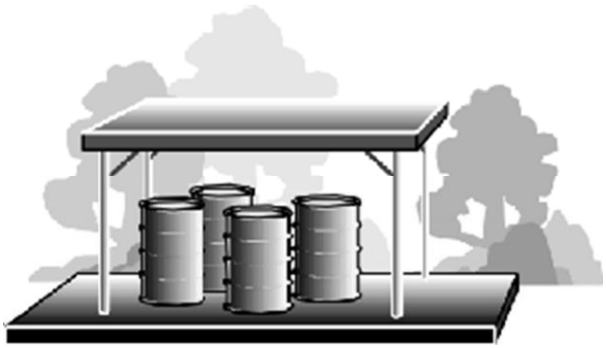
The tarps must be in place when the material is not being used. The tarps must be inspected weekly to ensure that no holes or gaps are present. Tarps are inexpensive, and therefore are a cost effective BMP for many activities. This BMP can be combined with containment for better effectiveness. See BMP Info Sheet 5 for more information.

The other option for covering is the use of a roof. The particular roof cover option used at a given site is subject to the site layout, available space, affordability, and limitations imposed by other regulations. The area of the roof should be sufficient to prevent any precipitation from reaching the contents underneath. This BMP should be implemented in conjunction with

prevention of stormwater run-on into the covered area. BMP Info Sheet 5 presents information on containment/run-on prevention. Examples of various structures are shown below.

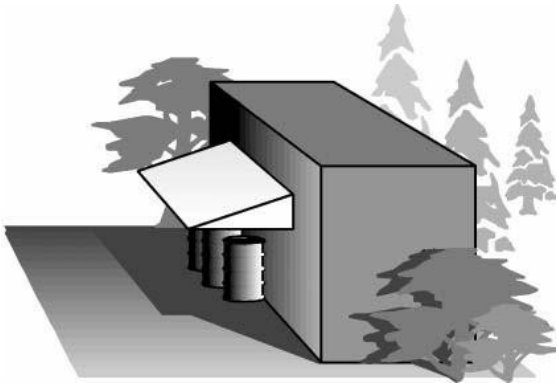


Lean-To Structure



Stand-Alone Canopy

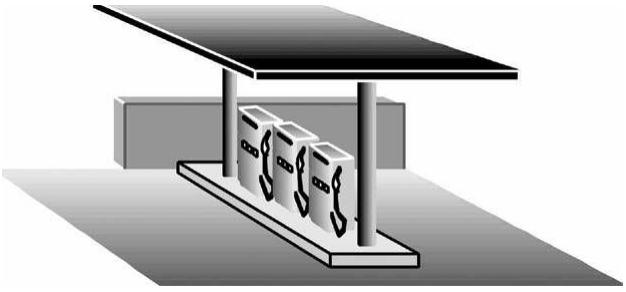
There are also numerous prefabricated storage sheds that can be purchased to enclose and cover materials. This may be a preferred alternative on some sites. Before purchasing these structures ensure they meet applicable building and fire codes.



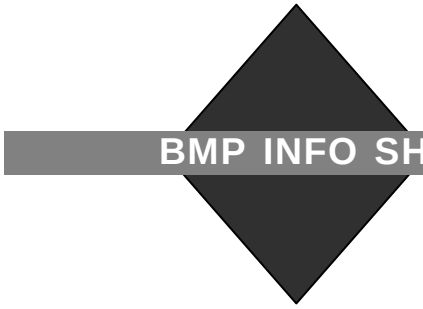
Overhanging Awning

Another option for covering an activity or stored materials is to use an overhanging awning of sufficient size to prevent precipitation from reaching the contents underneath. This cannot be an awning already in place over a public right-of-way such as a sidewalk in front of a store. Many of the building permit, fire code, and zoning code requirements mentioned above apply to these structures.

Activities such as fueling operations may be covered by an island-type overhanging roof. This roof arrangement is supported by columns along the center of the structure rather than at the corners, enabling vehicular traffic underneath while still providing sufficient protection from precipitation.



Island-Type Overhanging Roof



BMP INFO SHEET #4

Pave Area and Slope to Holding Tank

This BMP applies to several activities that cannot be covered effectively, and therefore require a method of controlling runoff from leaving your site that may be contaminated. It is particularly suited to activities with the potential for spills and leaks, but that otherwise do not generate excessive amounts of polluted runoff. In addition, this BMP is well suited to activities that intermittently produce wastewater such as washing or steam cleaning operations. A sump or holding tank serves to provide containment until the liquids can be pumped from the holding tank and disposed of properly. If the activity produces large amounts of runoff or wastewater, this BMP will not be very effective because contaminated water will overflow the sump or pass through the sump before collection and disposal are possible. The following information is intended for situations where this BMP can be effective.

A designated area must be paved and sloped to a drain connected to a central collection point. A sump, vault, or holding tank must be installed to capture the wastewater. Some materials, such as gasoline, can react with and cause deterioration of asphalt pavement. It is preferable for the area to be paved with Portland cement concrete. If the area is already paved with asphalt, an asphalt sealant should be applied to the pavement surface. Whichever paving material is used, the paved surface must be free of gaps and cracks.

The sump or holding tank should have a large enough capacity to contain the entire volume of wastewater generated by the activity, or the entire volume of a potential spill (whichever is applicable, or the greater of the two). Depending on the circumstances, the sump or tank can be equipped with an outflow pipe to allow discharge of normal, uncontaminated runoff to the storm drainage system. The local sewer authority may, in some instances, allow a connection to the sanitary sewer system.

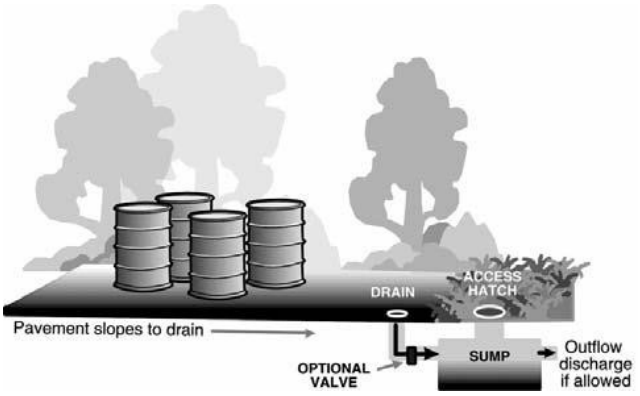
The paved activity area must also be contained to prevent stormwater runon and runoff. This can be achieved by constructing a curb, dike, or berm that directs uncontaminated surface water flows away from the area. See BMP Info Sheet 5 in this chapter for more information. This way, only the precipitation that falls within the activity area is discharged and/or treated along with the process water.

The catch basin/tank/sump must have a two-way valve installed at the outflow pipe so that uncontaminated runoff from the activity area can discharge to the storm drainage system at times when the pollutant generating activity is not occurring. The two-way valve must be able to easily be switched between discharges to the sanitary sewer, holding tank, or treatment facility, and discharges to the storm drainage system. Each time the activity is occurring, the two-way valve must be switched so that the polluted runoff discharges to the sanitary sewer, holding tank, or

treatment facility. After the pollutant generating activity operation is finished and no more process water is generated, the area must be sprayed, hosed, or otherwise washed down with the wash water discharging to the sanitary sewer, holding tank, or treatment facility. The two-way valve must be switched after clean up is completed so that subsequent runoff is discharged to the storm drainage system until the next time the activity that produces wastewater occurs. It is critical that careful attention be given to this valve so that it is always switched to the correct position. Approval for discharges with a two-way valve should be obtained from the King County Industrial Waste Program, the local sewer authority and King County Water and Land Resources Division, Water Quality Compliance Program.

If discharges to the storm drainage system or sanitary sewer are not allowed, the sump or holding tank contents will need to be pumped out periodically and disposed of properly. This requirement can make this BMP costly, especially during the wet season. See BMP Info Sheet 2 for disposal options.

An example of a paved activity area with a sump drain is shown to the right.



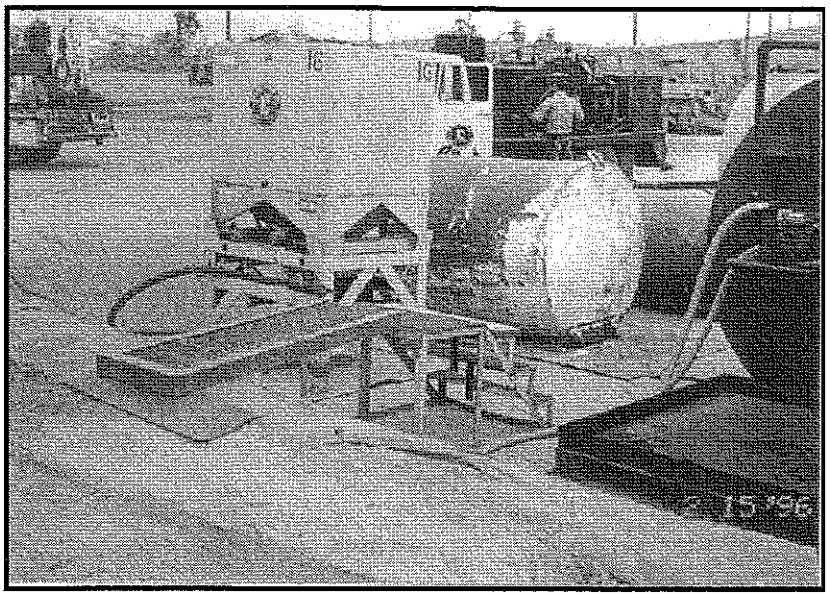
Paved Area with Sump Drain

Drainage into the sump or holding tank should only occur at times when the activity that generates wastewater is occurring. To keep disposal costs down, a drain cover, plug, or shutoff valve in the pipe leading to the sump should be used at times when the activity is not occurring. Before starting the activity (if the activity is intermittent), the cover, plug, or valve must be opened.

The cost of constructing a sump and disposing of accumulated contents can be high, so businesses should consider whether other allowable BMP alternatives could be used. Individual cities, sewer agencies and King County may charge additional fees if a sanitary sewer hookup is made. The fees depend on location, quantity of discharge, and whether the hookup is for a business or residence. A King County industrial waste permit may also be required in some situations.

Several commercial services are available for pumping out sumps and holding tanks. These can be found in your telephone directory's yellow pages under the headings "Sewer Contractors and Cleaners" ,and "Tank Cleaning." You can also find information on Drainage Maintenance Contractors on the King County Stormwater Services website at http://dnr.metrokc.gov/wlr/stormwater/DrainageMaintVendors.htm or by calling 206-296-1900. Septic system pump-out and hauling contractors must not be used for disposing wastes other than domestic sewage. They are not allowed to haul industrial wastes.

Outdoor Material Storage Areas SD-34



Design Objectives

Maximize Infiltration

Provide Retention Slow Runoff

Minimize Impervious and Coverage

Prohibit Dumping of Improper Materials

☑ Contain Pollutant

Collect and Convey

Description

Proper design of outdoor storage areas for materials reduces opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the stormwater conveyance system. Materials may be in the form of raw products, by-products, finished products, and waste products. The type of pollutants associated with the materials will vary depending on the type of commercial or industrial activity.

Approach

Outdoor storage areas require a drainage approach different from the typical infiltration/detention strategy. In outdoor storage areas, infiltration is discouraged. Containment is encouraged. Preventative measures include enclosures, secondary containment structures and impervious surfaces.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Some materials are more of a concern than others. Toxic and hazardous materials must be prevented from coming in contact with stormwater. Non-toxic or non,-hazardous materials do not have to be prevented :from stormwater contact. However, these materials may have toxic effects on receiving waters if allowed to be discharged with stormwater insignificant quantities. Accumulated material on an impervious surface could result in significant impact on the rivers or streams that receive the runoff:

Material may be stored in a variety of ways, including bulk piles, containers, shelving, stacking, and tanks. :Stormwater contamination may be prevented by eliminating the possibility of stormwater contact with the material storage areas either through diversion, cover, or capture of the stormwater. Control measures may also include minimizing the storage area. Design

SD-34 Outdoor Material Storage Areas

requirements for material storage areas are governed by Building and Fire Codes, and by current City or County ordinances and zoning requirements. Control measures are site specific, and must meet local agency requirements.

Designing New Installations

Where proposed project plans include outdoor areas for storage of materials that may contribute pollutants to the stormwater conveyance system, the following structural or treatment BMPS should be considered:

- Materials with the potential to contaminate stormwater should be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the stormwater conveyance system, or (2) protected by secondary containment structures such as berms, dikes, or curbs.
- The storage area should be paved and sufficiently impervious to contain leaks and spills.
- The storage area should slope towards a dead-end sump to contain spills and direct runoff from downspouts/roofs should be directed away from storage areas.
- The storage area should have a roof or awning that extends beyond the storage area to minimize collection of stormwater within the secondary containment area. A manufactured storage shed may be used for small containers.

Note that the location(s) of installations of where these preventative measures will be employed must be included on the map or plans identifying BMPs.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

Additional Information

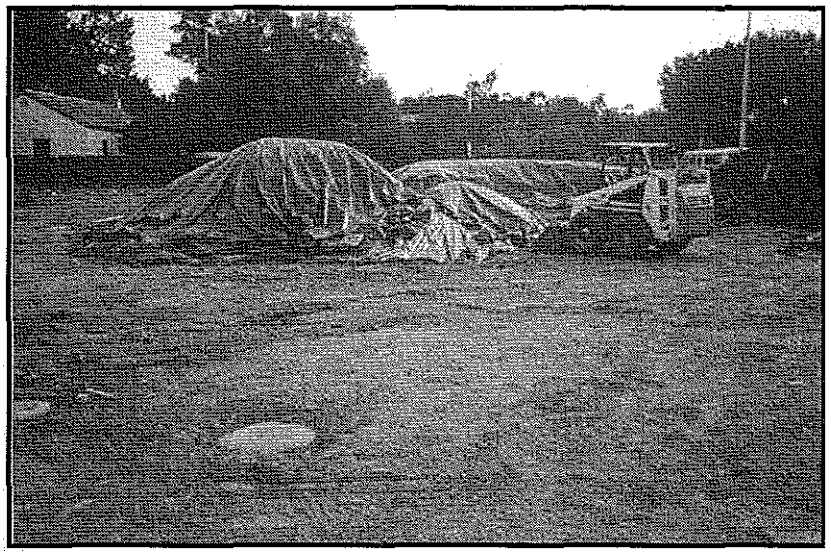
Stormwater and non-stormwater will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and cannot be discharged directly to the storm drain or sanitary sewer system without the appropriate permits.

other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Outdoor Storage of Raw Materials SC-33



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize

Description

Raw materials, by-products, finished products, containers, and material storage areas exposed to rain and/or runoff can pollute stormwater. Stormwater can become contaminated when materials wash off or dissolve into water or are added to runoff by spills and leaks. Improper storage of these materials can result in accidental spills and the release of materials. To prevent or reduce the discharge of pollutants to stormwater from material delivery and storage, pollution prevention and source control measures, such as minimizing the storage of hazardous materials on-site, enclosing or covering materials, storing materials in a designated area, installing secondary containment, conducting regular inspections, preventing stormwater runon and runoff, and training employees and subcontractors must be implemented.

Targeted Constituents

Sediment	O
Nutrients	O
Trash	O
Metals	
Bacteria	
Oil and Grease	O
Organics	O
Oxygen Demanding	O

Approach

Pollution Prevention

- Employee education is paramount for successful BMP implementation.
- Minimize inventory of raw materials.
- Keep au accurate, up-to-date inventory of the materials delivered and stored on-site.
- Try to keep chemicals in their original containers, and keep them well labeled.

SC-33 Outdoor Storage of Raw Materials

Suggested Protocols

General

- Store all materials inside. If this is not feasible, then all outside storage areas should be covered with a roof, and bermed, or enclosed to prevent stormwater contact. At the very minimum, a temporary waterproof covering made of polyethylene, polypropylene or hypalon should be used over all materials stored outside.

- Cover and contain the stockpiles of raw materials to prevent stormwater from running into the covered piles. The covers must be in place at all times when work with the stockpiles is not occurring. (applicable to small stockpiles only).

- If the stockpiles are so large that they cannot feasibly be covered and contained, implement erosion control practices at the perimeter of your site and at any catch basins to prevent erosion of the stockpiled material off site,

- Keep liquids in a designated area on a paved impervious surface within a secondary containment.

- Keep outdoor storage containers in good condition.

- Keep storage areas clean and dry.

- Design paved areas to be sloped in a manner that minimizes the pooling of water on the site, particularly with materials that may leach pollutants into stormwater and/or groundwater, such as compost; logs, and wood chips. A minimum slope ofl.5 percent is recommended.

- Secure drums stored in an area where unauthorized persons may gain access to prevent accidental spillage, pilferage, or any unauthorized use.

- Cover wood products treated with chromated copper arsenate, ammonical copper zinc arsenate, creosote, or pentachlorophenol with tarps or store indoors.

Raw Material Containment

- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items in secondary containers if applicable.

- Prevent the run-on of uncontaminated stormwater from adjacent areas as well as runoff of stormwater from the stockpile areas, by placing a curb along the perimeter of the area. The area inside the curb should slope to a drain. Liquids should be drained to the sanitary sewer if allowed. The drain must have a positive control such as a lock, valve, or plug to prevent release of contaminated liquids.

- Tanks should be bermed or surrounded by a secondary containment system.

- Release accumulated stormwater in petroleum storage areas prior to the next storm. At a minimum, water should pass through an oil/water separator and, if allowed, discharged to a sanitary sewer.

Outdoor Storage of Raw Materials SC-33

Inspection

- Conduct regular inspections of storage areas so that leaks and spills are detected as soon as possible.
- Conduct routine inspections and check for external corrosion of material containers. Also check for structural failure, spills and overfills due to operator error, failure of piping system.
- Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa.
- Visually inspect new tank or container installations for loose fittings, poor welding, and improper or poorly fitted gaskets.
- Inspect tank foundations, connections, coatings, and tank walls and piping system. Look for corrosion, leaks, cracks, scratches, and other physical damage that may weaken the tank or container system.

Training

- Employees should be well trained in proper material storage.
- Train employees and contractors in proper techniques for spill containment and cleanup.

Spill Response and Prevention

- Refer to SC-11, Spill Prevention, Control & Cleanup.
- Keep your Spill Prevention Control and countermeasure (SPCC) plan up-to-date, and implement accordingly.
- Have spill cleanup materials readily available and in a known location.
- Cleanup spills immediately and use dry methods, if possible.
- Properly dispose of spill cleanup material
- Have employees trained in spill containment and cleanup present during loading/unloading of dangerous waste, liqo.id chemicals and other potentially hazardous materials.

Other Considerations

- Storage sheds often must meet building and fire code requirements. Storage of reactive, ignitable, or flammable liquids must comply with the Uniform Fire Code and the National Electric Code.
- Space limitations may preclude storing some materials indoors.
- Some municipalities require that secondary containment areas (regardless of size) be connected to the sanitary sewer, prohibiting any hard connections to the storm drain. Storage sheds often must meet building and fire code requirements.
- The local fire district must be consulted for limitations on clearance of roof covers over containers used to store flammable materials.

SC-33 Outdoor Storage of Raw Materials

Requirements

Costs

- Costs will vary depending on the size of the facility and the necessary controls. They should be low except where large areas may have to be covered.

Maintenance

- Accurate and up-to-date inventories should be kept of all stored materials.
- Berms and curbs may require periodic repair and patching.
- Parking lots or other surfaces near bulk materials storage areas should be swept periodically to remove debris blown or washed from storage area
- Sweep paved storage areas regularly fur collection and disposal of loose solid materials, do not hose down the area to a storm drain or conveyance ditch.
- Keep outdoor storage areas in good condition (e.g. repair roofs, floors, etc. to limit releases to runoff).

Supplemental Information

Further Detail of the BMP

Raw Material Containment

Paved areas should be sloped in a manner that minimizes the pooling of water on the site, particularly with materials that may leach pollutants into stormwater and/or groundwater, such as compost, logs, and wood chips. A minimum slope of 1.5 percent is recommended.

Curbing should be placed along the perimeter of the area to prevent the runon of uncontaminated stormwater from adjacent areas as well as runoff of stormwater from the stockpile areas.

The storm drainage system should be designed to minimize the use of catch basins in the interior of the area as they tend to rapidly fill with manufacturing material

The area should be sloped to drain stormwater to the perimeter where it can be collected or to internal drainage alleyways where material is not stockpiled.

If the raw material, by-product, or product is a liquid, more information for outside storage of liquids can be found under SC-31, Outdoor Container Storage.

Examples

The "doghouse" design has been used to store small liquid containers. The roof and flooring design prevent contact with direct rain or runoff. The doghouse has two solid structoral walls and two canvas covered walls. The flooring is wire mesh about secondary containment. The unit has been used successively at Lockheed Missile and Space Company in Sunnyvale.

References and Resources

King County Stormwater Pollution Control Manual - http: //dnr.metrokc.gov /wlr /dss/spcm.htm

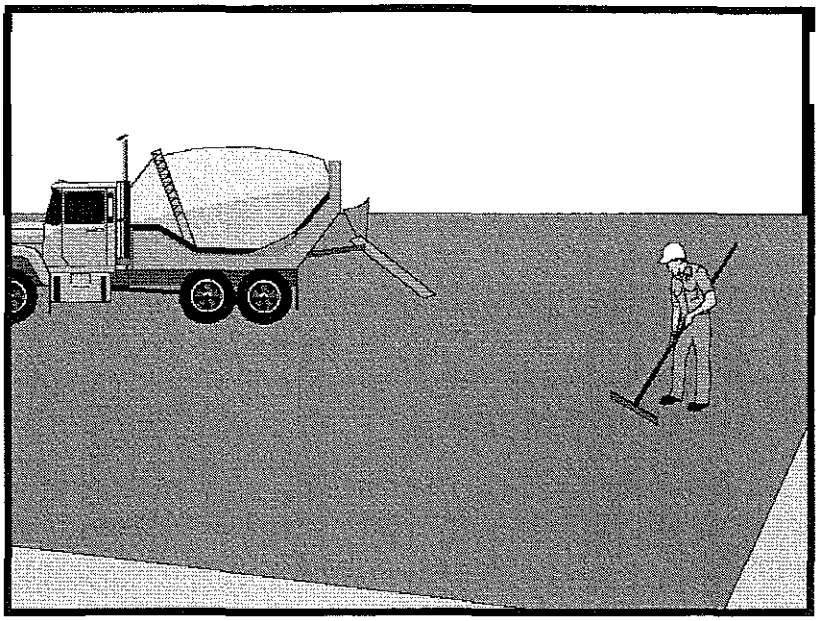
Outdoor Storage of Raw Materials SC-33

Model Urban Runoff Program: A How-To-Guide for Developing Urban Runoff Programs for Small Municipalities. Prepared by City of Monterey, City of Santa Cruz, California Coastal Commission, Monterey Bay National Marine Sanctuary, Association of Monterey Bay Area Governments, Woodward-Clyde, Central Coast Regional Water Quality Control Board. July i998 (Revised February 2002 by the California Coastal Commission).

Orange County Stormwater Program
http: f /www.ocwatersheds.com/StormWater /swp introduction.asp

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http: / /www.pro jectcleanwater.org/pdf/Model%20Program%2.0Municipal%20Facilities.pdf

Paving and Grinding Operations NS-3



Objectives

EC	Erosion Control	
SE	Sediment Control	
TR	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stormwater Management Control	☑
WM	Waste Management and Materials Pollution Control	☑

Legend:
☑ **Primary Objective**
☒ **Secondary Objective**

Targeted Constituents

Sediment	☑
Nutrients	
Trash	
Metals	
Bacteria	
Oil and Grease	☑
Organics	

Potential Alternatives

None

Description and Purpose

Prevent or reduce the discharge of pollutants from paving operations, using measures to prevent runon and runoff pollution, properly disposing of wastes, and training employees and subcontractors.

Suitable Applications

These procedures are implemented where paving, surfacing, resurfacing, or sawcutting, may pollute stormwater runoff or discharge to the storm drain system or watercourses.

Limitations

- Finer solids are not effectively removed by filtration systems.
- Paving opportunities may be limited during wet weather.

Implementation

General

- Avoid paving during the wet season when feasible.
- Reschedule paving and grinding activities if rain is in the forecast.
- Train employees and sub-contractors in pollution prevention and reduction.
- Store materials away from drainage courses to prevent stormwater runon (see WM-1, Material Delivery and Storage).

- Protect drainage courses, particularly in areas with a grade, by employing BMPs to divert runoff or to trap and filter sediment.
- If paving involves an onsite mixing plant, follow the stormwater permitting requirements for industrial activities.
- Stockpile material removed from roadways away from drain inlets, drainage ditches, and watercourses, These materials should be stored consistent with WM-3, Stockpile Management.
- Disposal of PCC and AC waste should be in conformance with WM-8, Concrete Waste Management.

Saw Cutting, Grinding, and Pavement Removal

- Shovel or vacuum saw-cut slurry and remove from site. Cover or barricade storm drains during saw cutting to contain slurry.
- When paving involves AC, the following steps should be implemented to prevent the discharge of grinding residue, uncompacted or loose AC, tack coats, equipment cleaners, or unrelated paving materials:

  AC grindings, pieces, or chunks used in embankments or shoulder backing must not be allowed to enter any storm drains or watercourses. Install silt fence until structure is stabilized or permanent controls are in place. Examples of temporary perimeter controls can be found in EC-9, Earth Dikes and Drainage Swales; SE-1, Silt Fence; or SE-5, Fiber Rolls.

  Collect and remove all broken asphalt and recycle when practical. Old or spilled asphalt must be recycled or disposed.

  Any AC chunks and pieces used in embankments must be placed above the water table and covered by at least 1ft of material.

- Do not allow saw-cut slurry to enter storm drains or watercourses. Residue from grinding operations should be picked up by means of a vacuum attachment to the grinding machine, should not be allowed to flow across the pavement, and should not be left on the surface of the pavement. See also WM-8, Concrete Waste Management, and WM-10, Liquid Waste Management.
- Dig out activities should not be conducted in the rain.
- Collect dig out material by mechanical or manual methods. This material may be recycled for use as shoulder backing or base material.
- If dig out material cannot be recycled, transport the material back to an approved storage site.

Asphaltic Concrete Paving

- If paving involves asphaltic cement concrete, follow these steps:

Paving and Grinding Operations NS-3

Do not allow sand or gravel placed over new asphalt to wash into storm drains, streets, or creeks. Vacuum or sweep loose sand and gravel and properly dispose of this waste by referring to WM-5, Solid Waste Management.

0Id asphalt must be disposed of properly. Collect and remove all broken asphalt from the site and recycle whenever possible.

Portland Cement Concrete Paving

- Do not wash sweepings from exposed aggregate concrete into a storm drain system. Collect and return to aggregate base stockpile or dispose of properly.
- Allow aggregate rinse to settle. Then, either allow rinse water to dry in a temporary pit as described in WM-8, Concrete Waste Management, or pump the water to the sanitary sewer if allowed by the local wastewater authority.

Sealing Operations

- During chip seal application and sweeping operations, petroleum or petroleum covered aggregate must not be allowed to enter any storm drain or water courses. Apply temporary perimeter controls until structure is stabilized.
- Drainage inlet structures and manholes should be covered with filter fabric during application of seal coat, tack coat, slurry seal, and fog seal.
- Seal coat, tack coat, slurry sea or fog seal should not be applied if rainfall is predicted to occur during the application or curing period.

Paving Equipment

- Leaks and spills from paving equipment can contain toxic levels of heavy metals and oil and grease. Place drip pans or absorbent materials under paving equipment when not in use. Clean up spills with absorbent materials rather than burying. See NS-10, Vehicle and Equipment Maintenance, WM-4, Spill Prevention and Control, and WM-10, Liquid Waste Management.
- Substances used to coat asphalt transport trucks, and asphalt spreading equipment should not contain soap and should be non-foaming and non-toxic.
- Use only non-toxic substances to coat asphalt transport trucks and asphalt spreading equipment
- Paving equipment parked onsite should be parked over plastic to prevent soil **contamination.**
- Clean asphalt coated equipment offsite whenever possible. When cleaning dry, hardened asphalt from equipment, manage hardened asphalt debris as described in WM-5, Solid Waste Management. Any cleaning onsite should follow NS-8, Vehicle and Equipment Cleaning.

Thermoplastic Striping

- Thermoplastic striper and pre-heater equipment shutoff valves should be inspected to ensure that they are working properly to prevent leaking thermoplastic from entering drain inlets, the stormwater drainage system, or watercourses.
- Pre-heaters should be filled carefully to prevent splashing or spilling of hot thermoplastic. Leave six inches of space at the top of the pre-heater container when filling thermoplastic to allow room for material to move when the vehicle is deadheaded.
- Do not pre-heat, transfer, or load thermoplastic near drain inlets or watercourses.
- Clean truck beds daily of loose debris and melted thermoplastic. When possible, recycle thermoplastic material.

. ***Raised/ Recessed Pavement Marker Application and Removal***

- Do not transfer or load bituminous material near drain inlets, the stormwater drainage system, or watercourses.
- Melting tanks should be loaded with care and not filled to beyond six inches from the top to leave room for splashing when vehicle is deadheaded.
- When servicing or filling melting tanks, ensure all pressure is released before removing lids to avoid spills.
- On large-scale projects, use mechanical or manual methods to collect excess bituminous material from the roadway after removal of markers.

Costs

- All of the above are low cost measures.

Inspection and Maintenance

- Inspect and verify that activity-based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and at two-week intervals in the non-rainy season to verify continued BMP implementation.
- Keep ample supplies of drip pans or absorbent materials onsite.
- Inspect and maintain machinery regularly to minimize leaks and drips.

References

Blueprint for a Clean Bay: Best Management Practices to Prevent Stormwater Pollution from Construction Related Activities; Santa Clara Valley Nonpoint Source Pollution Control Program, 1995.

Hot Mix Asphalt-Paving Handbook AC 150/5370-14, Appendix I, U.S. Army Corps of Engineers, July 1991.

Stormwater Quality Handbooks - Construction Site Best Management Practices (BMPs) Manual, State of California Department of Transportation (Caltrans), November 2000.

Standard Operating Procedure for:

3.21 Petroleum and Chemical Storage - Small Quantity

Purpose of SOP: To protect stormwater from pollution by properly storing petroleum products or chemicals (containers smaller than 55-gallons).

Always:

- Store materials away from high traffic areas.
- Store materials according to manufacturer's specifications (e.g. in a flammable materials storage cabinet).
- Dispose of unused or waste materials properly.
- Train employees on proper storage procedures for petroleum and chemical products. Store materials in their original containers to maintain appropriate labeling.
- Be prepared for spills by having a spill kit nearby. Frequently inspect the storage areas for leaks or spills.
- Conduct annual employee training to reinforce proper storage techniques for petroleum and chemical products.

Never:

- Never store petroleum or chemical products near a floor drain or stormwater inlet.

Standard Operating Procedure for:

3.18 Petroleum and Chemical Disposal

Purpose of SOP: To protect stormwater from petroleum and chemical products due to improper disposal practices.

Always:

- Dispose of petroleum/chemicals according to manufacturer's specifications and state and federal regulations.
- Maintain tracking of chemicals and petroleum products being disposed off-site.
- Store waste petroleum/chemical products in a designated area labeled as such.
- Label each waste container with its contents.
- Transport used petroleum and chemical products with a licensed transporter and maintain records for three years.
- Train employees on proper disposal practices.
- Drain used oil filters for 24-hours before disposal (disposal in regular trash allowed).
- Inspect waste storage areas for staining/leaks on a regular basis.

Whenever Possible:

- Minimize the number of solvents used to reduce the variety of waste generated and to make recycling easier.
- Use safer alternatives. (see Alternative Products SOP)
- If burning used oil for on-site heat, analyze for Maine Waste Oil parameters (Arsenic, Lead, Cadmium, Chromium, F- listed Halogens, Flashpoint, PCBs) approximately once every 1,000 gallons.

- **Never:**
- Never place hazardous waste in solid waste dumpsters.
- Never pour liquid waste down floor drains, sinks or outdoor storm drain inlets.
- Never mix petroleum waste and chemical waste.
- Never dispose of any gasoline-contaminated waste in the regular trash. Dispose of it only as a hazardous waste.

Standard Operating Procedure for:

3.19 Petroleum and Chemical Handling

Purpose of SOP: To protect stormwater by properly managing petroleum products and chemicals used by municipalities.

Always:

- Train employees in hazardous material handling, safety, spill cleanup and reporting on an annual basis.
- Handle petroleum products and chemicals according to manufacturer's specifications. Conduct oil changes indoors for equipment that fits indoors.
- Use proper protective equipment.
- Maintain Material Safety Data Sheets (MSDS) for all chemicals used.
- Make MSDS sheets available on materials that require special handling, storage and/or disposal.
- Create a sign-off sheet for employees stating that they know the location of the MSDS(s).

Whenever Possible:

- Assess hazardous material needs to minimize the amount and variety of hazardous material in storage.
- Transfer materials from one container to another indoors in a well ventilated area. Properly label containers.
- Train new employees within six months of hire.

Never:

- Never treat or dispose of hazardous materials unless licensed to do so.
- Never mix petroleum or chemicals unless directed by manufacturer's instructions.

Standard Operating Procedure for:

3.20 Petroleum and Chemical Storage - Bulk

Purpose of SOP: To protect stormwater by properly storing bulk petroleum products and chemicals (containers larger than 55 gallons).

Always:

- Store materials away from high traffic areas, posted with appropriate signage.
- Store materials according to manufacturer's specifications in approved containers and conditions.
- Be prepared for possible spills by having a spill kit nearby.
- Develop and use a Spill Prevention Control and Countermeasure (SPCC) plan if storing more than 1,320 gallons of petroleum (required).
- Store incompatible hazardous materials in separate areas.
- Inspect storage areas for leaks or drips frequently.
- Store bulk items within secondary containment areas if bulk items are stored outside.
- Conduct annual employee training to reinforce proper storage techniques for petroleum and chemical products.

Whenever Possible:

- Store bulk chemicals and petroleum products inside or under cover.
- Provide secondary containment for interior storage.

Never:

- Never store bulk chemicals or petroleum products near a storm drain.

Standard Operating Procedure for:

3.29 Road Maintenance - Salt Application

Purpose of SOP: To protect stormwater by improving application techniques of salt, sand, and other deicing materials.

Always:

- Calibrate sand/salt trucks in accordance with Maine DOT and Salt Institute recommendations.

Whenever Possible:

- Use the minimum amount of salt and sand needed to get the job done.
- Use coarse, clean sand, which is free of fine particles and dust and easier to clean in the
- spring.
- Train drivers to improve application techniques and reduce losses.
- Establish "low salt and/or sand areas" near sensitive environments. Sand may be detrimental in areas sensitive to sedimentation, such as streams, and salt can impact water supply wells.
- Remove snow manually from driveways and sidewalks.
- Limit toxic metals in specifications for deicers.
- Cleanup road grit as soon as possible.
- Use less harmful deicers such as calcium magnesium acetate, potassium acetate, or organic
- deicers such as Magic Salt™.
- Consider road temperatures when determining volume of salt to apply. Control the rate of spreading by equipping trucks with ground-speed sensors.

3.28 Road Maintenance - Sand and Salt Storage

Purpose of SOP: To protect stormwater by properly storing deicing materials. Sand, salt and other deicing materials used during winter can be transported by runoff into the storm drain system and eventually into waterbodies if not stored properly.

Always:

- Cover sand/salt and salt piles that are situated on impervious surfaces.
- Register all new sand/salt storage areas with the MDEQ.

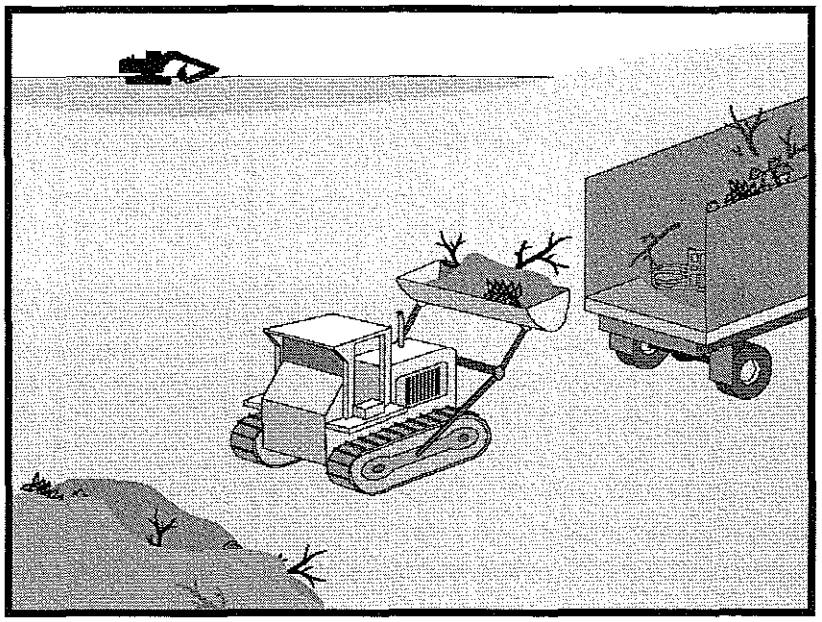
Whenever Possible:

- Contain wash water from trucks used for salting and sanding in a holding tank for disposal or discharge into sanitary sewers.
- Place salt piles in areas not subject to flooding.
- Cover sand/salt and salt piles with a tarp (polyethylene) during non-freezing spring and summer months when storage facilities are not available.
- Contain stormwater runoff from areas where salt is stored by using buffers to diffuse runoff before entering waterbodies.
- Use diversion berms to minimize run-on to storage areas. Cleanup "track out" after storm events.
- Have the MDEP review your snow storage/disposal location(s).

Never:

- Never dispose of wash water from sanding and salting trucks into the storm drain system, a waterbody or septic system drain fields.

Solid Waste Management WM-5



Objectives

EC	Erosion Control	
SE	Sediment Control	
TC	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stomwater Management Control	
WM	Waste Management and Materials Pollution Control	☑

Legend:
☑ **Primary Objective**
☒ **Secondary Objective**

Targeted Constituents

Sediment	☑
Nutrients	☑
Trash	☑
Metals	☑
Bacteria	
Oil and Grease	
Organics	

Potential Alternatives

None

Description and Purpose

Solid waste management procedures and practices are designed to prevent or reduce the discharge of pollutants to stormwater from solid or construction waste by providing designated waste collection areas and containers, arranging for regular disposa and training employees and subcontractors.

Suitable Applications

This BMP is suitable for construction sites where the following wastes are generated or stored:

- Solid waste generated from trees and shrubs removed during land clearing, demolition of existing structures (rubble), and building construction
- Packaging materials including wood, paper, and plastic
- Scrap or surplus building materials including scrap metals, rubber, plastic, glass pieces and masomy products
- Domestic wastes including food containers such as beverage cans, coffee cups, paper bags, plastic wrappers, and cigarettes
- Construction wastes including brick, mortar, timber, steel and metal scraps, pipe and electrical cuttings, non-hazardous equipment parts, styrofoam and other materials used to transport and package construction materials

- Highway planting wastes, including vegetative material, plant containers, and packaging materials.

Limitations

Temporary stockpiling of certain construction wastes may not necessitate stringent drainage related controls during the non-rainy season or in desert areas with low rainfall.

Implementation

The following steps will help keep a clean site and reduce stormwater pollution:

- Select designated waste collection areas onsite.
- Inform trash-hauling contractors that you will accept only watertight dumpsters for onsite use.
- Inspect dumpsters for leaks and repair any dumpster that is not watertight.
- Locate containers in a covered area or in a secondary containment.
- Provide an adequate number of containers with lids or covers that can be placed over the container to keep rain out or to prevent loss of wastes when it is windy.
- Plan for additional containers and more frequent pickup during the demolition phase of construction.
- Collect site trash daily, especially during rainy and windy conditions.
- Remove this solid waste promptly since erosion and sediment control devices tend to collect litter.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
- Do not hose out dumpsters on the construction site. Leave dumpster cleaning to the trash hauling contractor.
- Arrange for regular waste collection before containers overflow.
- Clean up immediately if a container does spill.
- Make sure that construction waste is collected, removed, and disposed of only at authorized disposal areas.

Education

- Have the contractor's superintendent or representative oversee and enforce proper solid waste management procedures and practices.
- Instruct employees and subcontractors on identification of solid waste and hazardous waste.
- Educate employees and subcontractors on solid waste storage and disposal procedures.

- Hold regular meetings to discuss and reinforce disposal procedures (incorporate into regular safety meetings).
- Require that employees and subcontractors follow solid waste handling and storage procedures.
- Prohibit littering by employees, subcontractors, and visitors.
- Minimize production of solid waste materials wherever possible.

Collection, Storage, and Disposal

- Littering on the project site should be prohibited.
- To prevent clogging of the storm drainage system., litter and debris removal from drainage grates, trash racks, and ditch lines should be a priority.
- Trash receptacles should be provided in the contractor's yard, field trailer areas, and at locations where workers congregate for lunch and break periods.
- Litter from work areas within the construction limits of the project site should be collected and placed in watertight dumpsters at least weekly, regardless of whether the litter was generated by the contractor, the public, or others. Collected litter and debris should not be placed in or nei..-1: to drain inlets, stormwater drainage systems, or watercourses.
- Dumpsters of sufficient size and number should be provided to contain the solid waste generated by the project.
- Full dumpsters should be removed from the project site and the contents should be disposed of by the trash hauling contractor.
- Construction debris and waste should be removed from the site biweekly or more frequently as needed.
- Construction material visible to the public should be stored or stacked in an orderly manner.
- Stormwater runon should be prevented from contacting stored solid waste through the use of berms, dikes, or other temporary diversion structures or through the use of measures to elevate waste from site surfaces.
- Solid waste storage areas should be located at least 50 ft from drainage facilities and watercourses and should not be located in areas prone to flooding or ponding.
- Except during fair weather, construction and highway planting waste not stored in watertight dumpsters should be securely covered from wind and rain by covering the waste with tarps or plastic.
- Segregate potentially hazardous waste from non-hazardous construction site waste.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.

- For disposal of hazardous waste, see WM-6, Hazardous Waste Management. Have hazardous waste hauled to an appropriate disposal and/or recycling facility.

- Salvage or recycle useful vegetation debris, packaging and surplus building materials when practical. For example, trees and shrubs from land clearing can be used as a brush barrier, or converted into wood chips, then used as mulch on graded areas. Wood pallets, cardboard boxes, and construction scraps can also be recycled.

Costs

All of the above are low cost measures.

Inspection and Maintenance

- Inspect and verify that activity based BMPs are in place prior to the commencement of associated activities. While activities associated with the BMP are under way, inspect weekly during the rainy season and of two-week intervals in the non-rainy season to verify continued BMP implementation.

- Inspect BMPs subject to non-stormwater discharge daily while non-stormwater discharges **occur**

- Inspect construction waste area regularly.

- Arrange for regular waste collection.

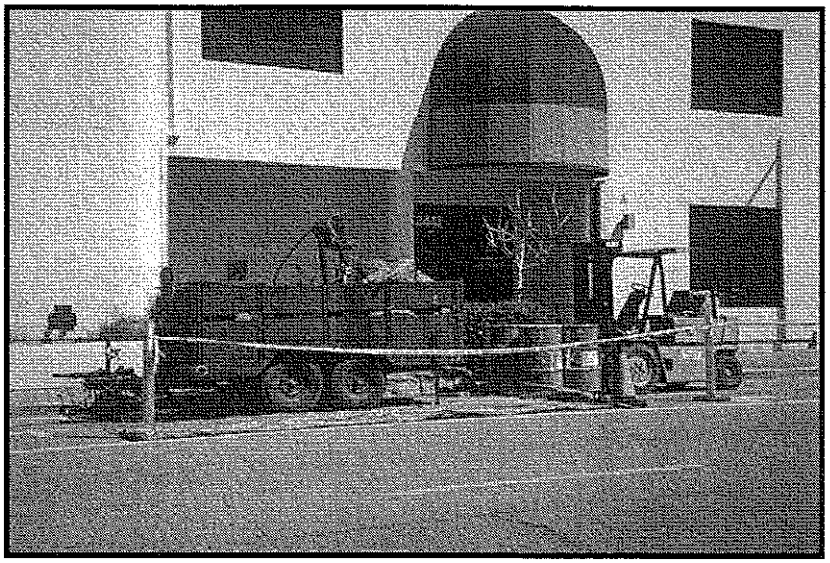
References

Processes, Procedures and Methods to Control Pollution Resulting from All Construction Activity, 430/9-73-007, USEPA, 1973.

Stormwater Quality Handbooks - Construction Site Best Management Practices (BMPs) Manual, State of California Department of Transportation (Caltrans), November 2000.

Stormwater Management for Construction Activities; Developing Pollution Prevention Plans and Best Management Practice, EPA 832-R-92005; USEPA, April 1992.

Spill Prevention, Control & Cleanup SC-11



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Description

Spills and leaks, if not properly controlled, can adversely impact the storm drain system and receiving waters. Due to the type of work or the materials involved, many activities that occur either at a municipal facility or as a part of municipal field programs have the potential for accidental spills and leaks. Proper spill response planning and preparation can enable municipal employees to effectively respond to problems when they occur and minimize the discharge of pollutants to the environment.

Targeted Constituents

Sediment	
Nutrients	☑
Trash	
Metals	☑
Bacteria	
Oil and Grease	☑
Organics	☑
Oxygen Demanding	☑

Approach

- An effective spill response and control plan should include:

  Spill/leak prevention measures;

  Spill response procedures;

  Spill cleanup procedures;

  Reporting; and

  Training

- A well thought out and implemented plan can prevent pollutants from entering the storm drainage system and can be used as a tool for training personnel to prevent and control future spills as well.

Pollution Prevention

- Develop and implement a Spill Prevention Control and Response Plan. The plan should include:

SC-11 Spill Prevention, Control & Cleanup

- A description of the facility, the address, activities and materials involved Identification of key spill response personnel
- Identification of the potential spill areas or operations prone to spills/leaks Identification of which areas should be or are bermed to contain spills/leaks
- Facility map identifying the key locations of areas, activities, materials, structural BMPs, etc.
- Material handling procedures
- Spill response procedures including:
  - Assessment of the site and potential impacts Containment of the material
  - Notification of the proper personnel and evacuation procedures Clean up of the site
  - Disposal of the waste material and Proper record keeping
- Product substitution - use less toxic materials (i.e. use water based paints instead of oil based paints)
-
- Recycle, reclaim, or reuse materials whenever possible. This will reduce the amount of materials that are brought into the facility or into the field.

Suggested Protocols

Spill/Leak Prevention Measures

- If possible, move material handling indoors, under cover, or away from storm drains or sensitive water bodies.
- Properly label all containers so that the contents are easily identifiable.
- Berm storage areas so that if a spill or leak occurs, the material is contained.
- Cover outside storage areas either with a permanent structure or with a seasonal one such as a tarp so that rain can not come into contact with the materials.
- Check containers (and any containment sumps) often for leaks and spills. Replace containers that are leaking, corroded, or otherwise deteriorating with containers in good condition. Collect all spilled liquids and properly dispose of them.

Spill Prevention, Control & Cleanup SC-11

- Store, contain and transfer liquid materials in such a manner that if the container is ruptured or the contents spilled, they will not discharge, flow or be washed into the storm drainage system, surface waters, or groundwater.
- Place drip pans or absorbent materials beneath all mounted taps and at all potential drip and spill locations during the filling and unloading of containers. Any collected liquids or soiled absorbent materials should be reused/recycled or properly disposed of.
- For field programs, only transport the minimum amount of material needed for the daily activities and transfer materials between containers at a municipal yard where leaks and spill are easier to control.
- Ifpaved, sweep and clean storage areas monthly, do not use water to hose down the area unless all of the water will be collected and disposed of properly.
- Install a spill control device (such as a tee section) in any catch basins that collect runoff from any storage areas if the materials stored are oil, gas, or other materials that separate from and float on water. This will allow for easier cleanup if a spill occurs.
- If necessary, protect catch basins while conducting field activities so that if a spill occurs, the material will be contained.

Training

- Educate employees about spill prevention, spill response and cleanup on a routine basis.
- Well-trained employees can reduce human errors that lead to accidental releases or spills:

  The employees should have the tools and knowledge to immediately begin cleaning up a spill if one should occur.

  Employees should be familiar with the Spill Prevention Control and Countermeasure Plan if one is available.

- Training of staff from all municipal departments should focus on recognizing and reporting potential or current spills/leaks and who they should contact.
- Employees responsible for aboveground storage tanks and liquid transfers for large bulk containers should be thoroughly familiar with the Spill Prevention Control and Countermeasure Plan and the plan should be readily available.

Spill Response and Prevention

- Identify key spill response personnel and train employees on who they are.
- Store and maintain appropriate spill cleanup materials in a clearly marked location near storage areas; and train employees to ensure familiarity with the site's spill control plan and/or proper spill cleanup procedures.
- Locate spill cleanup materials, such as absorbents, where they will be readily accessible (e.g. near storage and maintenance areas, on field trucks).

SC-11 Spill Prevention, Control & Cleanup

- Follow the Spill Prevention Control and Countermeasure Plan if one is available.
- If a spill occurs, notify the key spill response personnel immediately. Ifthe material is unknown or hazardous, the local fire department may also need to be contacted.
- If safe to do so, attempt to contain the material and block the nearby storm drains so that the area impacted is minimized. If the material is unknown or hazardous wait for properly trained personnel to contain the materials.
- Perform an assessment of the area where the spill occurred and the downstream area that it could impact. Relay this information to the key spill response and clean up personnel.

Spill Cleanup Procedures

- Small non-hazardous spills

  Use a rag, damp cloth or absorbent materials for general clean up of liquids

  Use brooms or shovels for the general clean up of dry materials

  If water is used, it must be collected and properly disposed of. The wash water can not be allowed to enter the storm drain.

  Dispose of any waste materials properly

  Clean or dispose of any equipment used to clean up the spill properly

- Large non-hazardous spills

  Use absorbent materials for general clean up of liquids

  Use brooms, shovels or street sweepers for the general clean up of dry materials

  If water is used, it must be collected and properly disposed of. The wash water can not be allowed to enter the storm drain.

  Dispose of any waste materials properly

  Clean or dispose of any equipment used to clean up the spill properly

- For hazardous or very large spills, a private cleanup company or Hazmat team may need to be contacted to assess the situation and conduct the cleanup and disposal of the materials.
- Chemical cleanups of material can be achieved with the use of absorbents, gels, and foams. Remove the adsorbent materials promptly and dispose of according to regulations.
- Ifthe spilled material is hazardous, then the used cleanup materials are also hazardous and must be sent to a certified laundry (rags) or disposed of as hazardous waste.

Reporting

- Report any spills immediately to the identified key municipal spill response personnel.

Spill Prevention, Control & Cleanup SC-11

- Report spills in accordance with applicable reporting laws. Spills that pose an immediate threat to human health or the environment must be reported immediately to the Office of Emergency Service (OES)

- Spills that pose an immediate threat to human health or the environment may also need to be reported within 24 hours to the Regional Water Quality Control Board.

- Federal regulations require that any oil spill into a water body or onto an adjoining shoreline be reported to the National Response Center (NRC) at 800-424-8802 (24 hour)

- After the spill has been contained and cleaned up, a detailed report about the incident should be generated and kept on file (see the section on Reporting below). The incident may also be used in briefing staff about proper procedures

Other Considerations

- A Spill Prevention Control and Countermeasure Plan (SPCC) is required for facilities that are subject to the oil pollution regulations specified in Part 112 of Title 40 of the Code of Federal Regulations or if they have a storage capacity of 10,000 gallons or more of petroleum. (Health and Safety Code 6.67)

- State regulations also exist for storage of hazardous materials (Health & Safety Code Chapter 6.95), including the preparation of area and business plans for emergency response to the releases or threatened releases.

- Consider requiring smaller secondary containment areas (less than 200 sq. ft.) to be connected to the sanitary sewer, if permitted to do so, prohibiting any hard connections to the storm drain.

Requirements

Costs

- Will vary depending on the size of the facility and the necessary controls.

- Prevention of leaks and spills is inexpensive. Treatment and/or disposal of wastes, contaminated soil and water is very expensive

Maintenance

- This BMP has no major administrative or staffing requirements. However, extra time is needed to properly handle and dispose of spills, which results in increased labor costs

Supplemental Information

Further Detail of the BMP

Reporting

Record keeping and internal reporting represent good operating practices because they can increase the efficiency of the response and containment of a spill. A good record keeping system helps the municipality minimize incident recurrence, correctly respond with appropriate containment and cleanup activities, and comply with legal requirements.

SC-11 Spill Prevention, Control & Cleanup

A record keeping and reporting system should be set up for documenting spills, leaks, and other discharges, including discharges of hazardous substances in reportable quantities. Incident records describe the quality and quantity of non-stormwater discharges to the storm drain.

These records should contain the following information:

- Date and time of the incident
- Weather conditions
- Duration of the spill/leak/discharge
- Cause of the spill/leak/discharge
- Response procedures implemented
- Persons notified
- Environmental problems associated with the spill/leak/discharge

Separate record keeping systems should be established to document housekeeping and preventive maintenance inspections, and training activities. All housekeeping and preventive maintenance inspections should be documented. Inspection documentation should contain the following information:

- The date and time the inspection was performed
- Name of the inspector
- Items inspected
- Problems noted
- Corrective action required
- Date corrective action was taken

Other means to document and record inspection results are field notes, timed and dated photographs, videotapes, and drawings and maps.

Examples

The City of Palo Alto includes spill prevention and control as a major element of its highly effective program for municipal vehicle maintenance shops.

References and Resources

King County Stormwater Pollution Control Manual - http://dnr.metrokc.gov/wlr /dss/spcm.htm

Orange County Stormwater Program
http://www.ocwatersheds.com /stormwater/swp_introduction.a@

Spill Prevention, Control & Cleanup SC-11

San Diego Stormwater Co-permittees Jurisdictional Urban Runoff Management Program (URMP)
http:/ /www.projectcleanwater.org/pdf /Model%20Program%20Municipal%20Facilities.pdf

Dec. 1, 1992

Dust Control

Description

Dust is generated when vegetation is removed and soil is exposed to wind. Light winds can pick up and transport silty soils, fine sands and clays. Course sands can also become erodible when winds are strong. Soil particles and any attached chemicals such as fertilizer and pesticides may settle out in surface waters. Airborne particles can scour leaves and tender shoots of vegetation. Clouds of dust can create a traffic hazard.

Dust control measures should be implemented to prevent the soil and attached pollutants from leaving the site. Acceptable dust control practices include watering, snow fencing (see the Construction Barriers BMP), using mulch (see the Mulching BMP), establishing vegetation, and using spray-on adhesives.

Pollutants Controlled and Impacts

Maintaining an effective dust control program helps keep the lighter soils (silt, clay) on the site and sustains the textural qualities necessary for good vegetative growth. It also prevents sediment and attached chemicals such as fertilizer and pesticides from entering surface waters.

Application

Land Use
Rural, urbanizing and transportation

Soil/Topography/Climate
Special attention needs to be given to dust control during the drought months of the year when the ground is dry. Less severe conditions usually exist during the fall and winter months when the ground is frozen or covered with snow.

When to Apply
Dust control measures should be applied any time dust is generated on a construction site or road.

Where to Apply
Apply this practice on any area subject to wind erosion; especially construction sites and roads.

Relationship With Other BMPs

Dust control is an alternative control measure for temporary and permanent vegetation on areas that are to be surfaced with impervious materials. Mulching is another method of dust control.

Specifications

1. Use seeding, mulching and sodding to cover bare soil and prevent dust. Follow specifications in the Seeding and Mulching or Sodding BMPs.

2. On larger areas, consider planting trees and shrubs as wind breaks. Follow specifications in the Trees, Shrubs and Ground Covers BMP.

3. Watering should be done at a rate which prevents dust but does not cause soil erosion.

4. Any snow fencing that is used should be installed following manufacturer's specifications.

5. Use spray-on adhesives according to Table 1, below. **We recommend using these adhesives only if other methods cannot be used. Many of these adhesives are messy, sticky and form fairly impenetrable surfaces.**

Table 1

Type of emulsion	Water dilution	Nozzle type	Apply Gal/Acre
Anionic asphalt emulsion	7:1	Coarse spray	1,200
Latex emulsion	12.5:1	Fine spray	235
Resin-in-water emulsion	4:1	Fine spray	300

Source: Excerpted from the Maryland Erosion and Sediment Control Planning and Design Manual.

Maintenance

To prevent dust from becoming a public nuisance and causing off-site damages, dust control should be ongoing during earth change activities.

Dec. 1, 1992

Equipment Maintenance and Storage Areas

Description

The maintenance, repair, cleaning, and storage of construction machinery, vehicles, and equipment should be confined to areas specifically designed and designated for that purpose. This practice includes both open and covered equipment maintenance and storage areas, and emphasizes the importance of controlling runoff from both kinds of storage areas. It is applicable to construction sites as well as existing permanent storage facilities.

Other Terms Used to Describe

Service Area
Shop Area

Pollutants Controlled and Impacts

Equipment storage areas which properly control runoff will prevent oil, grease, solvents, hydraulic fluids, sediment, wash water, and other pollutants from being carried off the area and entering surface waters. Proper use of this practice will also prevent pollutants from filtering into the ground.

Application

Land Use
This BMP applies to all land uses.

Soil/Topography/Climate
Where possible, maintenance/storage areas should be placed on flat areas to prevent surface runoff from entering or leaving the area.

When to Apply
This practice should be implemented at all existing equipment maintenance and storage areas, and whenever construction will be ongoing long enough that construction equipment will need to be stored, serviced, maintained, or repaired on a construction site. Appropriate equipment maintenance/storage sites should be identified before any actual construction begins.

Where to Apply
Apply anywhere equipment is maintained and/or stored.

Relationship With Other BMPs

Where possible, the identification of an appropriate maintenance/storage area should be done before any construction is done on the site. Diversions should be considered to keep runoff from entering the storage area. Pesticides stored and used in the area should be handled, stored and disposed of according to specifications in the Pesticide Management BMP. Smaller quantities of hazardous wastes (i.e. quantities of approximately 1 gallon or less) should be disposed of following the specifications in the Household Hazardous Waste Disposal BMP. Larger quantities of hazardous

waste should be disposed of by consulting the MDNR, Waste Management Division at 517-373-2730.

Specifications

Planning Considerations for New Areas:
Determine site selection based on the following considerations.

If equipment is to be maintained and stored in an open area (i.e. **temporary storage**):

-The site should not be within the drip line of trees.

-The site should not be within 100 feet of a watercourse or wetland. Runoff should be diverted away from watercourses and wetlands.

If equipment is to be maintained and stored in a **permanent structure** (i.e. building):

-The building should not be located within 100 feet of a watercourse

-When possible, the building should not be constructed on or within 100 feet of a wetland.

Under no circumstances should buildings or equipment be located in floodplains, stream beds, or the channel of any watercourse.

General Considerations for All Equipment Maintenance/Storage Areas:

1. Runoff from equipment maintenance/storage areas should be directed to stabilized outlets designed to assimilate the volume and type of pollutants discharged to them. See the Stabilized Outlets BMP.

2. Heavy equipment should be well-maintained to prevent leaks.

3. Vehicles and other equipment should *not* be washed at locations where the runoff will flow directly into a watercourse or storm sewer.

4. Store, cover and isolate construction materials, including topsoil and chemicals, to prevent runoff of pollutants and contamination of groundwater, following the design guidance below.

5. A spill response plan should be developed which includes the procedures which will be taken in the case of a spill. This is discussed further in "Proper Storage, Use and Disposal of Chemicals," below.

6. A waste management plan should be developed. Empty canisters, cans or other chemical containers (i.e. from hydraulic fluids, etc.), scrap wood, scrap metal, and all other waste materials are to be disposed of daily or kept in sealed waste containers until they can be disposed of off-site in a landfill. Waste materials are *not* to be buried on-site.

7. Specific areas should also be designated and maintained for employee parking.

Equipment Maintenance and Storage in Structures (buildings):

1. All floor drains which discharge to storm sewers should be sealed/plugged. New floor drains should discharge to a sanitary sewer.

2. All floors should be constructed of cement or other impervious materials to prevent contaminants from leaching into the soils or groundwater.

3. Equipment wash areas should discharge into a sanitary sewer line. Depending on the amount of oil, grease and other pollutants, pre-treatment of wastewater may be needed before it enters the sanitary sewer.

4. Trucks and other equipment with large quantities of mud should be washed outside on designated wash areas, so as not to clog sanitary sewer lines.

Equipment Maintenance and Storage in Maintenance in Open Areas:

1. Ideally, all maintenance should be done on impervious areas surrounded with impervious berms. Where this is not possible, use pads designed to contain the pollutants which may leak or spill during maintenance operations. Impervious pads are particularly important on sandy and other course soils where spilled materials can easily leach into the groundwater.

2. Wash areas should be constructed out of 2-3" stone or other approved material, with a minimum 6-inch base. They should be underlain with geotextile materials, and protected using berms or Diversions to prevent the runoff water from leaving the site. See the Appendices for manufacturers of geotextile materials.

3. Equipment should never be stored within the drip line of trees.

4. Topsoil should be stored following specifications in the Spoil Piles BMP.

5. Follow the guidance below for the "Proper Storage, Use and Disposal of Chemicals."

Proper Storage, Use and Disposal of Chemicals:

1. Follow all federal, state and local laws regarding the storage of hazardous materials. In general:

   -All hazardous chemicals should be stored in sealed containers. Secondary containment should be incorporated into the design of the maintenance/storage facility to contain spills from all hazardous materials.

   -Pesticides should be stored according to the guidelines in the Pesticide Management BMP.

   -Keep labels on all products so that they are readable. Do not use a product without a label.

   -Maintain records of the use and application of all products stored on site.

   -Maintain proper ventilation. Post "no smoking" and other signs to warn of potential dangers. Keep the area locked.

2. Develop a spill response plan. This should include the steps that will be taken to contain and cleanup spills. All persons working with chemicals should be familiar with the spill response plan. For spills of hazardous materials which cannot be contained on-site, or when there is a known or potential impact to surface or ground water or soils, contact the Pollution Emergency Alert System (PEAS) line at 1-800-292-4706.

3. Absorbent materials such as hay bales, cat litter and absorbent pads should be kept on-site to prevent the migration of pollutants which are spilled on imperious areas.

4. Dispose of small quantities of material (i.e. less than 1 gallon) based on the type of pollutant absorbed:

    -Dispose of pesticides following specifications in the Pesticide Management BMP; and

    -Follow specifications in the Household Hazardous Waste Disposal BMP for small quantities of hazardous wastes (1 gallon or less);

    For other hazardous wastes, or wastes in excess of 1 gallon, contact the MDNR, Waste Management Division at 517-373-2843 for additional information.

5. Contact the MDNR, Environmental Response Division at 517-373-4823 for information on the Right-to-Know Law and for information on underground storage tanks.

Maintenance

Outside equipment/maintenance storage areas should be inspected daily to ensure equipment isn't being stored within the drip line of trees and to ensure the vehicles and equipment aren't leaking. Also make sure waste materials are being properly disposed of. Periodic checks of the equipment wash area should also be done to ensure it is not failing. Additional stone may be needed to maintain the wash area.

Ongoing maintenance of structural equipment maintenance/storage areas should include periodic inspections of the structure to check for cracks in the floor, and for other structural flaws. In existing buildings, be sure to inspect the floor drains to make sure they are not discharging to storm drains.

Additional Considerations

Draft revisions to Part 21 Rules of the Water Resources Commission (Act 245) will require construction permittees to provide facilities for containing any accidental losses of oil or other polluting substances, and comply with reporting procedures for on-land facilities under Part 5 rules. Approved equipment maintenance and storage areas must meet these Part 21 Rules.

Dec. 1, 1992

Fertilizer Management

Description

Nitrogen, phosphorus, potassium and other nutrients are necessary to maintain optimum growth and stress tolerance of most vegetation. This BMP addresses the proper selection, use, application, storage, and disposal of fertilizers.

Although most of the information in this BMP applies to trees, shrubs and ground covers, as well as turf, the *application* of fertilizer on trees, shrubs and ground covers should be done following the procedures given in the Trees, Shrubs and Ground Covers BMP. All storage, mixing and disposal of fertilizers should be done in accordance with this fertilizer management practice.

Other Terms Used to Describe

Nutrient Management
Nitrogen/Phosphorus Management

Pollutants Controlled and Impacts

Nutrients applied at appropriate times and rates will minimize the potential for pollution of surface and ground waters. Nutrients are also essential in order for vegetation to stay healthy. Healthy plants require fewer inputs.

Application

Land Use
This practice is applicable to all land uses--wherever fertilizers are used.

Soil/Topography/Climate
Fertilizer programs will vary from site to site, partially due to varying soil characteristics, topography and climate. For example, sandy soils are more prone to nitrogen leaching than finer-textured soils.

When to Apply
A fertilizer program for lawns should begin in the fall (as opposed to spring) to promote deep, healthy root systems and hardy lawns. This, in turn, will help grass compete with unwanted grass species and weeds. Spring applications of fertilizer will help the grass start growing, but may promote more top (leaf) growth than root growth. Shallow root systems are unable to sustain lawns through a drought or harsh winter.

Fertilizers should not be applied to turf when the soil is frozen because turf cannot utilize the nutrients and runoff rates are high. Fertilizers should also not be applied before significant intensive rainfall events.

Where to Apply
Fertilizer management practices should be applied in all areas where vegetation is managed.

Relationship With Other BMPs

A sound fertilizer management program is just one of the elements needed to maintain healthy vegetation. Healthy vegetation also requires proper irrigation management, Pesticide Management, Soil Management, and, in the case of turf grasses, using the proper mowing frequency and height. Many of these principles are mentioned in the Lawn Maintenance BMP, with additional specifications in individual BMPs.

Specifications

General Information:

Plants need a certain amount of nutrients (nitrogen, phosphorus, etc.) to grow and stay healthy. Nutrient deficiency may result in weaker plants, which may make them more susceptible to disease. This, in turn, may increase the amount of pesticides or other inputs needed. Proper fertilization will help plants stay healthy and reduce other inputs.

Excess nutrients which are applied beyond that needed by the plant may get washed off the soil and end up in lakes, streams and wetlands, or leach into ground water. When nutrients such as nitrogen and phosphorus run off into surface waters (i.e. rivers, lakes), they can cause algae blooms and nuisance aquatic plant growth.

Ground water can be impacted by excess nitrogen, which readily converts to nitrates. When nitrate leaches to ground water, it can contaminate drinking water supplies. Phosphorus generally doesn't affect groundwater since it binds readily with the soil.

Application rates for fertilizers should always be based on soil tests. To take soil samples, follow the directions in the Soil Management BMP.

The recommendations below are given to ensure healthy vegetation, while maintaining water quality. It includes the proper application, storage and disposal of fertilizers. **Always follow directions on the label**. If the label is not legible, contact the distributor for proper application and storage information.

General Considerations:

A fertilizer management plan should be developed for each of the vegetative species in the managed area, and for each use of that species. All vegetative species should be chosen following guidance in the Pesticide Management BMP, which includes integrated pest management (IPM) principles. The first step in any IPM program is selecting disease-resistant species. Proper species selection also depends on the use of the vegetation. For example, if the purpose of the vegetation is to give a natural appearance and prevent erosion, then fertilizer needs will be far less than for a turf used for golf course greens.

Fertilization rates will differ depending on the existing nutrient needs of the soil. Collect soil tests to determine existing nutrient needs, following specifications in the Soil Management BMP. Soils should be analyzed for nitrogen, phosphorus, potassium and any micro-nutrients of concern. Soil tests should be conducted regularly, such as every three years on low-maintenance turfs and every year for high-maintained turfs.

Types of Fertilizers:

Many liquid and solid fertilizers are available. The characteristic of common materials used in fertilizers are summarized in Table 1, below. The material used in a fertilizer determines the rate nutrients are released into the soil. For example, *water-soluble* nitrogen such as urea is readily available to turf roots and provides a quick response after application. These materials are the least expensive forms of nitrogen. However, water-soluble N fertilizers have a high potential for chemically burning turf. Again, select the type of fertilizer based on the intended use of that vegetation.

Table 1

Characteristics of Fertilizer Materials for Turf

Material	Type	Nutrient Content %	Soil Reaction	Rate of N Release	Burn Potential
Ammonium sulfate $(NH_4)_2SO_4$	inorganic	21 (N)	strong acidifier	water soluble	moderately high
Ammonium nitrate	inorganic	33.5-34 (N)	acidifier	water soluble	high
Urea $CO(NH_2)_2$	synthetic organic	45-46 (N)	acidifier	water soluble	moderately high
Activated sewer sludge	natural organic	5-6 (N)	no change	slowly soluble	low
Urea-formaldehyde	synthetic organic	38 (N)	no change	slowly soluble	low
IBDU	synthetic organic	31 (N)	no change	slowly soluble	low
Sulfur-coated urea	synthetic organic	31 (N)	acidifier	slow release	low
Triple super-phosphate $Ca(H_2PO_4)_2$	inorganic	45-46 (P_2O_5)	no change	–	low
Muriate of potash KCL	inorganic	60-62 (K_2O)	no change	–	high
Potassium sulfate K_2SO_4	inorganic	50-53 (K_2O)	no change	–	moderate
Ferrous sulfate monohydrate	inorganic	31.5 (Fe)	acidifier	–	high

Adapted from *Landscape Management* by J.R. Feucht and J.D. Butler.

Source: "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators". Michigan State University, Cooperative Extension Service, Bulletin E-2327.

Slow-soluble forms of N include natural and synthetic organic fertilizers. *Slow-release* products are formulated so that elements are released relatively slowly over time. Slow-release products are more expensive than water-soluble fertilizers, but fewer applications at higher rates are possible with less chance of burn.

Complete fertilizer contains nitrogen, phosphorus and potassium. As a rule, turf fertilizers have a

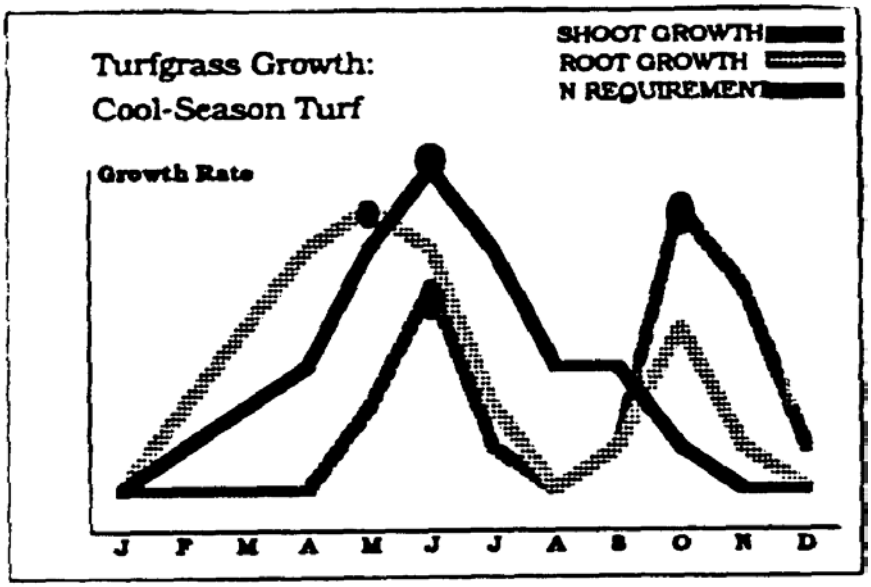
high ratio of nitrogen to phosphorus and potassium. The ratio of these three nutrients ($N:P_2O_5:K_2O$) is called the fertilizer analysis. Common turf fertilizer analyses include 20-10-5, 20-5-10, and 21-3-7. One hundred pounds of 20-10-5 fertilizer contains 20 pounds of nitrogen, 10 pounds of phosphorus and 5 pounds of potassium. The rest is inert material.

Before Applying Fertilizers:

Take soil tests and have them analyzed by Michigan State University or other approved laboratory for nitrogen, phosphorus, potassium, and any other nutrient of concern. Follow procedures in the Soil Management BMP.

Determine Appropriate Application Rates. Fertilizer applications should be based on a number of factors, including previous fertilizations, turf quality, environmental conditions, weather conditions, use of the turf, type of turf, and soil conditions. Be sure to give credit for leaving grass clippings on lawns--this can reduce fertilizer needs by 25-50%. What follows are general considerations for nutrient applications in all areas except gardens, which are discussed in the Lawn Maintenance BMP.

Table 2



Source:"Truth and Consequences: Turfgrass Environmental Management", Michigan State University, 1991.

The appropriate number of fertilizer applications is dependent upon the rate of application, and the growth stage of the plant. As shown in Table 2, turfgrass root and shoot growth occurs primarily in the spring, with another burst in the fall. Where only one application of fertilizer is needed (again, based on the results of soil tests), apply in the fall because strong root systems will make the plants more able to compete against weeds in the spring.

Appropriate Nitrogen Rates:

-may prevent turf susceptibility to moisture stress.

-may prevent foliar burn. Note that when applying fertilizers which can cause foliar burn, the turf should be watered immediately after application.

-should be coordinated with proper irrigation rates to provide the moisture needed by the turf, yet prevent over-watering which could result in leaching.

-is especially important where there are sandy soils and/or a high water table because leaching of nitrates may occur. This may impact drinking water supplies.

i. **Application rates and the number of applications should be based on the results of soil tests**, modified only to meet the use of that turf. Where needed based on soil tests and the intended use, consider split applications.

ii. When turf roots are very short, nitrogen applications should be done at lighter rates and at shorter intervals. An example would be a golf course green.

iii. Application rates and the number of applications may also need to be adjusted, depending on turf conditions and any unique problems which may exist. An example might be significant thinning of turf by disease, which may necessitate increased nitrogen fertilization to regain the desired turf density.

Appropriate Phosphorus Rates:
Phosphorus is necessary to maintain a dense, healthy turf. Phosphorus applied in excess of what the plant needs may enter water bodies if the soil to which it attaches is eroded.

i. **Application rates should be based on the results of soil tests.**

ii. Consider split applications in areas where runoff or soil erosion is likely to occur.

Appropriate Potassium Rates:
Potassium is important for maintaining a healthy, stress-tolerant turf. Although it can be leached readily from sandy soils, potassium and the associated anions in most of the carriers used on turf (i.e. chloride and sulfate) are not considered harmful to ground or surface waters at the rates being utilized for most turfs.

Application rates should be based on the results of soil tests.

Other Nutrients:
While other nutrients may be applied to turfs, the rates and frequencies of use are low. Sulfur is not known to be deficient in Michigan turf, so no sulfur applications are routinely made. Iron is a micronutrient that is commonly deficient in alkaline soils. It will normally produce a temporary "greening" effect on the turf when applied foliarly. Such applications are often made to enhance turf color when additional nitrogen is not needed. However, since the iron deficiency is due to soil alkalinity, long-term treatment requires modifying the soil pH. Other micronutrients, such as

manganese, copper and zinc may be used on turf occasionally, but rates and frequencies of application are very low and these nutrients are tied up quickly by soils.

Equipment Calibration:

Calibrate your equipment as needed to ensure the desired application rate. Follow the calibration procedures in Appendix 4 of the BMPs, entitled "Application Calculations and Calibration." Make sure all components of your equipment are in good working order. Do not use the equipment if you are not familiar with it. Contact the equipment supplier if you have questions.

Mixing the Fertilizer:

Before mixing fertilizers, determine the size of the area which needs fertilizing. Appendix 4 includes methods for measuring the area needing fertilization. After determining the area needing treatment, and using the amount of fertilizer needed based on soil test results, mix the appropriate amount using the "Common Measuring Equivalents for Pesticides and Fertilizers", which is Exhibit 2 of Appendix 4. The equivalents allows you to mix only the amount of fertilizer or pesticide needed for your application.

Pour/mix the fertilizer into the bin/spreader/sprayer over an impervious area such as cement, so that if the fertilizer is spilled it can be easily cleaned up. Never pour fertilizers into bins/spreaders/sprayers on the turf because large concentrations of fertilizer can kill the turf, and potentially impact surface and ground waters. Avoid back-siphoning of liquid fertilizers by keeping the end of the fill hose above the water level, or by installing devices which prevent back-siphoning.

Applying the Fertilizer:

1. Never apply fertilizers to frozen soils, before storms, or under real windy conditions. Except where fertilizers are being applied to surface waters to increase productivity (as is done in walleye pond management, for example), **never apply fertilizers directly in or adjacent to streams, rivers, lakes, or wetlands.**

2. Select the most appropriate method of applying the fertilizer. Follow fertilizer label directions, or discuss potential options with the grain elevator, local fertilizer store, or the local Cooperative Extension Service office. Hand application of fertilizers is not recommended because it is tedious and usually does not result in an even distribution of fertilizer. Improperly applied fertilizers can "burn" and destroy turf.

   For granular forms of fertilizers, the centrifugal (rotary) type of spreaders usually distribute the material more rapidly and with minimal overlapping compared to gravity (drop-type) spreaders. The latter are safer if herbicide-fertilizer mixtures are applied around susceptible shrubs and trees.

3. Make sure the equipment has been calibrated.

4. Adjust the application equipment to fit the application rates determined above.

5. Check equipment occasionally throughout the application to ensure it is delivering the appropriate amount of fertilizer to the turf.

6. Keep equipment well-maintained to ensure it functions as designed.

7. When establishing new grass by Seeding, mix the fertilizer into the top 3 inches of soil. This will encourage better rooting and reduce the amount of fertilizer nutrients which could be lost by erosion of topsoil from the site before the turf becomes well established.

After the Initial Fertilization:

A healthy turf requires a deep rooting system. A deep rooting system can remove nitrates further down in the soil, thereby reducing leaching potential. Several management variables can influence rooting of the turf, including:

1. Irrigation. A light irrigation immediately after fertilization can be helpful in moving fertilizer down into the thatch and the surface layer of soil. Do not apply water in excess of what can be taken up by the soil. Remember, most established turfs require about one inch of water per week. See the Lawn Maintenance BMP.

2. Mowing height. Mow according to specifications in the Lawn Maintenance BMP.

3. Diseases, insects and other pests. These should be controlled following specifications in the Pesticide Management BMP.

Storage and Disposal of Fertilizers:

1. **Always follow the storage and disposal directions on the label.**

2. Most fertilizers should be kept in a cool, dry place. Be sure to store granular fertilizers separate from any pesticide that can cause contamination of the fertilizer.

3. Liquid fertilizers, like pesticides, should be stored inside another container (i.e. **secondary containment**) in case the chemicals leak from the original containers.

4. For additional guidance, or where labels do not indicate proper storage and disposal, follow the specifications in the Pesticide Management BMP.

Spill Cleanup:

A **spill response plan** should be developed for all sites which contain fertilizers. The spill response plan should include the steps which will be taken to contain and cleanup any spilled fertilizers. In general:

Small quantities of spilled liquid fertilizers should be cleaned up by applying kitty litter or sawdust, then sweeping it, wrapping it in newspaper and disposing in the trash. Small quantities of powdered fertilizers should be swept and disposed of in the trash. Never wash fertilizer spills down floor drains or driveways--the concentrated runoff will likely either go to storm sewers (and consequently directly into the local river or stream) or could leach into the ground water.

For large spills, contact the Pollution Emergency Alert System (PEAS) system at 1-800-292-4706. Where possible, use any spilled fertilizer according to appropriate rates and methods.

Record Keeping:
It is advisable to keep records of the amount and type of fertilizer used (including percentages of nitrogen, phosphorus and other nutrients), type of equipment used, date of the last calibration, weather conditions, type of soil, specific area where applied, and the name of the applicator. This will help the manager in adjusting the application rates. The Pesticide Use Record sheet in the Pesticide Management BMP can be modified for fertilizers.

Maintenance

Proper fertilizer management is an ongoing practice, starting at the onset of the first fertilization, and ending when fertilizers are no long used or stored on the site. Ongoing maintenance includes a minimum annual check to ensure:

1. Applicators are applying fertilizers based on annual soil tests.

2. Equipment is calibrated for optimal use and is well-maintained.

3. The continued proper storage and handling of fertilizers. An annual check of all fertilizer labels should be made. Illegible labels should be replaced, where possible, or the fertilizers disposed of according to the disposal procedures above. There should be secondary containment for all fertilizers.

4. Information is being recorded on the application rates, etc., as listed above.

Dec. 1, 1992

Lawn Maintenance

Description

Lawn maintenance includes mowing, irrigating, pesticide and fertilizer management, soil management, and the disposal of organic debris such as lawn clippings, leaves and pruned branches and twigs. This BMP also briefly discusses home gardens. For the purposes of this BMP, "lawn" and "turf" are used interchangeably.

Other Terms Used to Describe

Urban Lawn Care
Rural Lawn Care

Pollutants Controlled and Impacts

Proper maintenance results in healthy lawns. Healthy lawns will:

-help keep soil on the site, thereby preventing erosion
-take up nutrients
-reduce the volume and rate of runoff and increase groundwater recharge
-decrease the need for pesticides

Application

Land Use
This practice is applicable to all land uses.

Soil/Topography/Climate
Lawn maintenance practices will differ, depending upon the soils, topography and climates.

When to Apply
Apply this BMP throughout the year.

Where to Apply
Apply on all lawns and gardens.

Relationship With Other BMPs

The Pesticide Management BMP walks users through the proper selection of turf species (the first and most important part of an integrated pest management program), as well as the proper use, storage and disposal of pesticides. Establishment of turf by seeding is discussed in the Seeding and Mulching BMPs. Establishment of turf by sodding is discussed in the Sodding BMP. This Lawn Maintenance BMP assumes turf is already in place.

Specifications

The following specifications are provided **to maintain healthy turf areas.** Much of the information, including both tables, is extracted from "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators", Michigan State University, Cooperative Extension Service, Bulletin E-2327.

Mowing:

Different types of grasses have different mowing requirements, based on the turf species and the intended use of that species. When you lower the mowing height, you reduce the root system. Root reduction decreases the amount of water available to support the turf stand. In addition, since close mowing weakens cool-season grasses, it invites weed invasion. Crabgrass, in particular can be reduced by the shading effects of the taller, denser growth of plants.

The chart below shows the proper cutting heights for typical cool-season grasses. Use this chart as a general guide. Where the mowing height is not dictated by the turf's use, mow at the "preferred height" listed in the chart.

Table 1

Cutting Heights for Cool-Season Grasses

Grass Type	Low Cut (inches)	Preferred Cut (inches)	High Cut (inches)
Kentucky bluegrass common types	1¼	2 to 3	4
Kentucky bluegrass improved types	¾	2	3
Perennial ryegrass common types	1½	2 to 3	4
Perennial ryegrass turf types	¾	1½ to 2	3
Fine fescue	1	1½ to 3	4
Tall fescue pasture types	2	2½ to 3½	4
Tall fescue turf types	1¼	1½ to 3	3
Creeping bentgrass	¼	½ to ¾	1
Colonial bentgrass	½	¾ to 1	2
Annual bluegrass	¼	½ to 1	2
Smooth bromegrass	2	3 to 4	5

From *Landscape Management* by J.R. Feucht and J.D. Butler.

During hot, dry periods turf stands need more water. Where uses don't limit mowing height, and to conserve water in grass plants experiencing drought, consider mowing less frequently and at a higher height of cut.

Grass clippings should be left on the grass because they offer a "free" source of nitrogen, and will decompose without affecting the quality of the grass. When clippings are regularly removed, fertilization must be increased by 25-50%. Grass clippings do *not* contribute to thatch. Mulching mowers can be used to cut the grass into tiny pieces which degrade faster.

Watering (Irrigation):

Too much water is as damaging to turf as drought. When turf is saturated, transpiration is slowed and infectious diseases encouraged.

Proper irrigation depends on weather conditions, soil type, grass variety preference, and turf use and maintenance practices. Generally, most turfs require about 1 inch of water per week. For site-specific water requirements, it is important to use a rain gauge to measure rainfall and determine the amount of irrigated water needed. Computer models are also available which can help determine watering requirements.

An irrigation system is complex and should be designed only by professionals experienced in their design. Each irrigation system should be custom designed to fit the site conditions--soils, availability of water, vegetation needing irrigating, etc.

For many purposes, the crude, but effective "footsteps" method can be used. With this method, you need to irrigate when turf begins to wilt and does not spring back when crushed (footsteps linger in turf). Other watering guidelines are discussed below.

In general:

1. The total precipitation and irrigated water should amount to about an inch of water per week. To determine how much water small sprinklers deliver, place a coffee can in a straight line from your sprinkler to the edge of the watering area. Turn the water on for 15 minutes and measure the average depth of the water that collects in the can. Multiply this number by four to determine the amount of water that would cover your lawn in one hour. Then calculate the amount of time (in hours) that it would take to apply an inch of water.

   With sprinkler systems, the uniformity of water application depends on the spacing, choice of sprinkler, water pressure, and wind velocity. System efficiency and effectiveness, in turn, is dependent on uniform application of water.

2. Do not apply water faster than it can soak into the soil. Any water running off the lawn indicates that the application rate is too high.

3. Many sources recommend applying supplemental water once a week during the early morning hours. However, during hot, droughty periods, turf may benefit from daily, light, afternoon waterings. Water during the heat of the day cools grass plants and replaces evaporated water. In addition, research conducted at Michigan State University found that injury due to patch diseases, including necrotic ring spot, was reduced on susceptible turf that received light, frequent waterings during the summer.

4. When a groundwater well is used, the well should be sited and constructed to avoid potential contamination of the groundwater supply. Locate the well on high ground to exclude the entrance of surface and near-surface water that may contain potential sources of contamination; such as drainage fields, and fertilizer and chemical storage and preparation areas. Adequate ground protection should include extending the well casing above grade, using a sanitary well seal or pitless adaptor at the well head, and sealing or grouting between the well casing and borehole. All wells must comply with state water laws and regulations.

   Any discharge pipe from the well or to the system must be protected against backflow in the well by installing backflow prevention devices.

5. By law, all abandoned wells must be sealed. Contact the local health department for assistance in sealing abandoned wells.

Dethatching:

A layer of thatch exists in all turf between the green vegetation and the soil surface. Thatch is composed of tightly intermingled living and dead stems, leaves and roots. A small amount of thatch in turf is beneficial in that it reduces soil compaction, moderates soil temperature, and limits evaporation of soil water.

Turf-inhabiting organisms such as earthworms break down thatch. In areas which are highly managed, excess fertilizer and routine pesticide applications significantly reduce these organisms. To keep beneficial organisms in turf, apply fertilizers and pesticides according to BMP specifications.

Because production of thatch is increased and break-down decreased, excessive thatch can be a problem of intensively-managed turf. Too much thatch restricts the movement of water, air, fertilizers and pesticides into the soil, encourages disease and insect pests, and reduces cold and heat tolerance. To determine if a stand has excessive thatch, cut a pie-shaped wedge out of the turf and measure the thickness of the thatch layer. If it is greater than one-half inch thick, take steps to reduce thatch.

To reduce thatch:

Practices that relieve soil compaction also help break down thatch. Vigorous hand-raking will remove thatch on small turf areas. Machines equipped with vertical knives or tines can remove thatch on larger areas. Dethatching machines cut and extract organic debris from turf. Because dethatching thins turf stands, thatch removal should be done during cool, moist periods when turf can recover quickly.

Organic Debris Disposal:

The following is summarized from the Organic Debris Disposal BMP. Refer to that BMP for the disposal of all leaves, grass and pruned branches:

1. Leave grass clippings on the grass.

2. Where it is necessary to remove grass clippings or leaves, dispose of them by composting. Information on how to construct and maintain a composting pile is discussed in the Organic Debris Disposal BMP.

3. Pruned branches should be disposed of either by chipping or by composting. Wood chips can be used as part of the landscaping.

4. Do *not* dispose of organic debris by dumping it in or near water bodies. Do not dump or sweep leaves, grass (or anything else) into sewers--storm sewers discharge into waterbodies. Do not put debris in the floodplains of rivers or streams. Follow all other Organic Debris Disposal specifications.

Fertilizers:

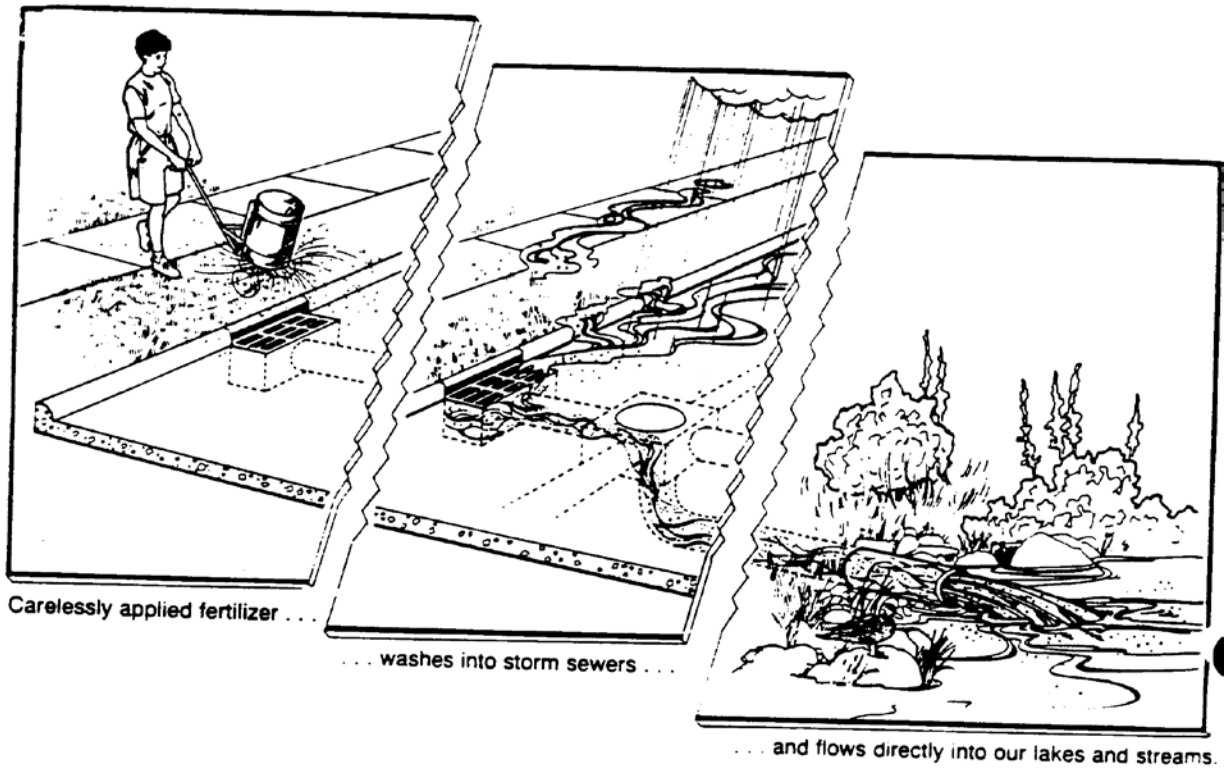
Plants require a certain amount of nutrients (nitrogen, phosphorus, etc.) to grow, thrive and stay green. Nutrients which are applied beyond that needed by the plant can be either washed off the soil and into lakes, streams and wetlands, or leach into groundwater. Nutrients such as nitrogen and phosphorus which enter surface waters can result in algae blooms and nuisance aquatic plant growth.

Groundwater can also be impacted by nutrients. Nitrogen readily converts to nitrate which, when leached to groundwater, can contaminate drinking water supplies. Coarse soils such as sands and loamy sands are more susceptible to leaching than fine-textured soils such as silts or clays. Phosphorus generally does not leach into groundwater because it binds readily with soil.

Complete fertilizers contain nitrogen, phosphorus, and potassium. The ratio of the three nutrients is called the fertilizer analysis. Common turf fertilizer analyses include 20-10-5, 20-5-10, and 21-3-7. A 100 pound bag of complete fertilizer with an analysis of 20-10-5 contains 20 pounds nitrogen, 10 pounds phosphorus and 5 pounds potassium.

Slow-release fertilizers are formulated so that elements are released relatively slowly over time. Fertilizers are also available that do not contain one of the three common nutrients. For example, in areas where soil tests indicate phosphorus levels are adequate for turf growth, you can use fertilizers which contain no phosphorus.

A fertilizer program for lawns should begin in the fall (as opposed to the spring) to promote deep, healthy root systems and hardy lawns. This, in turn, will help grass compete with unwanted grass species and weeds in the spring. Spring applications of fertilizer will help the grass start growing, but may promote more top (leaf) growth than root growth. Shallow root systems are unable to sustain lawns through a drought or a harsh winter.



Source:University of Wisconsin - Extension bulletin: Lawn and Garden Fertilizer.

Application rates for fertilizers should always be based on soil tests. To take soil samples, follow directions in the Soil Management BMP. Where soil samples cannot be taken, follow the "Nitrogen guidelines" in the attached exhibit.

Fertilizers should *not* be applied to turf when the soil is frozen because turf cannot utilize the nutrients, and runoff rates are high. Fertilizers should *not* be applied before significant intensive rainfall events.

Always follow all specifications in the Fertilizer Management BMP for the proper handling, storage, use and application of fertilizers. Calibration procedures are also included in that BMP.

Pesticides:

Pesticides are a family of chemicals which kill insects (insecticides), weeds (herbicides), fungus (fungicides) and rodents (rodenticide). Over-application of pesticides can results in fish kills in lakes and streams, contaminated groundwater, and damaged turf.

When most people identify a weed or insect problem, the most common response is to buy pesticides to eliminate the problem. However, in some situations, hand removing weeds and large insects will be as effective as spot spraying them. It is also possible to interfere with the pests' habitat by altering the landscaping in a way which will not attract the pest. Using biological controls, such as the pests' predators, should also be considered. Keep in mind that not all pests are "bad". Many insects, for example, are natural predators of more harmful insects.

The Pesticide Management BMP discusses integrated pest management techniques, and the proper handling, application, storage and disposal of pesticides. Always follow the specifications in the Pesticide Management BMP whenever a pest is encountered.

The local Cooperative Extension Service (CES) office or a reputable private consultant can also be contacted for information on the best way to get rid of your problem pest. These professionals may ask you to bring in sample weeds, leaves or small branches to help identify the specific pest. CES staff and reputable consultants will then suggest ways to eliminate the problem, following the principles in the Pesticide Management BMP.

Gardens and Other Bare Soils:

Ideally, gardens and other bare soils in and around lawns should be covered with a light layer of organic material (such as grass clippings or leaves) to keep soil on-site. Organic material will reduce the impact of raindrops and allow rain to soak into the ground. Sweep any soil off paved areas (i.e. sidewalks and driveways) to prevent the soil from entering the storm sewer system.

For Unhealthy Turf:

The turf manager must first determine the reason for the unhealthy turf, then take steps to address the problem. The Pesticide Management BMP contains a section on monitoring techniques for turf. It may be necessary to take soil samples, following specifications in the Soil Management BMP to help determine the problem. Make soil amendments, including liming and sulfur additions for pH, and coring for compaction problems following BMP specifications. If soil tests indicate nutrients are lacking, add fertilizers following the Fertilizer Management BMP. If pests are the problem, determine the threshold of the pest, then use the Pesticide Management BMP to control or reduce the pest population. Sometimes unhealthy turf may benefit simply from adjusting irrigation schedules and/or raising mowing heights.

Shade may also be a problem for turf. The Pesticide Management BMP contains turf species which do better in shade than others. If trees which provide shade are hindering the growth of the turf, it may be beneficial to prune lower branches and thin out the crowns of shade-producing trees and shrubs. This increases the amount of light and air movement to the turf. It may also be necessary to aerate or adjust the pH of soils underneath trees, especially in areas where decomposing leaves may turn the soil acid. If all efforts to improve the turf fail, you may want to consider using mulch or shade-tolerant ground covers such as periwinkle, pachysandra, purple winter creeper, and English ivy in the place of turf.

To **irrigate** diseased turf: Managers of diseased turf should replace only the water lost in evapotranspiration (the amount of water that evaporates from turf stands plus the amount of water used in transpiration). Do not saturate the thatch. During hot, dry periods, apply daily a small amount of water (one-two tenths inch) during the heat of the day. Since this practice will not deliver a full inch of water per week, regularly check the moisture of deeper soil and apply additional water when necessary.

Exhibits

Exhibit 1: Nitrogen for New Lawns and Vegetable Gardens: Modified from Protecting Water Quality in Urban Areas, State of Minnesota. Table: Modified from University of Wisconsin-Extension.

Exhibit 1

Nitrogen Guidelines if Soil Tests Are Not Possible

New Lawns:
Apply 0.5 pounds nitrogen per 1,000 square feet before planting. Incorporate the nitrogen 0.5 to 1 inch into the soil, and mulch on top. (See the Mulching BMP).

Existing Lawns:
Several bulletins for lawn fertilizer applications recommend applying fertilizer two-four times a year, with a maximum of 1 pound N per 1,000 square feet. To save money and prevent excess nutrients from entering surface waters, we recommend starting with an application of 0.5 - 1.0 pounds (8 - 16 ounces) nitrogen per 1,000 square feet two times a year, once in May and once in October. Grass clippings left on your lawn is a source of nitrogen for your lawn and, if evenly distributed, can be equal to one fertilizer application per year.

If your lawn is not staying healthy with these rates, then use the chart below to increase your fertilizer use. Never apply more than 1.0 pound per 1,000 square feet in any one application. (Example: 20-5-10 is 20% nitrogen, so 5 lbs. of 20-5-10 is applied per 1,000 square feet in order to apply 1 lb. of actual nitrogen).

Nitrogen Application Guidelines for 4 Times/ Year Application
Pounds of Nitrogen per 1,000 square feet

Time of Application	Grass Clippings Removed	Grass Clippings Not Removed
October 1	1.50	1.50
Late May	1.5	1.00
Late June	0.75	0.50
Late August	0.75	0.50

Source: Modified from University of Wisconsin-Extension

Vegetable and Flower Gardens:
Apply 0.2 pounds (3.2 ounces) nitrogen per 100 square feet. An additional 0.18 pound (2.9 ounces) nitrogen per 100 square feet may be needed for corn, tomatoes and pole crops (beans).

To avoid nitrogen loss **on sandy soils** (and to protect groundwater supplies from nitrate contamination) apply nitrogen at one-half the rate but twice as often. Another option is to use slow-release nitrogen or natural organic nitrogen sources.

Source: "Protecting Water Quality in Urban Areas," State of Minnesota.

Dec. 1, 1992

Organic Debris Disposal

Description

For the purposes of this BMP, organic debris includes grass, leaves, pruned branches and any other vegetative material. This BMP discusses water quality concerns surrounding organic debris disposal methods.

Proper management of organic debris will likely become crucial as laws limiting the disposal of such waste in landfalls go into effect. As of March 27, 1993, yard waste collected or generated in Michigan on public property is banned from landfills and incinerators.

Other Terms Used to Describe

Composting
Yard Waste Management

Pollutants Controlled and Impacts

One significant impact of proper organic debris disposal is the reduction of organic debris in landfills. Since organic debris may contain pesticides and/or fertilizers, this may help reduce the amount of leachate that can impact groundwater.

Additional benefits include:

-compost and mulch contribute nutrients back into the soil. This reduces the amount of fertilizer needed.

-keeping compost piles and other organic debris out of surface waters and away from floodplains will help prevent the depletion of oxygen in surface waters. During decomposition, biological organisms deplete dissolved oxygen supplies in water.

-leaf composting prevents drains and sewers from clogging and reduces leaf burning by residents.

-increased organic material in soil results in improved water and nutrient holding capacity of the soil, better drainage, resistance to insects and diseases, easier cultivation, and better aeration.

Land Use

Although this BMP applies to all land uses, it is particularly important in urban and urbanizing areas where available land is limited. This practice is also important on golf courses and other large recreational areas.

Soil/Topography/Climate
Soils, topography and climate will all affect the types of organic debris disposal options available. These are discussed in more detail in the "Specifications" section, below.

When to Apply
For newly developed areas, an organic debris management plan should be incorporated into the overall site plan. All areas which currently require the disposal of organic debris should evaluate ongoing disposal practices and modify them based on the contents of this BMP.

Where to Apply
Apply in urban and urbanizing backyards, on golf courses, recreation areas and any other place where organic debris needs to be disposed of.

Relationships With Other BMPs

The Lawn Maintenance BMP includes information on the proper mowing heights of the most common turfgrasses, and the basics of irrigating grass. It also briefly discusses concepts derived from the Pesticide Management and Fertilizer Management BMPs, and refers to this BMP for organic debris disposal specifications.

The end product of organic debris disposal may be of use in Soil Management.

Diversions may be needed to prevent excess stormwater from entering a composting area.

Specifications

Grass Clippings:
The Michigan State University publication "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators" (Extension Bulletin, E-2627) indicates that each year, degrading clippings provide 4 pounds of nitrogen, 1 pound of phosphorus and 2 pounds of potassium per 1,000 square feet. When clippings are regularly removed, fertilization must be increased by 25-50%. Grass clippings in plastic bags increase the cost of commercial composting efforts.

Clippings are routinely removed from high-maintenance areas to improve appearance and texture. Managers also routinely remove clippings with the belief that doing so prevents excessive thatch build-up. **Grass clippings do not cause thatch.** Wherever possible, leave grass clippings on lawns.

Mulching mowers can be used to chop grass clippings into smaller pieces. This will increase the rate in which the clippings are broken down. Use mulching mowers on lawns which are not overly wet and where the grass height has not been left too long between cuttings. The height of the grass should be somewhat higher than typical settings for bagging mowers: the lawn is best cut when the grass is one-third higher than the height of the blade. For example, if the grass if left at two inches following mowing, the grass would be cut when it reaches three inches.

Although lawns cut by mulching mowers must be cut more frequently (every 5-6 days as opposed to once per week), the time actually spent in the yard is less because there is no need to continually stop and empty the grass catcher. In addition, since grass clippings return nutrients to the soil, fewer fertilizer applications will be needed.

The only times clippings *should* be removed is when doing so will limit the inoculum of some diseases.

When clippings are removed, use proper composting procedures. Some of the basics of composting are discussed below.

Leaves:
Like grass, leaves can also be mulched. Mulched leaves left on the ground over the winter will not harm grass, because grass goes dormant in the Michigan climate. Winter puts leaves through a "freeze-thaw" cycle that helps soften them for decomposition. Winter snow and spring rains provide needed moisture for the subsequent breakdown.

Leaves can be gathered and placed in wooded areas for mulching, as long as the wooded area is not a forested wetland, surface water or in a floodplain. Spread the leaves evenly so that they can decompose properly. To aid decomposition, moisten each layer lightly. If possible, spread leaves over the garden, in flower beds and wherever there is open soil.

Leaf mulching can be assisted by chopping, shredding, or mowing the leaves before using them as mulch. Make sure the machine selected for this is rated to handle leaves.

If it is not practical to mulch leaves, follow proper composting procedures, some of which are summarized below.

Tree Branches, Limbs, etc.
Ideally, tree branches should be chipped and the chipped material used in landscaping. The use of wood chips as mulch is discussed in the Mulching BMP.

Inclusion of brush and tree trimmings in a composting program will require a chipper or other device such as a tub grinder to reduce particle size and volume. Co-mingling brush with leaves and grass clippings is not advised prior to chipping, because leaves and grass clog chippers and brush will clog shredders and screens. Because brush breaks down more slowly than leaves and grass, chipped brush should not exceed 10% of the volume of materials being composted. Some people add wood chips to compost to increase aeration of the pile.

Composting:
Composting is the biological decomposition of organic matter. The micro-organisms which break down organic matter need food, air and water. Food is the organic waste. Air is provided by mixing and aerating. Water comes from rainfall and the garden hose. With the proper balance of food, air and water, coupled with sufficient volume to hold heat, micro-organisms will thrive and generate heat to initiate and sustain the composting reaction. The finished product--called compost or humus--can be a valuable mulch or soil conditioner if proper care is taken to avoid contaminants and if aerobic conditions are maintained during composting. See "Land Application," below.

The following is provided as a summary of the water quality concerns surrounding composting operations. Most of the information was extracted from two publications, both of which are available from the Michigan Department of Natural Resources, Waste Management Division. These publications are: "Mulching and Backyard Composting Guidebook," and "Yard Waste Composting Guidebook for Michigan Communities."

The Type of Composting System:
The type of composting system required will vary depending on the amount of material expected. For backyard operations, small bins or a series of bins will work. For larger operations, organic debris should be put into several piles.

Land Application of Compost:
Compost is considered a soil amendment, not a fertilizer. Compost can be added into the soil to provide more organic matter, but only after the compost is cured. A cured compost is free from objectionable odors, has little oxygen demand, is dark and crumbles in the hand. Compost can also be spread around shrubs, trees or in the garden in 1-3 inch layers as concentrated **mulch**.

Direct land application of organic matter should not exceed 40 tons per acre, which would be approximately 400 cubic yards of yard waste at a density of 200 pounds per cubic yard spread to a 3-inch depth. Debris can be applied via a manure spreader or other methods, and can be incorporated into the soil 4-12 inches using a chisel plow or rototiller. Shredding leaves during collection makes soil incorporation easier and spreading rates more uniform. One of the best times to rototill compost is before seeding or sodding a new lawn.

Composting in Windrows (Rows of Piles):
As a rule of thumb, 3,500 to 5,000 lightly compacted cubic yards of incoming leaves requires about one acre of land. For bigger quantities of waste, or where large amounts of land are not available for direct land application, push thick layers of leaves into windrows. Windrows can be anywhere from 3-10 feet high and up to 18 feet wide. Leave space between windrows to allow air to circulate amongst the piles, and to allow access by equipment. Water lightly between layers. Mix and reform the windrow one or more times per year.

Decomposition time of large piles which sit on the ground and are mixed only once per year will not likely result in compost for several years. To increase decomposition time, more frequent mixing should be done, and watering should be done to prevent the piles from getting too dry. By increasing the rate of decomposition, yard waste can be stabilized in as little as 3-6 months. Follow all mixing, watering and aerating procedures in the guidebooks listed above.

Location of Composting Piles:
Soil type will help dictate the proper location of the bins or windrows. Natural soils should have a high enough percolation rate to move water away quickly so that standing ponds of water don't form. In bigger operations, the need for the soil to provide sufficient stability for heavy equipment must be balanced by the ability of the surface to drain off excessive rainwater.
To lessen the chances of ponding water, do not locate organic debris piles in areas with high water tables. Also avoid steep slopes. Soil surveys providing information on soil types, percolation rates, and depth to ground water are available for most counties in the local Soil Conservation District offices.

Never locate composting piles in wetlands or other surface waters, or in floodplains.

To reduce potential odor problems, the Department recommends a minimum 500-foot buffer zone between large, active compost operations and residences, with a 50-foot setback from compost windrow edges. Curing piles can be placed so as to create a berm around the perimeter of the site to serve as a visual and sound barrier.

The ideal composting site for most homes is a clear area, away from trees and landscaping. An area somewhere between 6' x 6' and 12' x 9' will suffice. Avoid tight and crammed corner spots. Provide plenty of room to access the working area with a pitchfork from all directions.

The Processes Involved in Composting:
It is beyond the scope of this BMP to discuss all the principles of composting. Composting requires proper aeration, watering and mixing in order to result in a useable end-product. Refer to the guidebooks listed at the beginning of this section for additional information. Those guidebooks also discuss various types of machinery that can be used, frequency of mixing, various types of bins, and the biological processes involved in composting. The purpose of this BMP was to encourage users to incorporate organic debris disposal in their overall site management scheme, and to locate their mulching and composting operations in a manner which will not impact surface waters.

Exhibits

Exhibit 1: "Compost Bin Manufacturers." Mulching and Backyard Composting Guidebook. Michigan Department of Natural Resources, Waste Management Division.

Exhibit 1

Compost Bin Manufacturers

This partial list was derived through a review of resource recovery magazines, lawn and garden catalogs, vendors at the 1990 National Hardware Association Annual Hardware Show, and lawn and garden product distributors. Some of these firms may not sell directly to consumers. No recommendation is made for any model, style, or manufacturer. Check with your local hardware, department store, or lawn and garden retailer for availability in your area. Many gardening and specialty magazines and catalogs advertise compost bins, aerators, mixers, and inoculants that can be purchased through the mail.

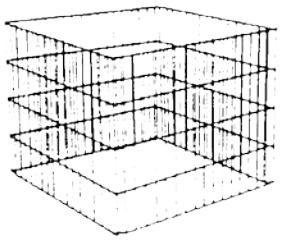
Wire Bins

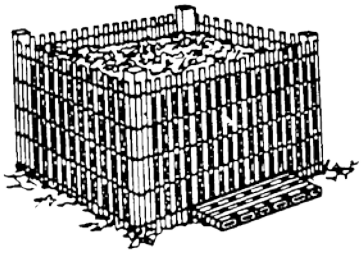
Keystone Steel and Wire
7000 SW Adams St.
Peoria Illinois 61641

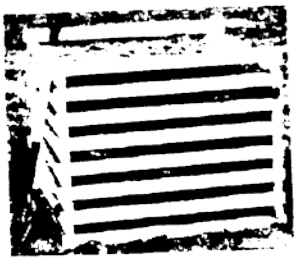
Spread All Manufacturing
2237 Marshaltown Blvd.
Marshaltown, IA 50158
800-383-5601

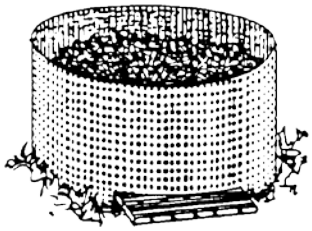
Vision Sales Inc.
Bartlett, Il. 60103
708-837-2967

Southwestern Products, Inc.
PO Box 421
Joplin, MO 64802
800-624-3800









Cedar Bins

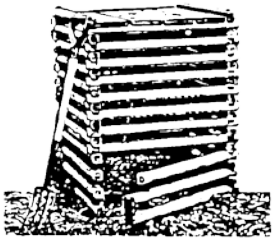
Evergreen Bins
PO Box 70307
Seattle, WA 98107
206-783-7095

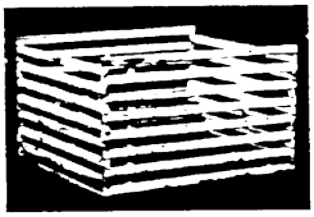
The Natursoil Company
1015 W. St. Germain, #400
St. Cloud, MN 56301
612-253-6153

R.C. Sales
Box 427
Shaftsbury, VT 05262
802-442-2071

BioBin
8407 Lightmoor Court
Bainbridge Island, WA 98110
206-842-6641

Zema Corporation
PO Box 12803
Research Triangle Park, NC 27709
800-334-5530

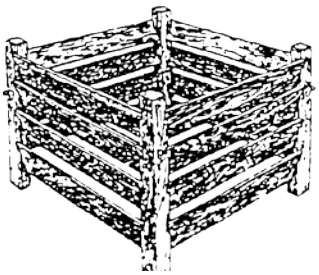




Treated Wood Bins

K-D Wood Products
PO Box 645
Bingham, ME 04920
207-672-4333

Al-ko Kober
25784 Borg Road
Elkhart, IN 46514
219-264-0631



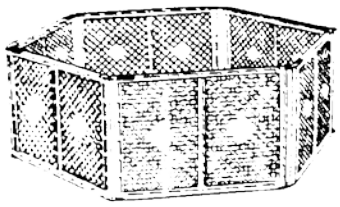
(Continued)

Exhibit 1 (Con't)

Compost Tumblers

Plant Right
7201 Rawson Road
Victor, NY 14564
800-752-6802

Green Magic Tumbler
Gardener's Supply
128 Intervale Road
Burlington, VT 05401
800-548-4784

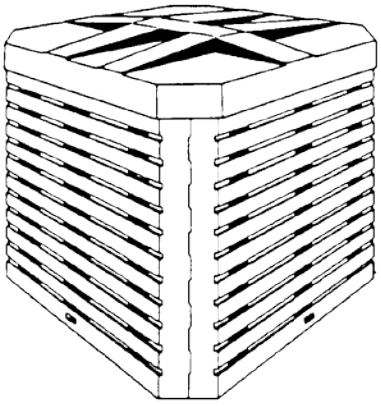


Kemp Compos-Tumbler
160 Koser Road
Lititz, PA 17543

Plastic Bins

North States Industries
1200 Mendelssohn Ave. Suite 210
Minneapolis, MN 55427
612-541-9101

Ringer
9959 Valley View Road
Eden Prairie, MN 55344
612-941-4180



Brave Industries, Inc.
115 E. Front Street
Annawan, IL 61234
800-627-1280

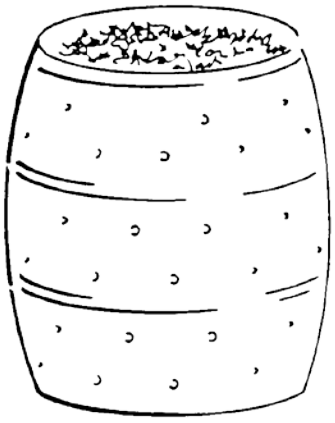
Plastigone Technologies
10700 N. Kendall Drive
Miami, FL 33176
305-274-8497

Kompost Industries Inc.
1640 Superior Avenue
Costa Mesa, CA 92627
714-548-8531

Bio Industries, Inc.
450 S. Lombard Rd.
Addison, IL 60101
708-953-9040

Compost Systems
16 Hillview
Barrington, IL 60010
800-848-3829

Barclay Recycling, Inc.
75 Ingraham Rd.
Toronto, Ontario M6M 2M2
416-240-8227

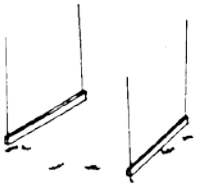


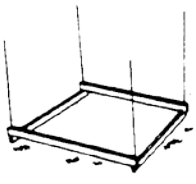
Shape Plastics
PO Box 1037
Crystal Lake, IL 60012
815-455-6310

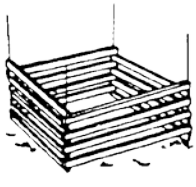
Solar Cone, Inc.
Box 67
Seward, IL 61077
815-247-8454

A Plastic 55 gallon drum can be turned into an effective compost bin in a few simple steps. Merely cut off the top and bottom of the barrel with a sabre saw and cut a series of 2" to 3" holes in the sides for aeration.

A lid can be formed by cutting off the top of the barrel 6" to 10" down along the side. The barrel is then inverted and the lid placed over what was the bottom of the drum. For more information on barrel and other composters, contact Wayne Koser through the Resource Recovery Section of the Waste Management Division at 517-373-4741.







Source: Mulching and Back Yard Composting Guidebook, Michigan Department of Natural Resources, Waste Management Division.

Dec. 1, 1992

Pesticide Management for Turfgrass and Ornamentals

Description

Pesticides are a family of chemicals used to manage pests. Common pesticides include herbicides, insecticides, and fungicides. This BMP offers guidance in the selection, use, storage and disposal of pesticides, with an emphasis on using integrated pest management principles. Much of the information included in this BMP is extracted from "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators", Michigan State University, Cooperative Extension Service, Bulletin E-2627.

Integrated pesticide management (IPM) is the use of all available strategies to manage pests so that an acceptable yield and quality can be achieved economically with the least disruption to the environment. The goal of IPM is to reduce and maintain pest populations at levels where aesthetic and economic losses are tolerable. The strategies used in IPM incorporate a wide range of pest controls, such as using resistant turf varieties, cultural controls, biological controls, mechanical controls, and the use of pesticides. IPM should not be considered "anti-pesticide." Pesticides are one of several management components within an IPM system. Knowledge of the pest and cultural requirements of the vegetation are keys to a successful IPM program.

This BMP addresses pesticide use in upland areas. It does not address pesticide use in aquatic resources, such as herbicides used to control nuisance aquatic weeds. Aquatic herbicides should be applied according to Act 368 of 1968 (Section 333.12561 - 333.12563, Public Health Code) and the rules promulgated thereunder. Permits for aquatic herbicide applications are not needed if the waterbody is a pond and is less than 10 acres **and** has one owner and no outlet. Contact the MDNR, Land and Water Management Division at (517)-373-1170 for information on aquatic herbicide use. The information contained in this BMP on pesticide storage, handling, transporting and record keeping are pertinent to aquatic pesticides.

Other Terms Used to Describe

Pest Management
Integrated Pest Management (IPM)
Integrated Turf Management (ITM)
Integrated Crop Management (ICM) See the Department of Natural Resource's Agricultural BMPs for ICM applications.

Pollutants Controlled and Impacts

The proper use of IPM principles will promote healthy vegetation, which require fewer inputs. (According to "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators", Michigan State University, Cooperative Extension Service, E-2327, some lawn care companies that implement IPM report a 40-60% reduction in pesticide usage). The proper storage, handling, application and disposal of pesticides will reduce the amount of pesticides available to contaminate surface waters and/or groundwater.

Application

Land Use
This practice is applicable to all land uses where pests are encountered or where pesticides are used or stored.

Soil/Topography/Climate
Soil adsorption, which is the tendency of the pesticide to be attached to soil, varies from one soil texture to the next. The higher the soil adsorption capacity, the greater the pesticide will attach to the soil and move off the land with soil erosion. This is discussed further in the "Specifications" Section, below.

It is particularly important to divert runoff from waterbodies and wetlands when pesticides are used on hilly terrain. Depending on the topography involved, certain application procedures may not be possible.

Climatic factors such as rainfall and temperature are discussed in the "Specifications" section, below.

When to Apply
For new development projects where pesticides will likely be used (such as parks/recreation areas, golf courses, etc.), a pesticide management program should be developed during the site planning process. On all existing sites where pesticides are applied, it may be appropriate to review the practices and adjust them based on specifications in this BMP.

Where to Apply
Apply this practice in all areas where pesticides are stored or applied.

Relationship With Other BMPs

Trees, Shrubs and Ground Covers should be used to select disease or insect-resistant varieties of trees, shrubs and ground covers, and to maintain healthy vegetation. To maintain healthy turf, use this BMP in conjunction with proper watering and mowing (see the Lawn Maintenance BMP), as well as Fertilizer Management and Soil Management.

Specifications

General Considerations:

Use Integrated Pest Management (IPM). IPM is a pest management system that uses all suitable techniques in a total management system to prevent pests from reaching unacceptable levels, or to reduce existing pest populations.

It is important to remember that vegetation cannot be both pest-free and benefit from biological control. For example, there are "good" insects which feed on pests. Accidently killing these insects through indiscriminate pesticide applications may cause more problems than if the pesticide hadn't been applied. Do not attempt to wipe out a pest population; take time and care to use only the management practices which will prevent unacceptable injury to the plant.

Plant Selection:

To **reduce pest problems**, the first step in any IPM program is to **select plants or materials that are resistant to pests and diseases**. Other considerations include selecting materials that provide food, moisture, or habitat to predators, parasitoids, and pathogens of pests. Selection should also be based on the soil characteristics, or with the intention of modifying that soil using the Soil Management BMP. Managers who choose well-adapted species are usually capable of minimizing management inputs while maintaining high quality vegetation.

Native plant species usually require fewer pest controls than introduced species. Choose adapted varieties based on environmental conditions, management level desired, and the intended use.

Species should also be selected based on where they will be planted. For example, most turf grasses generally do best in full to partial sun. The following lists turf performance in shady sites:

Satisfactory: rough bluegrass, fine fescue
Fair: tall fescue, perennial ryegrass
Poor: Kentucky bluegrass

Once the proper plant species is selected, **become knowledgeable in the management of that species**. Every species and every use of that species will involve different water requirements, mowing heights and frequency, and fertilizer rates. All of these factors can affect the health of that plant species.

Identify the Pest:

An organism should not be classified and treated as a pest until it is proven to be one. There are species of insects, fungi, nematodes, and bacteria that are harmless or beneficial to vegetation. Eliminating them with unnecessary pesticide applications often causes greater or additional pest problems. You cannot make appropriate management decisions until you identify the pest. Consider using reference books, the County Extension Service, and/or reliable consultants to help you identify pests.

Understanding pest life cycles and behavior allows applicators to effectively target pest control activities. Regular monitoring will allow you to determine when the pest is in the life stage that is susceptible to controls. See the attached exhibit for various monitoring techniques applicable to grasses.

Determine the Action Threshold:

The action threshold is the pest density at which action must be taken to prevent the pest from reaching the economic injury level. The economic injury level is defined as the density of pests at which the cost to manage the pest is equal to the losses that pest causes. This definition was developed for cash crops, where pest injury is easily converted into monetary losses. For turfgrass management, replacing damaged turf (for example) is an obvious cost of pest activity. However, damaged turf also reduces the aesthetic value of an area.

Action thresholds are usually set based on the judgment of the scout or applicator and reflect the level of treatment desired by the individual. Always take action before unacceptable injury occurs.

Select the Pest Control Strategy:

The best pest control strategy is one that most effectively controls the target pest and minimizes the potential for any adverse effect on the environment. This may include:

Cultural Controls. These include devising ways to change the conditions which are favorable to the pest to conditions that are not favorable to the pest, conditions which favor the pests' natural enemies, or conditions which encourage growth. Review the irrigation schedule, fertilizer rates, soil management, and, for turf, the mowing height and frequency, etc. All of these factors will affect the health of vegetation.

Consider modifying habitats, including components of the landscape and buildings, to enhance the environment required by the pests' predators. Crabgrass is a weed which out-competes turf in sunny, compacted areas. Aerating compacted soils will help desirable turf compete in this area.

Biological controls. Biological controls are living organisms which are used to control other living organisms. They include predators, bacteria, fungi and nematodes. Use of biological controls should only be done by professionals.

Mechanical controls. These include cultivating to control weeds, hand-picking weeds from turf and pests from plants, and screening living space to limit access by mosquitos and flies.

Traps/baits. If the pest is an insect, consider using pheromones (insect hormones) or other attractants to lure or confuse the pest; and use traps to capture pests.

Monitor pest populations using one or more of the following:

-detection kits
-computer models
-disease models
-traps
-knowledgeable (trained) scouts

Pest activity is predicted more accurately by monitoring weather conditions which influence pest development. Both plant and pest development depend on the amount of heat that surrounds the organisms. Turf pest development and their activity is best predicted with **degree days**. Degree days are figured in several ways, but are all based on a common principal: the development of plants and pests begins when the air temperature reaches a certain level, and usually continues until the temperature falls below that threshold. Degree days precisely measure the occurrence of above-threshold temperatures. The threshold is called the base temperature and is between 40-60 degrees F for most organisms.

The Crop Advisory Team (CAT) of Michigan State University (MSU) reports degree days with base temperatures of 42 degrees and 50 degrees F for several areas in Michigan. Pest management references, such as the CAT Alert, Landscape Edition (MSU, Cooperative Extension Service) identify what stage of pest development occurs at specific degree day totals. There are also many commercially-available weather monitoring devices and computer programs to help you predict pest development.

Turf managers: When selecting monitoring equipment, keep in mind that climatic information that most accurately measures the conditions affecting turf is gathered at the crown level of turfgrass. Consider using one of the monitoring techniques listed in
Exhibit 1.

Pesticides. Choose the most appropriate pesticide after considering pest resistance, human exposure, and environmental impact (including impact or surface and ground water). (See the next section for additional information). Follow the "Applications" section, below.

Educate all persons who will be involved in the use of pesticides. Inform them of potential pest problems (i.e. what to look for). Review irrigation and mowing schedules. Review pesticide and fertilizer management practices, including integrated pest management practices.

Selecting Pesticides:
Selection of the appropriate pesticide should first be based on the type of pest which needs to be controlled: either a plant (use a herbicide), insect (use an insecticide), rodent (use a rodenticide) or fungus (use a fungicide). If more than one pesticide can be used to control the pest, choose the pesticide that will yield the desired control results and have the lowest potential to cause any adverse environmental impacts. Choose the pesticide that fits into your pest management strategy and is the least toxic alternative. Ideally, you would want to choose a chemical with low leachability, low runoff potential, a low persistence value, low water solubility, and high soil adsorption capacity. (See the discussion below on the specific compound).

Where more than one formulation can be used (e.g. powder, gas, liquid, etc.), consult Exhibit 2.

Buy only the amount needed to give the desired results.

Selection of the specific compound should be based on the following considerations:

1. Persistence (Half-life). This is the term given to the days required for the pesticide in soil to degrade to one-half of its previous concentration. In general, the longer the half-life, the greater the likelihood the pesticide will be able to move into surface or ground waters and cause environmental impacts. **A pesticide with a half-life greater than 21 days may persist long enough to leach or move with surface runoff before degrading**.

2. Water solubility. The degree to which a pesticide can dissolve in water is given in parts per million (ppm). Solubility affects how easily a pesticide can runoff or leach. In general, pesticides with solubilities of 1 ppm or less tend to remain at the soil surface, tend not to leach, but may move off-site with soil. **Pesticides with solubilities greater than 30 ppm are more likely to leach**.

3. Soil adsorption capacity. Each soil type has a soil adsorption property, which is the tendency of the pesticide to become attached to soil. The higher the soil adsorption capacity, the greater the pesticide will attach to the soil and move off the land with soil erosion. The lower the adsorption capacity, the less likely the pesticide will bind with the soil, but the more likely the pesticide will have the potential to runoff or leach to groundwater. In general, soils with adsorption numbers greater than 1,000 strongly attach to soil, and those with number less than 300-500 are more readily available to run off or leach. See the

appendices to these BMPs for specific soil adsorption values.

4. Leaching and runoff potential. These characteristics are directly related to the soil adsorption and water solubility characteristics. Quite often a trade-off must be made between two pesticides, and the final selection of that pesticide should be based on the soil and groundwater conditions. If one pesticide has a low leachability and another a high leachability factor, then the low leachable one should be chosen to protect the groundwater.

5. Toxicity. After considering all other aspects of pest management, the applicator should choose the least toxic pesticide that is capable of producing the desired effect. Applicators need to remember that pesticides are inherently toxic by their nature, and utilize appropriate protective equipment to minimize their exposure.

   In selecting the appropriate pesticides, applicators need to be aware of the potential for pest resistance. To reduce pest resistance potential, applicators should choose alternative control measures in their pest management strategies.

Pesticide labels contain the following information:

a. Name of the chemical, including trade name, common name, chemical name and formulation

b. EPA registration number

c. Amount of active ingredient per unit, and net contents of the package

d. Information on how to store, mix, apply and dispose of the product and container

e. Manufacturer or formulator name, address and telephone number, and EPA establishment number

f. Use classification. Certain chemicals have restricted use which requires applicator certification to purchase and use.

g. Use recommendations, including timing and the minimum number of days between applications.

h. Pest(s) controlled by the pesticides.

i. Precautionary statements pertaining to physical and environmental hazards. Includes information such as keeping out of reach of children.

j. Persistence (half-life), which is the duration it takes the pesticide to break down to one-half its previous concentration. See "Selecting Appropriate Pesticides," below.

k. Statements regarding the toxicity of the pesticide. Pesticides are categorized based on toxicity:

   Class I- Danger-Poison. Includes skull and crossbones; poisonous if swallowed. Do not

breathe vapor. Do not get in eyes, on skin, or on clothing.

Class II- Warning. May be fatal if swallowed. Do not breathe vapors. Do not get in eyes, on skin, or on clothing.

Class III- Caution. Harmful if swallowed. Avoid breathing vapors. Avoid contact with skin.

Class IV- Caution. No caution statement required.

Never purchase a pesticide that doesn't contain a label.

Review the pesticide label prior to mixing. **Follow label directions**.

Note that if you choose a **restricted use pesticide**, by law, you MUST have the credentials to use it. Restricted use pesticides are usually toxic or environmentally persistent chemicals which can cause significant health or environmental damage if misused. See the "Applicator Certification/Registration" section, below.

Pesticide Applications:
Read the label before application.

1. Application techniques include everything from hand-spraying to aerial spraying. Follow the application procedures on the label.

2. If the label lists more than one acceptable application procedure, use Exhibit 3 to apply the pesticide using the most target-specific method that effectively controls the pest. It is essential that the pesticide be applied in a manner to maximize the percentage of material on-target, and minimize any potential off-target effects.

3. Purchasers and applicators of restricted-use pesticides are required to pass an examination administered by the Michigan Department of Agriculture. See "Additional Considerations," below.

4. Equipment should be in sound mechanical condition, free of leaks and other defects or malfunctions which might cause a pesticide to be deposited off-site, or in a manner inconsistent with its label.

5. Application equipment should be **calibrated** frequently enough to ensure proper and safe application and comply with label directions. All pesticide applicators must follow label directions when using pesticides. Appendix 4 of these BMPs contains calibration procedures for the most common types of chemical application equipment. **Follow calibration procedures in the Appendix for all pesticide applications.**

Mixing and Loading:
Read the label before mixing and loading.

1. Always wear protective clothing when mixing and applying pesticides.

2. Mix the chemicals away from people and animals, on an impermeable surface, preferably a sealed concrete pad. Ideally, the pad should drain to a sump which can contain any spilled pesticides until they are pumped back into the sprayer and used according to label directions.

3. Never leave the filling operation unattended.

4. Have material available to contain any potential spill (see information on spills, below).

5. Fill the tank (or sprayer) approximately half full with water before adding pesticides.

6. Accurately measure chemicals in accordance with label directions. If measuring in teaspoons, use level spoonfuls, not heaping spoonfuls. Never use the same measuring device for food preparation.

   Appendix 4, entitled "Supplemental Fertilizer and Pesticide Applications" includes a list of "Common Measuring Equivalents for Pesticides and Fertilizers." The equivalents allow users to mix only the amount of pesticide (or fertilizer) needed for a single, specific application.

7. If the tank is used to mix two or more chemicals, make sure the two chemicals are compatible with each other. When mixing two or more chemicals in a tank, be sure to mix them according to the sequence below:

   a. Wettable powders
   b. Flowables
   c. Water solubles
   d. Emulsifiable concentrates

8. Pesticide application equipment designed to draw water must have a properly functioning **anti-siphoning device**. Avoid back-siphoning by keeping the end of the fill hose above the water level, or by installing devices which prevent back-siphoning. For additional information, see Michigan State University, Cooperative Extension Service bulletin E-2349, "Protect Water Supplies from Back-Siphoning of Ag Chemicals."

Application Procedures:

1. Prior to an application of pesticides, the applicator should identify any sensitive areas (i.e. wetlands, lakes, streams, etc.) within and adjacent to the target area.

2. Pesticide applications should be made in a way which will prevent direct discharge of pesticides and reduce drift to the lowest extent possible. To do this:

   - Avoid applying pesticides prior to a rain storm, in heavy winds, or during any other weather conditions which may result in runoff. Do not apply on frozen ground.

   - When spraying pesticides, leave an unsprayed buffer strip around surface waters or near other sensitive areas (such as wetlands). Where possible, **leave a minimum 30-35-foot buffer between the edge of the spray area and the watercourse to avoid drift and/or runoff into surface waters**.

3. Where possible, apply pesticides only to those areas which are known to be impacted by the pest. Avoid applying to areas not affected by the pest.

4. **Always spray at the rate recommended on the label**. On the advice of experts, you may be able to apply less than the label recommended rate.

5. All applicators should apply pesticides during the most vulnerable or appropriate stage in the pests' life cycle. Insects, for example, have several life stages, some of which make them more vulnerable than others. The pesticide label may indicate the best time of year to apply the pesticide based on the type of pest being controlled.

6. Special precautions should be implemented in areas where the groundwater is high or where soils are coarse and groundwater could be easily impacted. Routine applications of pesticides that have the potential to impact groundwater should be avoided.

7. Pesticides should be applied in a manner which minimizes exposure to humans, livestock, domestic animals and non-target wildlife.

8. Use up excess pesticide mixtures according to label directions.

Pesticide Storage:
Read the label to determine appropriate storage procedures

1. Store all pesticides away from food products, seeds, fertilizer, and protective equipment.

2. Store all pesticides in a cool dry location, out of direct sunlight. Ideally, pesticides should be stored in a secure room/building. Buildings should be located no closer than 150 feet from a well and no closer than 200 feet from surface water (i.e. lake, river, stream, wetland). Where these restrictions are not being adhered to, additional water source protection methods should be used.

   The following applies to the room/building where pesticides are stored:

   *Post the room/building with highly visible warning and "NO SMOKING" signs.

   *The room/building should be properly ventilated with an exhaust fan.

   *The room/building should contain a sealed cement floor that will prevent spilled pesticides from leaking through cracks.

   *Where possible, the room/building should be fireproof and explosion proof.

   *The room/building should be locked when not in use. Keep all pesticides out of the reach of children, pets and unauthorized persons.

   *If pesticides are stored in a separate building, there should be a containment dike around the building to prevent potential runoff.

*The pesticide storage room/building should contain metal shelves for smaller containers and pallets on the floor for large drums.

3. Store pesticides in their original container. **Secondary containment should be provided for all pesticide containers.**

4. Store all pesticides by classification (herbicide, fungicide, etc.) to prevent misuse or contamination.

5. Mark the date of purchase on each container so older material can be used first.

6. Have supplies for the clean-up of pesticide spills readily available. These include kitty litter, sawdust, and buckets. A fire extinguisher approved for chemical fires should also be readily accessible.

7. Have emergency telephone numbers visibly posted, and first aid equipment readily available.

8. Store protective clothing in a location separate from the pesticides.

9. Store equipment for measuring and mixing pesticides in the pesticide storage room/building.

10. Do not store pesticides in underground tanks.

11. MSU Cooperative Extension Service bulletin E-2335, "On-Farm Agri-Chemical Storage and Handling," contains additional information on pesticide storage.

Pesticide Disposal:
Read the label for specific disposal instructions.

1. Do not discard partially-filled pesticide containers in the trash.

2. Before disposing of empty pesticide containers, triple rinse or power rinse the container. If conducted at a common site, the rinsing operation should be performed over an impervious pad, otherwise the operation should occur in the field at the time of application. To triple rinse, follow the steps below:

    a. Allow concentrate to drain into the tank for 30 seconds.

    b. Add water to the container (10% of the tank volume), replace lid and rotate container.

    c. Dump rinse water into tank and drain for 30 seconds.

    d. Repeat twice more.

    e. Use the rinseate according to label directions.

It is critical that pesticide containers are rinsed immediately after they are emptied. Once pesticide residues become dry in the containers, they are difficult to remove.

3. Puncture the container so it is not used for other purposes.

4. Where possible, recycle plastic containers.

5. Dispose of glass containers in a sanitary landfill.

6. Never reuse a pesticide container.

7. Open burning of pesticide containers is prohibited by law.

8. For additional information on pesticide disposal, contact the Michigan Department of Natural Resources, Waste Management Division at (517)-373-2730, or the Michigan Department of Agriculture, Pesticide and Plant Pest Management Division, (517)-373-1087.

Spill Cleanup:

Develop a spill response plan to identify the procedures which will be followed to contain and clean up spills.

Below are guidelines for spill cleanup if a pesticide is spilled indoors and if the area drains to a sanitary sewer. For all outdoor spills, and indoor spills with areas which drain to storm sewers, contact the Michigan Department of Natural Resources at the Pollution Emergency Alert System (PEAS) number: 1-800-292-4706.

1. If the pesticide is a liquid, surround the area with an absorbent material to keep the pesticide from moving.

2. If the pesticide is a liquid, sprinkle sawdust, kitty litter or other absorbent materials over the spill. Wear gloves and rubber boots.

3. Collect the absorbent material and read label directions for the proper disposal of the waste. If in doubt as to the proper disposal of the waste material, contact the MDNR, Waste Management Division at (517)-373-2730, or your local Cooperative Extension Service office.

4. After removing the waste material, contact the wastewater treatment plant operator. Upon their approval, wash the area down with water, again, only **if the area drains to a sanitary sewer. Do not wash into a storm sewer.**

Record Keeping:

The Michigan Pesticide Control Act (Act 171) requires that all commercial applications of pesticides be recorded by the applicator. Records are useful when runoff, drift or leaching occurs. Records should include:

-Date of application
-Chemical applied (trade name and formulation)

-Rate per acre (acres or square feet)
-Method of application
-Area treated with pesticides
-Purpose of application (target pest(s))
-Weather and soil conditions at time of application
-Most recent date of calibration
-Name of applicator

Exhibit 4 is a Pesticide Use Record form which can be used for each pesticide application.

Maintenance

Proper pesticide management is an ongoing practice, beginning on or before the first pesticide is brought onto the site, and ending only when pesticides are no longer stored or used on the site. Ongoing maintenance should include a minimum annual check to ensure that:

1. Applicators are applying pesticides according to label directions.

2. Equipment is calibrated so that pesticides are applied at the appropriate rate.

3. Labels on the pesticide containers are legible.

4. Pesticides are being stored according to the label directions, and that there is secondary containment for all pesticides.

5. Records are being kept which accurately document the use and application of the pesticide.

Transporting Pesticides:
Proper transporting of pesticides should include:

-Securing containers to avoid breakage and leakage

-Packaging containers to avoid contamination with other chemicals, seed, fertilizer, animal feed and human food

Additional Considerations

Wildlife:
Bees and amphibians such as toads, frogs and salamanders, are sensitive to pesticides. Avoid spraying near wetlands used by breeding amphibians, especially during the breeding season of April, May and June.

Applicator Certification/Registration:
Anyone purchasing and applying restricted use pesticides in Michigan must be certified by the Michigan Department of Agriculture via a testing procedure. Recertification is required every three years.

For persons employed by **commercial certified applicators**: The Pesticide Control Act of 1976 was

amended in 1988 to create a new classification of pesticide applicators called "registered technicians." Under this amendment all commercial applicators must be either "certified" or "registered" in order to apply any pesticide.

Notification and Posting:

Commercial applications on golf courses, lawns, community rights-of-way, as well as all indoor applications, should be indicated on a placard visible to employees and visitors, stating that pesticide applications do occur from time to time. On golf courses, signs should also be placed on the first and tenth tees at the time of application, noting the date and time of application and product information, until label reentry requirements have been fulfilled.

Right-of-way applications will likely only be posted at multiple use areas. Persons that want notification should be aware that notification may occur via newspaper advertisement in the legal section of a community paper.

Exhibits

Exhibit 1: Monitoring Techniques for Turf. "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators", Bulletin E-2627.

Exhibit 2: Pesticide Formulations. USDA, Soil Conservation Service (Michigan), 1992.

Exhibit 3: Pesticide Application Equipment and Methods. USDA, Soil Conservation Service (Michigan), 1992.

Exhibit 4: Pesticide Use Record. "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators", Bulletin E-2627.

Exhibit 1

Monitoring Techniques for Turf

There are a number of ways to monitor turfgrass for information used in a pest management program. One of the most common detection methods is the actual sighting of pests and their damage. The following describes turf pest detection methods.

1. Visual inspection. Get down on your hands and knees and part the grass with your fingers. Concentrate on the edge of the damaged area where fungal disease and insects are likely to be abundant. Watch for insect movement and check grass blades and thatch for insect cases or excrement (grass), or for fungal fruiting bodies.

2. Coffee can technique. Use this technique to flush turf insects out of grass crowns and thatch. First cut both ends out of a 2-pound coffee can. Drive one end a couple of inches into the turf, then fill the can with water. Wait a few minutes for insects to float to the surface.

3. White paper test. Use a sod lifter, cup cutter, sturdy knife, or a trowel to remove a small piece of sod. Slowly peel the sample including soil, thatch, and grass plants apart over a sheet of white paper. Against the white background, living organisms will be easily detected.

4. Turf roll-back. Cut a section of turf one foot square and roll it back to expose root-feeding grubs.

To be useful in turf management, detection information should include detailed information such as the specific area of turf showing injury, level of injury, or number of pests present per sample area. To keep detection information uniform, develop a system to rank turf condition. Use a standardized monitoring sheet.

Source: "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators", Michigan State University, Cooperative Extension Service, Bulletin E-2627.

Exhibit 2

Pesticide Formulations

Pesticide Formulations	Water Quality Hazard		Potential Environmental Hazard
	Med	Low	
Aerosol		X	Drift
Aqueous suspension	X		Runoff, Drift, Leach
Bait		X	Runoff, Leach
Controlled release formulation		X	Runoff, Leach
Dry flowable (water dispersable granule)	X		Drift, Runoff, Leach
Dry soluble	X		Drift, Runoff, Leach
Emulsifiable concentrate	X		Drift, Runoff, Leach
Emulsifiable solution	X		Drift, Runoff, Leach
Encapsulated	X		Runoff, Leach
Flowable	X		Drift, Runoff, Leach
Gas		X	Drift
Granule		X	Runoff, Leach
Liquid	X		Drift, Runoff, Leach
Pellet		X	Runoff, Leach
Soluble powder		X	Drift, Runoff, Leach
Ultra low volume		X	Drift
Wettable powder	X		Drift, Runoff, Leach

The pesticide formulation is a product of the pesticide's active ingredient and the inert carrier. The inert carrier and any additives--such as surfactants, stickers, defoaming agents, etc.--determine how easily and effectively the active ingredient is applied to the target pest. The formulation strongly influences the pesticide's potential for drift during application.

The runoff and leaching potentials of pesticides are strongly influenced by the pesticide's chemistry. The pesticide chemistry (i.e. the composition, structure and properties of the active ingredient and transformations it undergoes) becomes a potential environmental hazard after the pesticide is applied.

Exhibit 3

Pesticide Application Equipment and Methods

Pesticide Application Method	Potential Drift Hazard To Surface Water Quality		
	High	Med	Low
Airplane and helicopter (aerial spraying)	X		
Air assisted applicator (band application)			X
Airblast sprayer (broadcast application)	X		
Backpack sprayer, duster		X	
Controlled droplet applicator			X
Dips and drenches			X
Fogger	X		
Fumigation equipment			X
Granular application			X
Hand gun			X
Hand sprayer			X
Hopper box application			X
Impregnated fertilizer		X	
Incorporation into asphalt			X
Injector			X
Irrigation equipment (chemigation)		X	
Low volume applicator		X	
Mister		X	
Recycling sprayer			X
Roller			X
Seed treatment			X
Spreader		X	
Transplanter and seeder			X
Wick			X
Wiper			X

This Exhibit provides the user a comparison of pesticide application methods. Each method is ranked as having a high, medium, or low potential to drift from the target pest and affect surface water quality.

Exhibit 4

Pesticide Use Record	
Name of applicator: Certification or Registered Technician number:	Date of application: Time of application:
Name of client and address of target area: Specific area(s) treated:	Target pest or purpose: Life stage of pest:
Air temperature: Windspeed and direction:	Soil moisture and texture: Sunny/cloudy: Rain before/after application? When?
Pesticide product name: Pesticide EPA registration number:	Pesticide rate: Amount applied:
Sprayer or spreader used: Date of last calibration:	Nozzle or gun size: Spray pressure or spreader setting:

Source: "Turfgrass Pest Management: A Training Manual for Commercial Pesticide Applicators", Michigan State University, Cooperative Extension Service, Bulletin E-2627.

Stream Bank Stabilization

updated September, 1997

Description

This BMP discusses the thought process that should be used when eroding stream banks are deemed in need of stabilization. Emphasis is placed on stabilization at the watershed level first, then individual sites. Several systems of BMPs are discussed, with reference to specific BMPs. Emphasis is given to “softer”, less rigid structures.

In all aspects of stream bank erosion—from source and cause identification to design and implementation of BMPs—people are encouraged to work with Department of Environmental Quality (DEQ) Nonpoint Source staff in Surface Water Quality Division, or with other stream bank experts.

Note that all stream bank stabilization activities will require permits from the Department of Environmental Quality, Land and Water Management Division. For a discussion on the use of gabions, seawalls and retaining walls, groins, shoreline revetments, and breakwalls, see the Slope/Shoreline Stabilization BMP.

Other Terms Used to Describe

Armoring
Revetments
Riprapping (Note that Riprap is a separate BMP)
Soil Bioengineering/Bioengineering
Stream Bank Protection

Pollutants Controlled and Impacts

Stabilizing stream banks can:

* Prevent the loss of land or damage to utilities, roads, buildings or other facilities adjacent to a watercourse, and prevent the loss of stream bank vegetation,
* Reduce sediment loads to streams,
* Maintain the capacity of the stream channel,
* Improve the stream for recreational use or as habitat for fish and wildlife, and
* Control unwanted meander of a river or stream.

Application

Land Use
This practice is applicable to all land uses.

Soil/Topography/Climate
The site-specific stream bank practices used will be partially dependent upon the types of soils present, the slope of the bank, gradient of the river, flow, and uses of the watercourse.

When to Apply
The appropriate time to apply stream bank erosion controls is dependent upon the method used. Some seasonal limitations are included in the specifications of referenced BMPs.

Where to Apply

Apply this practice in areas where stream banks are eroding.

Relationship With Other BMPs

Geotextile materials (Filters) are often used underneath Riprap.

Specifications

Since each reach of a watercourse is unique, stream bank protection techniques must be selected on a site-by-site basis; the specifications for each technique differ. The following is guidance which can be used to determine appropriate stream bank erosion control practices.

Planning Considerations:

It is important to remember that streams are dynamic. Even without human influence streams may meander, and in the process, cause banks to erode. Therefore, not all eroding banks are "bad" and in need of repair. In fact, the wrong system of BMPs installed in the wrong place may cause more damage downstream (and therefore to the entire stream system) than leaving the stream in its natural state. For example, "hard structures" like large riprap or gabions, placed on one eroding bank, can displace the stream's energy downstream to a previously stable bank, causing the downstream bank to erode. If this downstream bank is also stabilized with a hard structure, the stream's energy may be moved further downstream to another previously stable bank, and so on.

So before stabilizing stream banks, consider the cause of the stream bank erosion. If the banks are eroding due to a natural meander, then it may be best to leave the bank alone. If the banks are eroding due to fluctuations in hydrology, the hydrologic fluctuations should be addressed before the banks are stabilized.

Once the cause of erosion is addressed, determine the goal in stabilizing the stream banks. Some banks are stabilized to protect buildings and land. Others are stabilized to keep soil from entering the stream and to allow angler access to the stream. The purpose for stabilizing the banks and the users of the stream will help determine the type of structures needed.

Once the above concerns have been addressed, then it is important to work with agencies with expertise in stream bank erosion techniques to address stream bank erosion at the watershed level. Looking at the entire watershed will help prioritize bank stabilization efforts. If you are only interested in site-specific alternatives, please turn to "Methods" on page 5.

1) compile land use data on the watershed to determine if there is a direct link between land use and soil erosion. For example, land in livestock production can be a source of sediment if the livestock have direct access to the stream. If land uses are being converted from agriculture to urban, the increased impervious areas may cause increased flows to the stream, which may scour stream banks and cause erosion. Put simply, land uses can help pinpoint potential sources of erosion.

The DEQ, Land and Water Management Division's Michigan Resource Information System (MIRIS) database contains information on the soils, land uses, streams, roads and other features in watersheds throughout the state. Keep in mind that as of the date of this printing, MIRIS data was based mostly on 1978 land use data. Many Soil Conservation District offices also have land use data (often based in part on the MIRIS). Several universities have sophisticated land use decision-making ca-

pabilities (which may include MIRIS data), as well as the capabilities to determine future land uses based on current trends.

Other important sources of land use information include topographic maps of the area, soil maps (if available), and aerial photos. These will show the pattern of the river as it meanders through the watershed. Comparing recent aerial photos to historic photos will also help determine if the river is widening, meandering or otherwise in a state of change.

2) Field verify the data. Because land uses change, it is important to field verify land use data in order to ensure decisions are made based on current and accurate information. This is particularly important in rapidly developing areas. Field verify data by walking or canoeing the entire river, or, if granted permission by property owners, by walking the stream banks. If you're not familiar with the river or stream, contact the DEQ, Surface Water Quality Division or Land and Water Management Division, or DNR, Fisheries Division to find out if the stream is wadable. In National Forest Service lands, contact the US Forest Service. These and other agencies will likely have some information on the stream you're interested in.

When you go out in the field, take a measuring tape, clipboard, pencil or waterproof pen, and multiple copies of the attached worksheet (Exhibit 1). A camera is also important when discussing site-specific conditions with other people. On wadable streams, take hip boots or waders. Use the attached worksheet while noting the specific areas of stream bank erosion. Note soil type and any log jams, construction activities, eroding road crossings, and improper stream access (e.g. cows in the water, areas where people have accessed the river for recreational opportunities, etc.). Where possible, measure the length and height of the eroded stream banks.

Back in the office, incorporate your visual observations with the land use data. Ideally, this will be done by incorporating your notes into the land use database.

3) Estimate the magnitude of the erosion and all potential sources of erosion. Sources of sediment to the stream may include angler access, livestock access, or poorly maintained or improperly designed road crossings. The magnitude of the erosion can be determined by ranking each site as severe, moderate or minor, using the attached field sheet (Exhibit 1). Use of the Universal Soil Loss Equation is discussed in an appendix of the Guidebook of BMPs.

4) Rank the sites. At its simplest, ranking sites can be based on addressing the most severe sites first and working from upstream to downstream, including tributaries. Another alternative is to rank sites based on four criteria: 1) degree of impact (severe, moderate, minor); 2) the cost of installing the system of BMPs needed; 3) landowner willingness to cooperate; and 4) "demonstration-ability." (i.e. amount of public visibility). "Demonstration-ability" is important if you plan to solicit volunteers or funding for stabilization efforts. This site ranking method was used in the Bear Creek watershed, Kent County.

5) Determine appropriate options for the high priority sites. Use the information gathered on land use and from visual observations (including photos) to evaluate stream bank stabilization alternatives. The BMPs selected should also help to achieve the overall goals for the watershed (such as improving fish habitat or providing greater recreational access). Review the scenarios below, the various Methods on page 5, and then contact stream bank experts to discuss site-specific options.

Stream Bank Stabilization Scenarios:
The following hypothetical scenarios illustrate various alternatives for stream bank stabilization:

Scenario 1: Visual observations show several minor stream bank erosion sites. Erosion was determined to be caused by stream flow. The amount of human influence on flow is low (i.e. it is naturally "flashy" versus flashiness caused by increased flow from urbanization). The decision in this case is to leave the eroding banks alone.

Scenario 2: Comparing aerial photos from 1938 and 1990 shows that the stream hasn't meandered much, yet there are hundreds of banks along the stream that are bare, mostly due to angler and canoeist access. The stream is a high quality trout stream and local people hold the river in high esteem. Since sediment is detrimental to trout habitat, the decision was made to stabilize stream banks in this watershed, providing access via stairways and canoe landings, and restricting access via practices such as fencing and brush mulch. Since the greatest reduction in sediment load will be gained by stabilizing severe sites, the most severe banks will be stabilized first, going from upstream areas, downstream. If more money becomes available, then moderate sites would be stabilized, again, starting upstream.

Scenario 3: The predominant land use is urban. Severe erosion is observed downstream of the urban area. In this hydrologically unstable area a stormwater management plan will be developed in conjunction with or prior to stream bank stabilization to reduce extreme hydrologic fluctuation and velocities. In this example, the decision was also made to work on an ordinance which would address stormwater practices to prevent additional flows to the stream.

Scenario 4: The predominant land use is agricultural. Moderate and severe bank erosion is occurring at several livestock access areas. In this example, cattle exclusion systems, including fencing and alternative watering areas, were designed and implemented in conjunction with stream bank stabilization techniques.

Scenario 5: Visual observations and historical aerial photographs show the stream to be relatively stable. Most of the adjoining land is rural/agricultural but is expected to experience 35% growth in the next 15 years: therefore, additional flows to the stream are expected. Two new road crossings are causing severe erosion downstream of the crossings. The decision was made to stabilize the banks downstream of the new crossings with structures which help absorb some of the energy from stream flow (see soil bioengineering structures, below). The decision was also made to work with the road commission so that future road designs would be done such that downstream areas are not impacted. An ordinance to provide on-site detention/retention of stormwater from the newly constructed area was also proposed.

Other Things to Consider
In selecting site-specific options to stabilize eroding stream banks, consult the Michigan Department of Environmental Quality (Surface Water Quality Division or Land and Water Management Division), local Conservation District, or other agencies or consultants experienced in stream bank erosion control. Also, be sure to check Exhibit 2 to see if your river is included on the list of Natural or Wild and Scenic Rivers. These rivers have special restrictions, depending on their designation. Contact the MDEQ, Natural Rivers Program staff for further information on the types of stream bank practices that can be used in Natural Rivers.

It is also important to get input from the people who may use the watercourse at the specific site in need of stabilization, (i.e. river boat guides, anglers, canoeists, etc.). Consider working through a local watershed steering committee, if available. These committees include representatives from a variety of backgrounds and interests.

NOTE: While considering BMP options, remember that no removal of sediment bars, snags, stumps, debris drifts, trees, brush or similar material should be done unless absolutely necessary, and upon approval by the MDEQ, Land and Water Management Division. This in-stream cover is necessary for channel diversity and aquatic habitat.

Methods:

There are numerous methods available to stabilize stream banks. Rather than discuss all of them or any of them in detail, below is a discussion of the most common practices.

Riprap:

Riprap is one of the more commonly used stream bank stabilization techniques. It is a permanent cover of rock used to stabilize stream banks, provide in-stream channel stability, and provide a stabilized outlet below concentrated flows. It is generally used on stream banks at the toe (bottom) of the slope, with other structures placed up-slope to prevent soil movement. It is often a component of many soil bioengineering techniques. Specifications for riprap used in stream bank stabilization is discussed in the Riprap BMP.

Picture 1, above: The bank was stabilized with rock riprap from the toe (bottom) of the bank to the top of bank. This may be needed on streams with unstable hydrology (i.e. “flashy” streams), and where banks have groundwater seeps. Source: North Branch Chippewa River Nonpoint Source Project.

The Department supports the use of natural fieldstone for riprap; only natural fieldstone is allowed in rivers designated under the Natural Rivers program. The use of vegetation in conjunction with riprap is encouraged to "soften" stream bank structures.

Picture 2, right: Riprap was placed to 3 feet above the ordinary high water mark and a portion back-filled with soil. Log terraces were placed on the bank and the bank was seeded. This approach can be used on top of fish lunker structures and on banks where stream flows are relatively stable. Also note the fence and stairway to direct recreationist access. Source: Boardman River Nonpoint Source Project.

Soil Bioengineering:

Soil bioengineering is a method of using vegetation to stabilize a site with or without structural controls. Some refer to bioengineering as softening the traditional rock-the-bank approach because non-invasive vegetation is used to blend the site into its surrounding landscape. Bioengineering techniques may be as simple as using stop-logs to form terraces, then seeding exposed soil to help prevent soil movement. Techniques also include using fascines (long bundles of willow or dogwood), with layers of brush, along with individual plantings.

Picture 3, left, shows a fascine, brush layering and live stakes. **Picture 4, below,** shows new growth from a live stake. Source: Whetstone Creek Nonpoint Source Watershed Project.

Chapter 18 of the USDA Soil Conservation Service (now Natural Resource Conservation Service (NRCS)) Engineering Field Handbook is one of the most comprehensive sources of information on soil bioengineering. Chapter 18 describes soil bioengineering as a combination of biological and ecological concepts to arrest and prevent shallow slope failures and erosion. Rather than duplicate NRCS' efforts to describe soil bioengineering techniques here, people interested in exploring soil bioengineering are encouraged to work with the NRCS, MDEQ, and other agency staff familiar with bioengineering practices.

As another example of a system of practices used to stabilize a bank, refer to Picture 2. In addition to riprap, seed and log terraces, the system of BMPs on the bank in Picture 2 included fencing to direct foot traffic, and a set of stairs.

Maintenance

A maintenance plan should be included with all site plans. The maintenance plan should indicate when inspections of the site will be made and who will be responsible for needed maintenance. Site inspections, conducted to ensure the stream bank structures are staying in place, are particularly important within the first few months of installation, and following storm events which result in bankfull streams. More specific maintenance procedures can be found in the referenced BMPs.

Exhibits

Exhibit 1: Field Data-Entry Form which can be used in the stream bank erosion inventory, Northwest RC&D Council. (This type of approach has been used to identify and rank eroding sites on the Muskegon, Au Sable, Pine and Betsie Rivers).

Exhibit 2: Michigan's Natural Rivers System. List of rivers designated or proposed under the Natural Rivers program.

Exhibit 1

Field Data-Entry Form for Stream Bank Erosion Inventory

This form is intended to be used to compare the severity of eroding stream banks within a watershed. Results can be used to help prioritize stream bank stabilization efforts. Fill in all known information. Where provided, fill in the appropriate number per each category, then total the "points" on the last page.

Date: _____
County: _____
Stream: _____
Observer: _____

SITE LOCATION:
Township Name:_____No._____Range_____Sec. _____
Bank (right or left, looking downstream): _____
Property Owners: _____
Other info re: location: _____
Accessibility for machinery/materials (good/bad)
Access Problems:_____

SITE NUMBER: _____

MEAN WIDTH OF RIVER: _____
(no points)

CONDITION OF BANK:

	5	Toe and upper bank eroding
	3	Toe undercutting
_____	1	Toe stable, upper bank eroding

	5	Length of eroding bank > 50 ft.
	3	Length of eroding bank 20-50 ft.
_____	1	Length of eroding bank < 20 ft.

	5	Side slope vertical 1:1
	3	Side slope 2:1, 3:1
_____	1	Side slope 4:1 or flatter

PROBLEM TREND

	5	Increasing
_____	1	Decreasing or stable

(continued, next page)

Exhibit 1 (continued)

DEPTH OF RIVER

	1	> 3 feet
_____	2	< 3 feet

VEGETATIVE COVER

	5	Vegetative cover 0-50%
	3	Vegetative cover 50-80%
_____	1	Vegetative cover 80-100%

MEAN HEIGHT OF BANK

	5	Mean height of bank > 20 ft.
	3	Mean height of bank 10-20 ft.
_____	1	Mean height of bank < 10 ft.

SOIL TYPE OR TEXTURE

	3	Sand
	2	Gravel
	2	Stratified
_____	1	Clay or loam

APPARENT CAUSE OF EROSION

	1-Light access traffic
	1-Obstruction in river
	1-Bank seepage
	1-Gullying by side channels
	2-Bend in river
	3-Road-stream crossing, grade/shoulder runoff
	3-Moderate access traffic
	5-Heavy access (foot, horse, etc.) traffic
_____	5-Construction site erosion

_____	TOTAL POINTS:	more than 36 — severe 30-36 — moderate less than 30 — minor

RECOMMENDED TREATMENT

Describe a potential system of BMPs for the site:

NOTE: Sketch location on a separate sheet, showing any unusual circumstances. Also, provide black-and-white or color photograph, if possible.

Source: Modified from the inventory sheet used in the Upper Manistee Stream Bank Erosion Inventory.

Exhibit 2

SBS-10

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Dec. 1, 1992

Soil Management

Description

Soil management is managing soil to provide the best growing conditions for turf and other vegetation. It may include adding lime, fertilizer, topsoil or other constituents to the existing soil to address low fertility, abnormal moisture content or inappropriate pH. It also includes cultivation and drainage techniques.

All soil additions (amendments) should be based on the results of **soil tests**. Soil samples should be taken following procedures in the attached Exhibit.

Other Terms Used to Describe

Liming
Soil conditioning
Soil preparation

Pollutants Controlled and Impacts

Proper soil treatment applied in conjunction with proper vegetative establishment will help prevent erosion and promote the filtering of runoff water. Soil treatment will also reduce the potential of groundwater contamination by providing a better environment for vegetative growth.

Application

Land Use
The BMP is applicable to all land uses where soils will be used for vegetative establishment.

Soil/Topography/Climate
Soil management varies based on soil classification and the use of that soil.

When to Apply
Certain aspects of this BMP will need to be applied at various times throughout the year. For example, when establishing new turf areas, liming materials should be incorporated into the soil before or during final seedbed or sodbed preparation.

Where to Apply
Apply to all soils.

Relationship With Other BMPs

This BMP is used in conjunction with all vegetative BMPs, as well as the Pesticide Management and Fertilizer Management BMPs.

Specifications

General Considerations:

Naturally existing soils are divided into layers called horizons (see Exhibit 1). These horizons may differ by pH, organic content, moisture, texture, etc. For the purposes of providing good soils for vegetation, only the top two soil layers are of concern. Exhibit 2 shows typical plants which can survive at various pHs.

Changes to the characteristics of the soil may be needed if the soil is not suitable for its intended use (e.g. if the soil is to support a building, its composition will be completely different than if its purpose is to grow grass). Therefore, first determine what the intended use of that soil is.

Since many land uses involve the establishment of grasses and other vegetation, the remaining text of this BMP is devoted to soil amendments for improving vegetative growing conditions. Refer to Exhibit 3, the USDA Soil Texture Classification, to determine soil texture based on the percentage of clay, silt or sand. This chart helps clarify what soils like "loam" and "clay loam" are comprised of.

All soil additions should be done based on the results of soil tests. Exhibit 4 is a step-by-step procedure for collecting soil samples. The Michigan State University, Cooperative Extension Service (MSU, CES) lab can analyze the samples, and staff can offer suggestions on the appropriate amount of fertilizer and other additives that are needed. Exhibit 5 lists the MSU CES laboratory fees.

The discussion below includes possible treatments which will be needed based on the results of the soil test. Much of the information was derived from "Turfgrass Pest Management," Michigan State University, Cooperative Extension Service, Bulletin E-2327.

pH:

pH is a measure of acidity. Soils with a pH less than 7 are considered acid, while soils with pH greater than 7 are considered alkaline. A pH of 7.0 is considered to be neutral.

Although most turf grasses grown in Michigan will grow well under a wide range of soil pH conditions, the optimum pH range for turf grasses is 5.0 to 7.5, depending on the turf species selected. Some acid-loving plants such as blueberries and rhododendrons prefer pHs between 4.0 and 7.0. Again, the type of plant to be grown in the soil will determine the pH requirements. Determine pH by soil test.

If the pH is too low:

Soils that are too acidic for the plant type should be treated with **lime** to raise the pH. This is particularly important because as the soil becomes more acidic, metals become more soluble. As metals become soluble they can be more easily transported to surface and ground waters. Lime should be mixed into the soil to a depth of at least 3 inches before seeding or sodding.

If the pH is too high:

pH levels higher than the optimum range (to 7.5) are generally not encountered in Michigan. Where necessary, sulfur or sulfur compounds may be added to lower the pH to the optimum range.

In droughty soils:
Droughty soils may be caused by a lack of irrigation, or because of a lack of organic material. Determine the cause of the droughty condition, then adjust the irrigation schedule, or add organic matter, loamy material, or preferably, topsoil to increase the moisture holding capacity of the soil.

Nutrients (Phosphorus and Nitrogen):
Nutrients in a soil are in constant flux, becoming more or less available as soil conditions change. Fertilizers sold commercially contain varying amount of the 16 mineral elements essential for turf growth and development, nitrogen, phosphorus and potassium being the three most common elements. Remember that only a soil sample will tell you how much of each nutrient is available in your soil.

Nitrogen:
Nitrogen is an essential element for plant growth. Because nitrogen makes grass "green," it is often used in excess of what the plant needs. Nitrogen which is not absorbed by vegetation can leach through the soil and into the groundwater. During this leaching process, nitrogen is converted into nitrate, which can contaminate drinking water supplies and cause health problems. The Environmental Protection Agency limits the acceptable level of nitrate in drinking water to 10 ppm (parts per million).

Nitrogen is often unavailable to turf roots because it leaches through the soil rapidly. Turf deficient in nitrogen may have poor color, decreased elasticity, and is less able to compete with weeds. Apply nitrogen based on soil tests. Do not apply any more than one pound of actual nitrogen per 1,000 square feet during a single application.

Phosphorus:
Phosphorus is important for root development, maturation, and seed production. This element is found chemically bound to oxygen; two particles of phosphorus are bonded to five oxygen particles (P_2O_5). Since this molecule is practically immobile in soil, few soils are deficient in phosphorus. Soils that are deficient show purpling of grass blades. Note that this symptom can be confused with the color change induced by cold weather.

Many Michigan soils have been historically over-applied with phosphorus. Since phosphorus binds readily with soil, excessive applications of phosphorus which are carried off in eroded soil can result in algae blooms and nuisance aquatic plant growth. This, in turn, results in eutrophication.

Phosphorus fertilizer must be delivered directly to turf roots. This can be done by fertilizing after aeration or by liquid fertilizer injection. Apply all phosphorus amendments based on the results of soil tests.

Potassium:
Turf uses potassium in quantities second only to nitrogen. This element is important for rooting, and wear and climatic stress tolerance. While rarely visually evident, turf deficient in potassium has yellowing and dead blade tips.

Potassium generally does not cause water quality problems, nor is it over-applied in the same manner as phosphorus and nitrogen. Apply potassium amendments on the basis of soil test results.

For all Nutrient-Deficiencies:
If soils are nutrient-deficient, follow specifications in the Fertilizer Management BMP.

Micro-Nutrients:
Micronutrients are elements used by plants in relatively small amounts. They include manganese, boron, copper, and zinc. Typically, micronutrients required by turf are naturally present in Michigan soils in adequate amounts. High soil pH, however, can render these elements insoluble, making them unavailable to turf roots. Iron is an example of a micronutrient that is commonly deficient in alkaline soils (i.e. those soils with a pH greater than 7). Iron is required for chlorophyll production, and therefore the green coloring of plants. It is also important for root and shoot development and drought resistance. Iron-deficient turf usually has blotchy yellow patches. Severe iron deficiencies may result in white grass blades or the death of plants. Application of iron fertilizer will provide temporary green-up of turf. Since the deficiency is due to soil alkalinity, long-term treatment requires modifying the soil pH.

Soil Organisms:
Living and decaying soil organisms contribute greatly to a soil's organic matter and fertility. As they burrow, organisms break down organic matter, making nutrients available for absorption by turf roots.

Earthworms are the best known of soil organisms, but a great number of microorganisms also occupy the soil. One teaspoon of soil can contain a billion bacteria, a million fungi, and several thousand algae. Most of these organisms improve soil conditions for plants.

Turf managers who appreciate the benefits of soil life are careful not to destroy it with unnecessary soil amendments. Again, make amendments to the soil based on the result of soil tests.

Managing for Compacted Soils:
Compacted and heavy clay soils contain less air and have a hard surface that drains poorly. Turf growing in such soils lack air and beneficial micro-organisms, and suffer from poor drainage. Root development and turf quality declines.

Mechanical aerators create holes in compacted and heavy soils. This practice increases the movement of air in the soil and improves drainage. Machines that remove cores from the soil are generally more efficient aerators than those that spike or slit the soil. Coring machines remove a quarter to one-inch diameter cores and deposit them on the surface of the turf. Fall is the best time to aerate turf, when weed seed germination is at a minimum.

When practical, break up deposited cores by dragging chain-linked fence or similar material over them. Cores of poor quality soil should be discarded. Holes will more rapidly be covered by turf if the area is top dressed, seeded and fertilizer is applied directly after aeration. Follow this with a light watering. Fall is the best time to aerate turf, when weed seed germination is at a minimum.

Site Preparation:
For established areas:
1. Collect soil samples following the procedures in the attached Exhibit.

2. Discuss the soil test results with the local Soil Conservation District or Cooperative

Extension Service staff, and buy the recommended amount of fertilizers, lime, or other needed amendments. Apply fertilizers following specifications in the Fertilizer Management BMP. Lime should not be spread using a hydroseeder. It can be blown onto steep slopes in dry form. For the application of compost, see the Organic Debris Disposal BMP.

For a typical seeding or sodding operation as part of a construction project:

1. Collect soil samples following the procedures in the attached Exhibit.

2. Discuss the soil test results with the local Soil Conservation District or Cooperative Extension Service staff and buy the recommended amount of fertilizers, lime, or other needed amendments.

3. In large areas, topsoil should be removed and stored in storage piles according to specifications in the Spoil Piles BMP.

4. Where appropriate, grade following specifications in the Grading Practices BMP. Complete all cut and fill activities. Use Diversions and other BMPs to prevent soil erosion and sedimentation. Follow the site plan.

5. The earth bed upon which the topsoil is placed for seedbed and sodbed preparation should be at the required grade.

6. Work lime, fertilizer and other additives into the topsoil, either before or during final seedbed preparation, or before sod is laid. Lime should be mixed into the soil to a depth of at least 3 inches before seeding or sodding. Lime should not be spread using a hydroseeder. It can be blown onto steep slopes in dry form. For all seeding applications, follow specifications in the Seeding BMP.

   For all sodding applications, follow specifications in the Sodding BMP. For the application of compost, see the Organic Debris Disposal BMP.

7. Inoculate all legume seed in accordance with the manufacturer's recommendations.

Maintenance

If the vegetation doesn't grow according to its intended use, additional soil tests may need to be taken and analyzed for other parameters. Additional soil samples should also be taken as new areas are developed.

Once vegetation is established, additional soil amendments, including fertilizers, should only be made based on the results of soil tests.

Additional Considerations

Treating soils on-site is less expensive than importing soils from off-site. Existing soils are also usually compatible with the lower horizons.

Exhibits

Exhibit 1: Soil Horizons. Michigan Department of Natural Resources, Soil Erosion Control Unit.

Exhibit 2: pH Toxicity Chart. Michigan Department of Natural Resources, Soil Erosion Control Unit.

Exhibit 3: USDA Soil Texture Classification.

Exhibit 4: How to Collect a Soil Sample. Compiled from several sources.

Exhibit 5: Michigan State University Testing Laboratory Fee Schedule. Lists prices effective July 1, 1990.

Exhibit 1:

Soil Horizons

Horizon O - This uppermost horizon consists of detritus, leaf litter, and other organic material lying on the surface of the soil. This layer is dark because of the decomposition that is occurring, and is usually 0" to 2" deep, or it may be as deep as 16" for poorly drained, unclassified soil.

Horizon A - The second layer of soil, called topsoil, is darker than the lower layers. It is loose and crumbly with varying amounts of organic matter. In cultivated fields, the plowed layer is topsoil. As water moves down through the topsoil, many soluble minerals and nutrients dissolve. The dissolved materials leach from the topsoil. This is generally the most productive layer of soil, and ranges from 2" to 10" in depth.

Horizon B - The third layer is commonly called subsoil. This layer is usually light colored, dense, and low in organic matter. The subsoil is a zone of accumulation since most of the materials leached from the topsoil accumulate here. This zone ranges from 10" to 30" in depth.

Horizon C - This layer is beneath the subsoil. It is lighter in color than the subsoil. It is typically described to a depth of 60" in soil survey reports, but may be many feet thick. It may or may not be like the material from which the A and B horizons have formed. If it is dissimilar, it is designated as 2C or IIC.

Horizon R - This layer represents bedrock.

Source: Michigan Department of Natural Resources, Soil Erosion Control Unit.

Exhibit 2

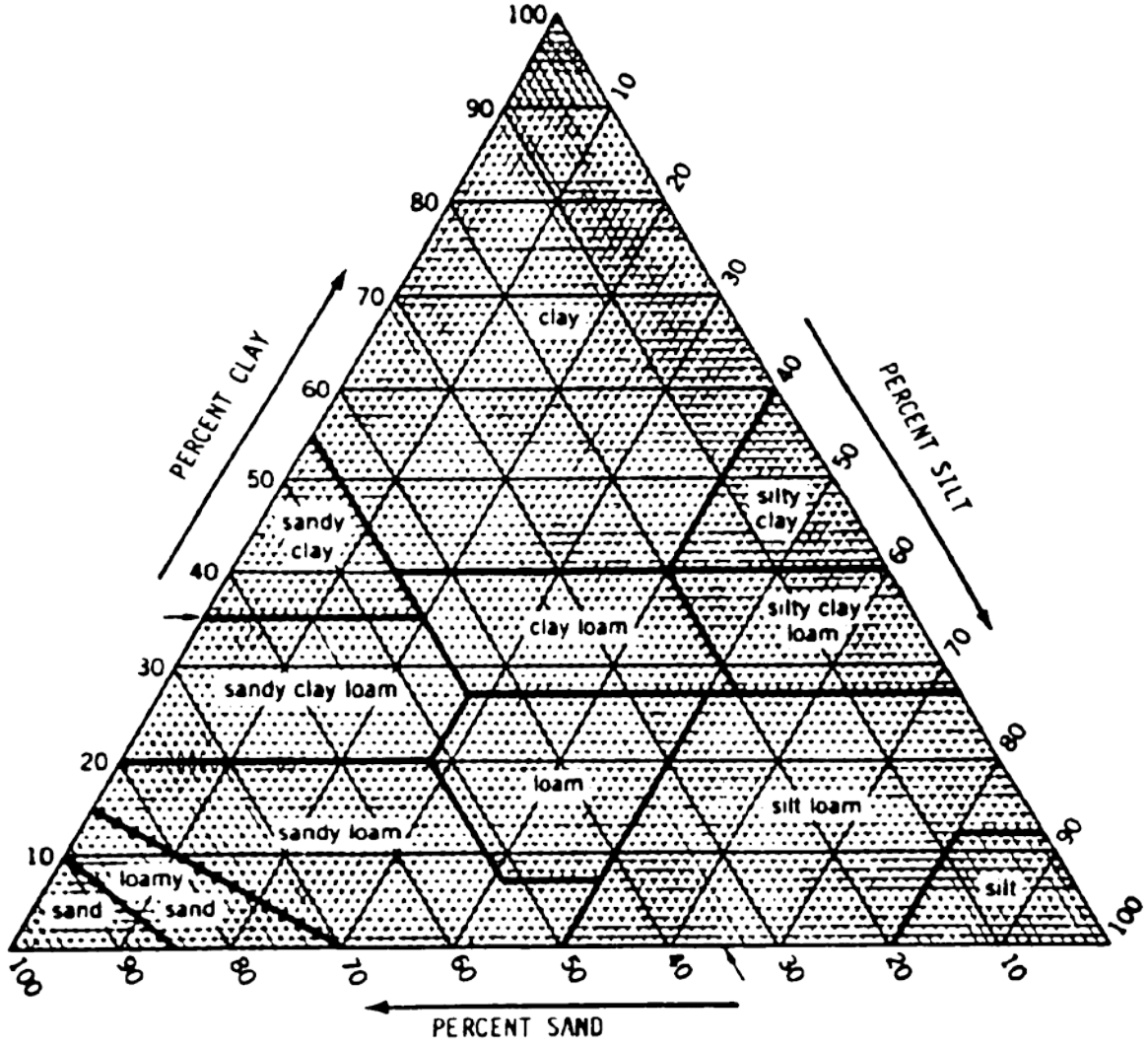
pH Toxicity Chart

	pH		
	14		
B	13		
			Typical Plants
A	12	Typical Basic Soils	Tolerant of Basic Soils
		Alpena, Aurelius,	Willow, American Elm,
S	11	Brry, Belleville	Poison Sumac, Poison Ivy
I	10		
C	9		
	8		
	7	Neutral	Vegetation grows best when it is within the range of 5.5 and 8.0
	6		
	5		
A	4		
			Typical Plants
C	3	Typical Acid Soils	Tolerant of Acid Soils
		Burt, Champion,	Red Maple, Balsam Fir,
I	2	Gogebic, Isabella	Bunchberry
D	1		
	0		

Source:Michigan Department of Natural Resources, Soil Erosion Control Unit.

Exhibit 3

USDA Soil Texture Classification



Source: USDA, Soil Conservation Service

Exhibit 4:

How To Collect a Soil Sample

Soil tests are generally collected and analyzed for nitrate-nitrogen, phosphorus, and pH. As discussed in the Lawn Maintenance BMP and above, BMP, nitrogen and phosphorus are two of the three primary nutrients which make up commercial fertilizers. Fertilizers put on the soil in excess of that which is needed by the plant may 1) run off the soil into lake, rivers and streams, causing algae blooms; or 2) leach through the soil and impair groundwater supplies.

Generally, a representative sample should be taken. This may mean only a few samples, as in the case of an average one-acre yard, or a dozen or more, as in the case of a large field. The more variety of soil textures in the area to be vegetated, the more samples that should be taken. Turf areas that differ significantly in grass type, use, or growing conditions should be analyzed separately.

Remember that there are three primary types of soil textures are sands, silts and clays. Soil which is comprised of a mixture of sand, silt and clay is called loam. Use Exhibit 3, the USDA Soil Texture Classifications, to determine the soil textures of your soils.

Step by step process:

For Yards/Lawns Less than 1 Acre:

1. Take a spade or trowel and stick it in the soil to a depth of 4-5 inches at a 45-degree angle (to make a V-shaped cut). Take the spade out and move it 1/2-inches away from the first cut and dig out a 1/2-inch chunk of soil. Then, trim off from each side of the spade all but a thin ribbon of soil down the center of the spade face. Place this in a clean bucket, plastic container or paper bag. Do not contaminate samples by mixing them in a metal container.

2. Take additional samples, as needed for different textures of soils, and for the different ways turf can differ--by grass type, use, or growing conditions. Add the soil to the bucket/container and mix thoroughly.

3. Air dry the sample by spreading the soil out in the bottom of the bucket/container, or, if a lot of soil is collected, in the bottom of a flat pan.

4. When the soil is dry, mix it thoroughly. Then take out about a half-pint, and put it in a jar for testing.

5. Take the soil test to the county Cooperative Extension Service (CES) office or a private lab experienced in the analysis of soils. Be prepared to answer questions about the amount of fertilizer you've used in the past, the spreading/spraying technique used, and the type of grass or sod the fertilizer will be applied to. Also indicate to the CES staff any problems which have been encountered on the lawn: look for thin spots, brown spots, etc.

Exhibit 4 (Con't)

6. The CES staff will have the soil test analyzed and present you with the results, along with a recommendation for the amount of fertilizer needed, the application rate, the best time to apply the fertilizer, and frequency of applications. By tailoring fertilizer applications to your lawn, you will put on only what is needed, thus saving money and protecting surface and ground waters, and will likely save money.

7. Homeowners should have their soil tested once every three or four years, unless additional problems arise.

For Yards Larger than 1 Acre, Including Parks, Cemeteries, etc.

1. Get a copy of a soils map from the Soil Conservation District or the Cooperative Extension Service to identify the number and types of soils on your property.

2. Collect soil tests to a depth of 4-5 inches and 1/2-inch thick using a spade, soil auger or soil sampling tube.

3. Trim off from each side of the spade all but a thin ribbon of soil down the center of the spade face. Place this in a clean bucket.

4. Take additional samples, as needed for each different type of soil identified on the soil map. If you were unable to access the soil map, at least take additional samples for each soil texture (sand, silt, or clay). Add the additional soil samples to the bucket.

5. Follow steps 3 - 6 in the above section.

6. People with large acres to manage should collect soil samples annually.

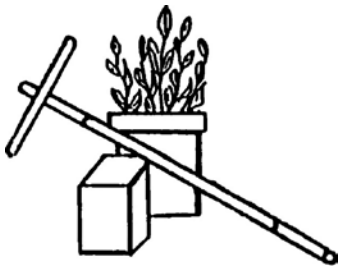
Compiled from several sources.

MICHIGAN STATE UNIVERSITY
SOIL TESTING LABORATORY

FEE SCHEDULE

Por
SOIL ANALYSIS
And ontKR MATERIALS

(EFFECTIVE JULY I, 1990)



Cooperative Extension Service
Crop and Soil Sciences Department
ARI Plant and Soil Sciences Building
East Lansing HI 48824-1125

Telephone (517)355-018
PAI (517)355-1732

Exhibit 5

PRICES EFFECTIVE July I, 1990

1 a. REGULAR FIELD SOIL TEST $6.oo"
pH, lime requirement, P, K, Ca, Hg & recommendations

lb. REGULAR FIELD TEST PLUS ZN & HN • • • • $10.oo*

•Samples coming into the lab not in pre-paid boxes add $.50 per sample for boxing

2. KICRONUTRIENT TESTS (Zn, Mn, Cu, & Fe) .$ 3.00/EA
(price is per micronutrient per sample)

3. GREENHOUSE TEST • • • • • • • • • • • • • $14.00
(For artificial growth media) pH, Nitrate-N, P, K, Ca, Hg, soluble salts, Na, Cl and nutrient balance

4. SUPPLEMENTAL SOIL TESTS

a. Nitrate - Nitrogen • . . . . $ 3.00
b. Nitrate - N + Ammonium • - N • $ 4.00
c. Sodium • . . . . . $ 3.00
d. Chloride . . . . . $ 3.00
e. Soluble Salts . . . . . .$ 3.00
f. Organic Matter . . . . . $ 3.00
g. pll . . . . . $ 2.00
h. Total Nitrogen $12.00
i. C.E.C. by amnonium saturation . . . $15.00
Sulfur 5.50
j. Boron (analyais by U.Of Wisconsin) .$ 5.50
$

5. PARTICLE SIZE ANALYSIS • • • • • $10.00
(percent sand, silt and clay)

6. GOLF COURSE ANALYSIS Sand Classification $15.00
(USGA size limits by wet sieving)

7. PP.AT FOR SALE • • • • • • • .$ 7.00
(pH, organic matter, moisture content, peat type)

PRE-PAYMENT IS ENCOURAGED - OTHERVISB A SERVICE
FE or $6.00 WILL BE ADDED

Exhibit 5 (con't.)

8. LIMESTONE ANALYSIS

a. Neutralizing Value, Sieve Analysis…….$18.00
% $MgCO_3$ and Moisture

b. Neutralizing Value only……...$ 6.00

c. Sieve Analysis only……..$ 6.00

d. Percent $MgCO_3$ only……$ 6.00

9. MARL ANALYSIS

a. Neutralizing Value, $CaCO_3$ equivalent per cubic yard, % $MgCO_3$, % moisture……...$18.00

b. Neutralizing Value, $CaCO_3$ equivalent per cubic yard and % moisture……...$12.00

c. Percent $MgCO_3$ only……$ 6.00

10. WATER TESTS

a. **COMPLETE…**…….$12.00
(soluble salts, alkalinity, pH, Nitrate-N, P, K, Ca, Mg, Na and chloride)
b. Total Soluble Salts…..…….$ 2.00
c. Alkalinity……..$ 2.00
d. Nitrate-N…..……$ 2.00
e. Nitrate-N + Ammonium-N……..……$ 3.00
f. Any single soluble element……...$ 2.00

11. PLANT TISSUE ANALYSIS

COMPLETE tissue analysis includes N, P, K, Ca, Mg, Zn, Mn, Cu, Fe, B, Al and Mo.
a. Field Crop & Vegetable tissue……$16.00
(includes interpretation of results)
b. Fruit trees, grapes, strawberries,…….$18.00
blueberries & raspberries (includes interpretation of results & computerized fertilizer recommendations)
c. Complete analysis <u>without N</u>……..….$12.00
d. N alone..……...$ 8.00

12. SUPPLIES

a. Soiltex pH kits……..$ 3.00

b. Hoffer Soil Sampling Probes……...$20.00

13. DISCOUNT INFORMATION
(on purchases of soil sample boxes only)

a. 0-99……..……..No discount
100-199…….4%
200-399…….8%
400 +……...10%

TURNAROUND TIME for Regular Soil Tests is one week, turnaround time for Greenhouse tests is two (2) days from receipt. A 20% surcharge will be added for Rush samples.

MSU SOIL TESTING LABORATORY
A81 Plant & Soil Sciences Building
Michigan State University East
Lansing, MI 48824
Phone: (517) 355-0218
FAX: (517) 355-1732

Dec. 1. 1992

Slope/Shoreline Stabilization

Description

This BMP addresses structures which stabilize shorelines and slopes that cannot be stabilized with vegetation. Structures included in this BMP are: revetments, gabions, seawalls, bulkheads, groins, breakwaters and retaining walls. Typical applications of each of these structures are included in this BMP. Note that some of these structures are also used to stabilize stream banks. For additional information on these and other practices which can be used to stabilize stream banks, see the Stream Bank Stabilization BMP.

Permits for the construction of slope/shoreline stabilization practices will be required by the Department of Natural Resources, Land and Water Management Division if the structure is below the ordinary high water mark of a lake (or stream), floodplain or wetland. In some situations, both MDNR and U.S. Army Corps of Engineer permit requirements will need to be met.

Other Terms Used to Describe

Breakwalls
Bulkheads
Gabions
Groins
Retaining Walls
Revetments
Seawalls

Pollutants Controlled and Impacts

These practices protect the shorelines of watercourses by stabilizing embankments, thus limiting the erosion of soils and their associated particles into a watercourse.

Application

Land Use
This practice is applicable to all land uses.

Soil/Topography/Climate
The type of shoreline stabilization method used will vary depending upon the soils, slope of the land, groundwater characteristics, and the climatic conditions of the area. Their use is very important in areas where there are steep slopes, highly erodible soils, and where conditions can significantly increase or create erosion (i.e. areas of flash floods, strong winds and lake shorelines).

Special consideration should be given to the design and use of structures that will be susceptible to the forces of ice movement. Ice action has been shown to weaken, dislocate, and destroy improperly designed and installed structures.

When to Apply
Slope/shoreline stabilization structures should be installed prior to or immediately after disturbing erodible soils. Seasonal limitations exist for the construction of several of these structures, some of which are included in the specifications.

Where to Apply
Apply this BMP in areas where there is active or foreseeable erosion of the soils adjacent to a watercourse or wetland, and/or on steep slopes. Note that the construction and installation of these structures should not result in encroachment into the watercourse or wetland.

Relationship With Other BMPs

Areas up-slope of these structures should be stabilized with vegetation following the Seeding and Mulching or Sodding BMPs. In some instances, Diversions can be used to divert water away from these structures while they are being developed. Geotextile Filters are often used under these structures to filter sediment.

Specifications

General Considerations:
All slope/shoreline stabilization structures should be designed by licensed professional engineers, or other persons trained and experienced in their design.

1. All slope/shoreline stabilization structures should be free of sharp edges and protruding metals.

2. All structures require a site visit to determine the appropriate structure. During a site visit:
   - determine the soil texture and its inherent stability
   - determine the normal and storm surge water elevations
   - measure the length and (where appropriate) height of the area
   - consider the elevation of the proposed location for the new structure in comparison to the elevation of the existing shoreline

3. When designing structures, always try to follow the contour of the existing shoreline.

Revetments:
Revetments are stone, rock, interlocking blocks, gabions (see below), stacked bags (filled with sand or grout), or special mats, which are placed at the toe of a bluff to protect against storm/wave action. Revetments are cost effective, beneficial to the affected property owner, and do little or no harm to a lake environment *provided* the revetment material is clean, stable, and tied to existing structures and/or the shore.

General Considerations:
1. The three basic components of a revetment are the armor layer which absorbs the wave energy, the underlying filter layer supporting the armor layer, and the toe protection to prevent displacement of the armor units. All components should be designed simultaneously.

2. The stability of a revetment depends on the underlying soil conditions and should therefore be constructed on a stabilized slope. Erosion may continue or accelerate on an adjacent shore if it was formerly supplied with material eroded from the now protected area.

3. Slopes steeper than two horizontal to one vertical (2:1) are generally not suitable for revetments.

Design and Construction:

1. Riprap design and installation should be done following specifications in the Riprap BMP. Upon Department approval, consider installing fish habitat structures in conjunction with rock rip-rap to both stabilize an embankment and improve fish habitat.

2. Inter-locking blocks and honeycomb-shaped plastic sections which are backfilled with soil have been used successfully on steep slopes. The manufacturer's/suppliers listing in the Appendix of the "Guidebook to Best Management Practices for Construction Sites and Urban Areas" includes companies which carry these type of products.

Gabions:

Gabions are flexible woven-wire or plastic baskets composed of two to six rectangular cells filled with stone. They can be used in lakes and steep shorelines (or where river flow is such that riprap will not hold). The following is modified from "Guidelines for Soil Erosion and Sediment Control," Connecticut, 1985.

General Considerations:

Since gabions are used where erosion potential is high, construction must be sequenced so that the gabions are put in place with the minimum possible delay. Disturbance of areas where gabions are to be placed should be undertaken only when final preparation and placement of the gabions can follow immediately behind the initial disturbance. Always work at the low lake level (or low stream flow level).

Design:

Gabions may be used when all the following conditions are met:

a. The design storm, riprap size and location, filter and quality criteria for riprap are met.

b. The design water velocity does not extend beyond that given in Table 1, below.

Table 1

Design Water Velocity

Gabion Thickness (ft.)	Maximum Velocity* (ft./sec.)
1/2	6
3/4	11
1	14

*Maximum velocity is the velocity at the gabion (not, for example, the mean stream velocity.

Source: U.S. Department of Agriculture, Soil Conservation Service, Storrs, Connecticut.

c. The Manning's "n" value used for gabions shall be 0.025.

d. The pH of the soil and water is above 5, and the soil water resistivity is more than 4,000 ohms/cm, or plastic coated gabions shall be used.

e. A filter is required unless the gabion has a thickness of at least three times the D_{50} size of the rock used to fill the gabions.

f. The rock used to fill the gabions shall be larger than the gabion mesh opening.

g. Manufacturer's specifications are followed.

Construction:

1. Each gabion should be assembled by binding together all vertical edges with a continuous piece of connecting wire looped twice around the vertical edges with a coil approximately every four inches, except the mattress type where the coil should be approximately every three inches. Empty gabion units should be set to line and grade as shown on the plans. Connecting wire should be used to join the units together in the same manner as described above for assemble. Internal tie wires should be uniformly spaced and securely fastened in each outside cell of the structure. When gabions are being placed as slope protection or channel lining, the internal tie wires may be deleted.

2. Care should be taken when placing aggregate to assure that the sheathing on PVC-coated gabions will not be broken or damaged.

3. A standard fence stretcher, chain fall, or iron rod may be used to stretch the wire baskets and to maintain an alignment. After a gabion has been filled, the lid should be bent over until it meets the sides and edges. The lid should then be secured to the sides, ends and diaphragms with the connecting wire in the manner described above for assembling.

4. When the mattress type gabions are placed on 1.5:1 (or steeper) slope, steel stakes should be driven through the gabion along the top edge, as necessary, to hold the structure in place. Manufacturer's directions should be followed closely.

Seawalls and Bulkheads:

A seawall is a structure that is built to protect the landward side of a slope from damaging wave action or currents. Seawalls may be constructed with concrete, steel sheet piles or wood. Bulkheads have two functions. The first is to retain or prevent sliding of material seaward, and the second, to protect the upland against damage from wave action. The effects of seawalls and bulkheads on the entire reach of shoreline (or stream edge) must be evaluated.

General Considerations:

1. If the adjacent property has a seawall, a similar seawall in height and location should be used. It should tie into existing adjacent walls.

2. If the adjacent property is not seawalled, the proposed wall should tie into the shoreline and include tie backs into the upland. Tie backs should be riprapped at the shoreline to prevent erosion of adjacent properties.

Design:

1. The structure should be located and designed such that the structure will not create navigation safety hazards, debris traps, accelerated erosion of adjacent property, or any other problems.

2. The design should be appropriate for the site. Consider using materials similar to adjacent property owners. This will make the water line look more aesthetically pleasing.

3. Tie-backs must be designed to prevent erosion from water flow around the sides. Typical tie-backs extend 10 feet into the upland.

4. Bulkheads and seawalls that rise vertically well above a water or wetland surface may need to be equipped with ladders or escape measures in case of accidental falls by users.

Construction:

In general, for proper installation of steel or timber bulkheads, one-third of the wall should be above the lake bottom and two-thirds of the wall should be into the lake bottom.

Groins:

A groin is a shoreline protection structure which is usually situated perpendicular to the shore to trap soil for creating a beach on the up-drift side of the groin. These structures may consist of a single groin, or be combined with several groins to form a groin field. Careful design is needed to avoid adverse erosional effects on the down-drift side of a project.

General Considerations:

1. Groins by themselves will usually not provide adequate protection to the backshore area during a large storm. A wood retaining wall at the toe of the bluff may also be necessary to provide adequate protection.

2. Since groins may affect the "down-drift" area, the groin should be located and designed such that any erosion caused by the groin does not affect unprotected shoreline. Determine the new littoral transport direction by visual inspection of other groins in the vicinity, or review aerial photographs.

3. Spacing of groins depends on local wave energy and the amount of littoral drift. Groins should be spaced so that drift accumulates along the entire distance between the structures. (If the groins are too far apart, part of each compartment will be unprotected due to lack of accumulation. If the groins are too close together, not enough littoral material will accumulate in the compartments). As a rule of thumb, space groins from 1 - 1.5 times their effective length apart.

Design:

1. The proposed groin should not be longer than other groins in the vicinity.

2. Groins must be:
   - designed to cause the least damage to the down-drift side of the project
   - designed with no more than one foot above the current water level at the lakeward end
   - designed to extend into the face of the bluff or upland area
   - designed so that it is at least one-half of its length away from the property line. If this is not possible, then written consent must be obtained from the adjacent land owner.
   - constructed perpendicular to the shore

Groins constructed of wood or steel should extend 2/3 of the length of the material below the beach or lake bottom.

Construction:

Construction should be perpendicular to shore and should be done according to the design.

Breakwaters:

The function of breakwaters is to intercept incoming waves, dissipate their energy, and thus form a low-energy zone on the landward side. This reduction in wave energy reduces the ability of sediment transport. Sand moving along the shore is therefore trapped behind the structures and accumulated. Breakwaters are often placed as segmented structures that allow for the protection of longer reaches of shoreline for less cost.

Design:

The design and construction of breakwaters is usually done by or with the supervision of the U.S. Army Corps of Engineers.

Retaining Walls:

Retaining walls are used to stabilize steep slopes. They may made using riprap, railroad ties, gabions or other appropriate materials.

Maintenance

Annual inspections are important to check and re-align structures for functionability and safety. Check for hazardous materials or conditions which may have resulted from flooding, ice, or other weather conditions (i.e. look for sharp metal objects, signs of piping around structures, animal burrows, shifted and/or damaged materials within the structure, etc.).

Exhibits

Exhibit 1: Typical Revetment. Michigan Department of Natural Resources, Land and Water Management Division. Construction Project Evaluation Manual.

Exhibit 2: Gabions. Virginia Soil Erosion and Sediment Control Handbook. 1980.

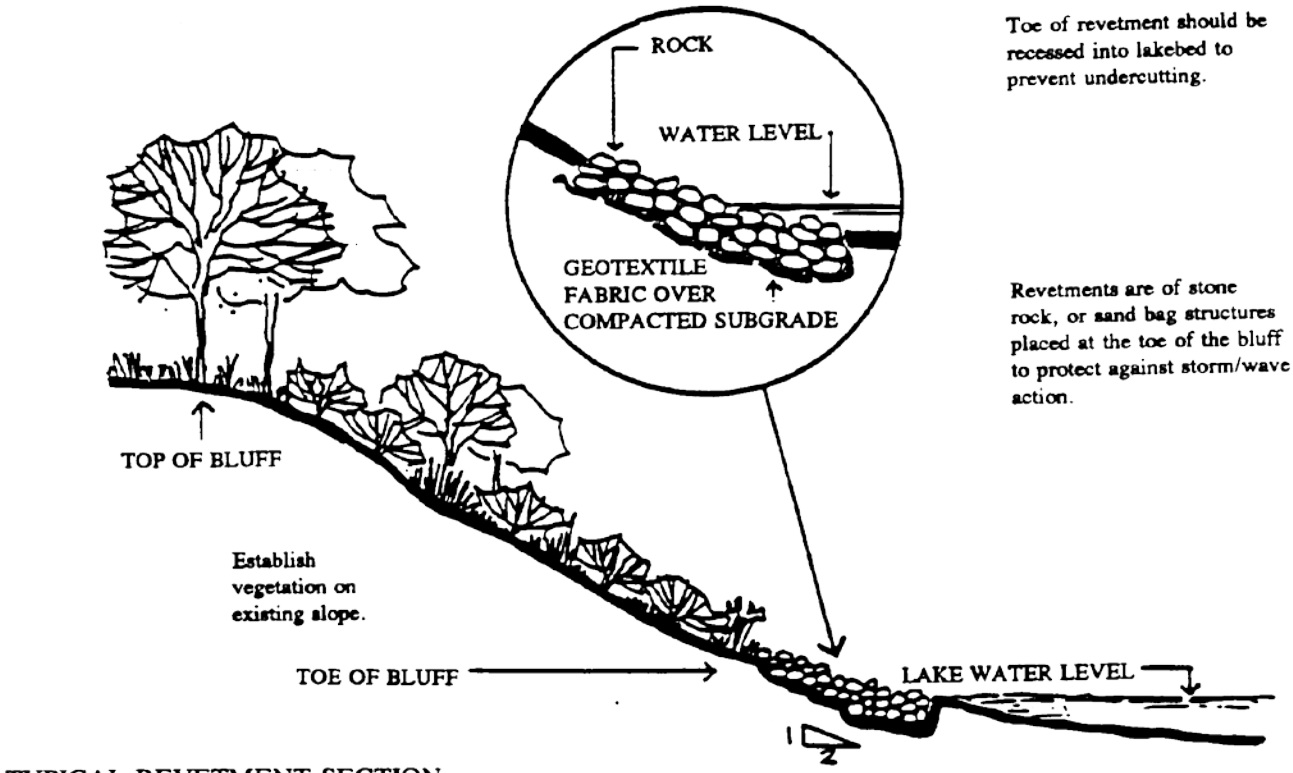
Exhibit 3: Seawalls: Four Situations and the Type of Structures Required. Michigan Department of Natural Resources, Land and Water Management Division. Construction Project Evaluation Manual.

Exhibit 4: Groins. Michigan Department of Natural Resources, Land and Water Management Division. Construction Project Evaluation Manual.

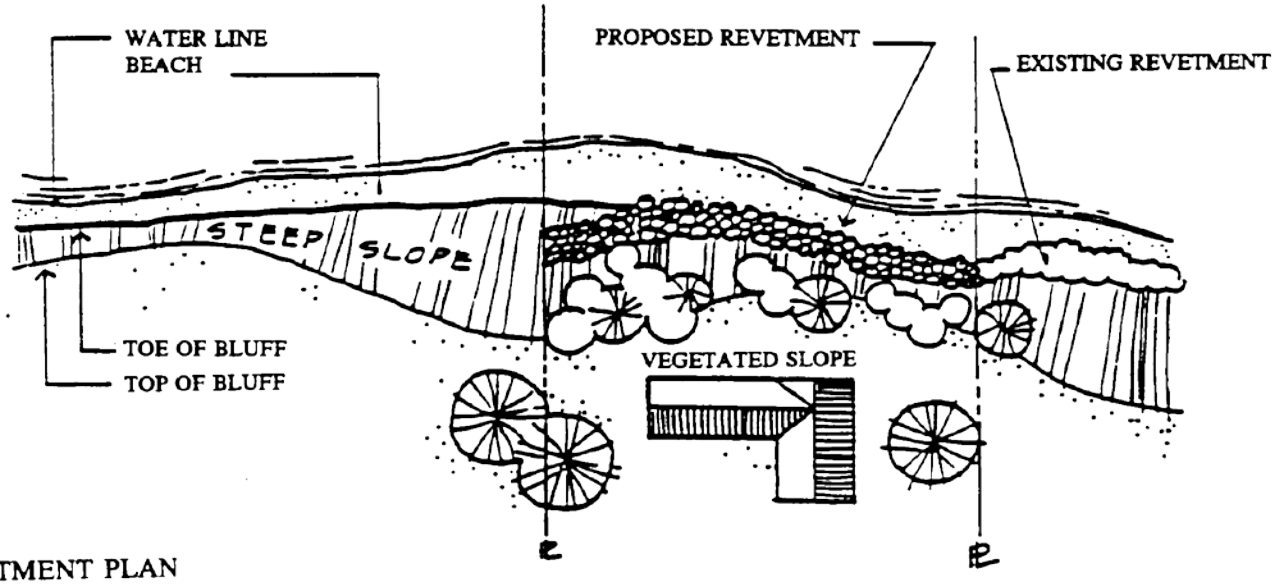
Exhibit 5: Retaining Wall. Michigan Soil Erosion and Sedimentation Control Guidebook. 1975.

Exhibit 1

Typical Revetment



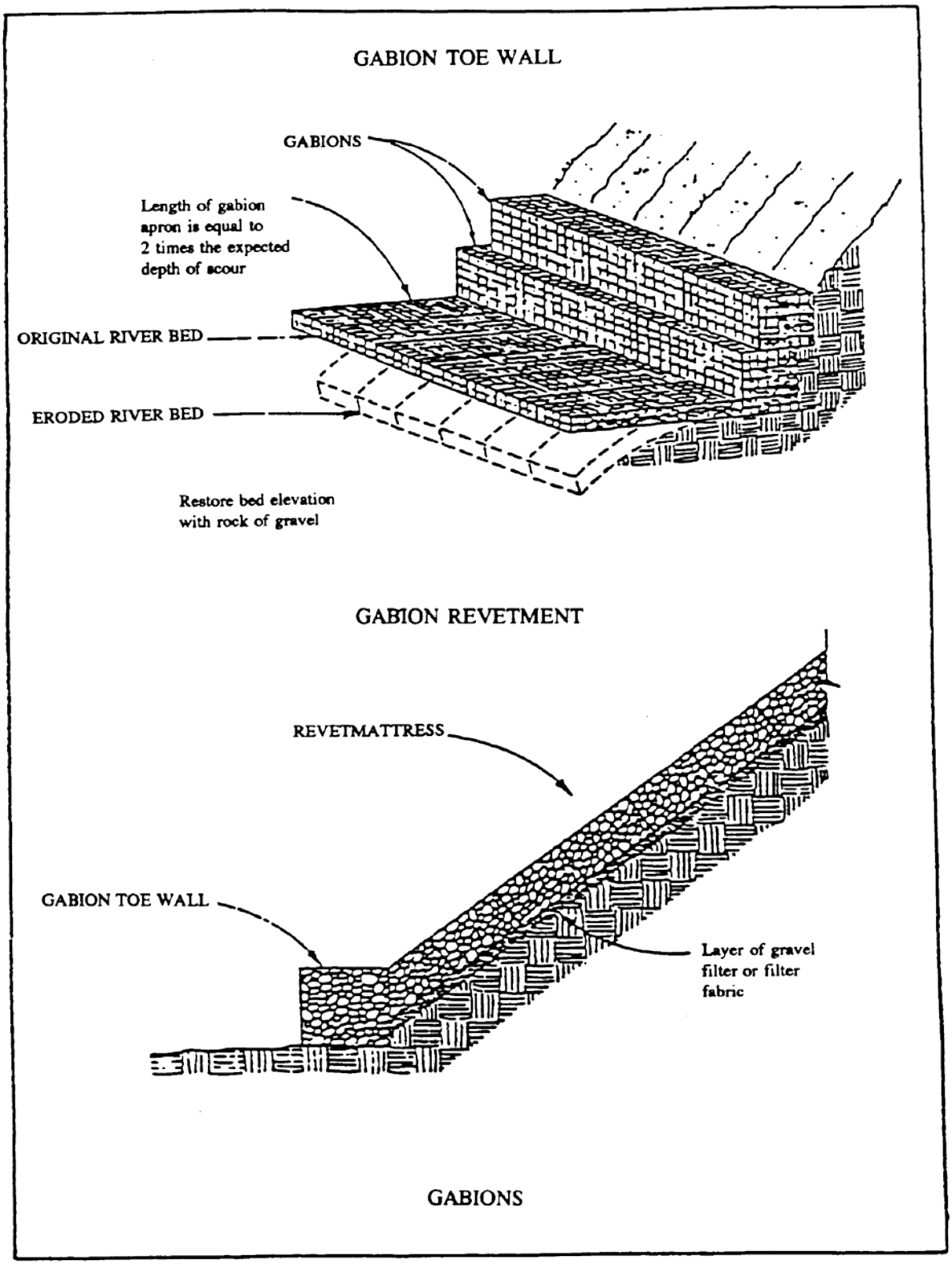
TYPICAL REVETMENT SECTION



REVETMENT PLAN

Source: Construction Project Evaluation Manual. MDNR, Land and Water Management Division.

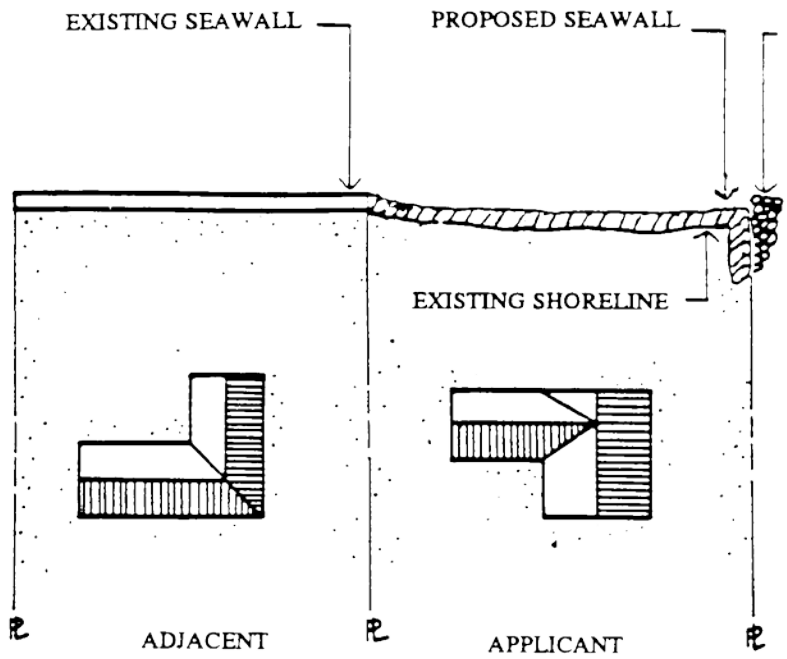
Exhibit 2
Gabions



Source: Virginia Soil Erosion and Sediment Control Handbook, 1980.

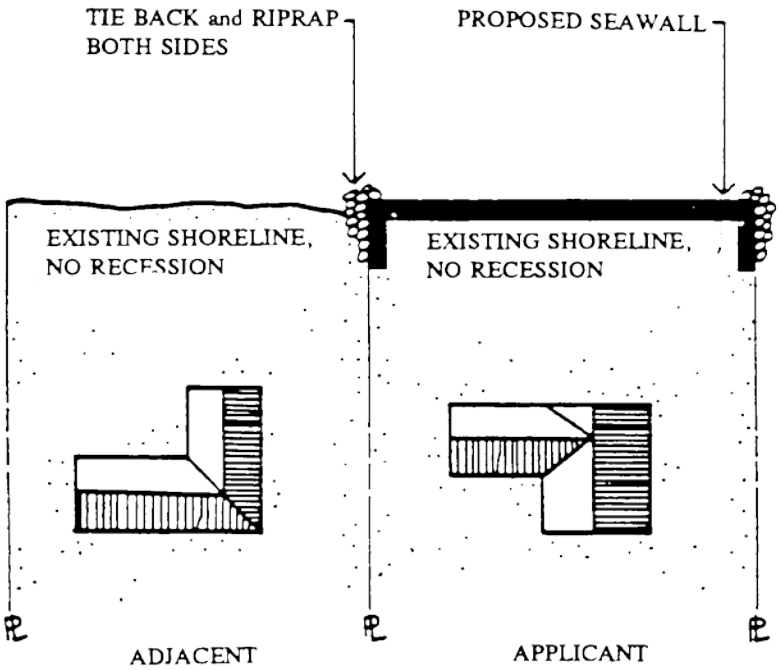
Exhibit 3

Seawalls: Four Situations and the Types of Structures Required



CONDITION ONE

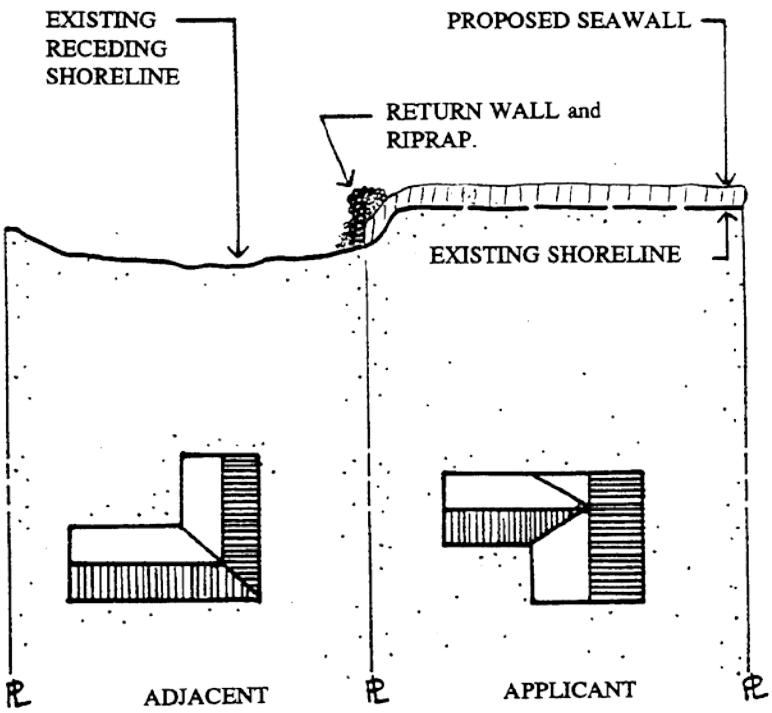
If adjacent shoreline has a seawall, a similar seawall in height and location should be used. Where possible, try to contour the new seawall with the existing shoreline, and use similar materials.



CONDITION TWO

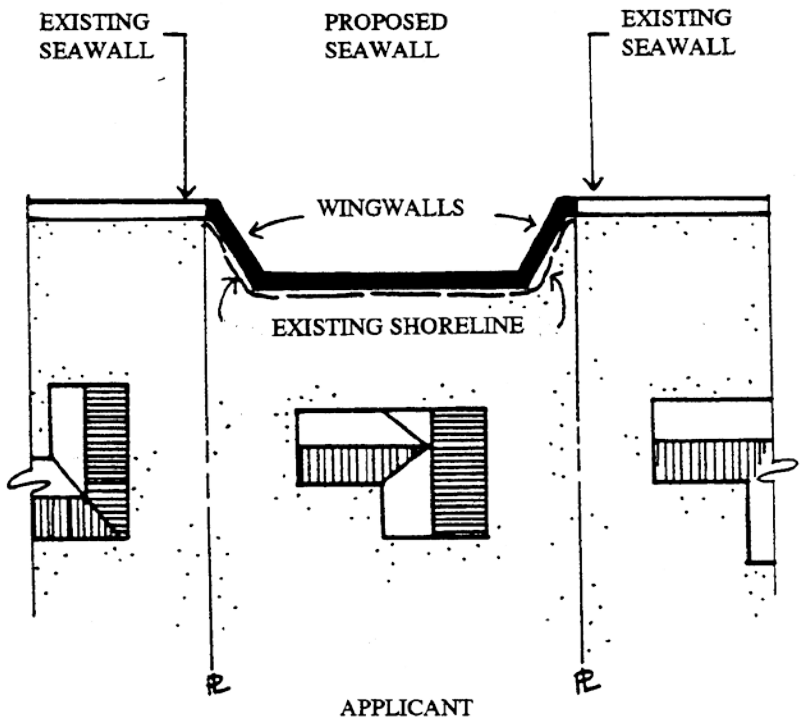
If adjacent shoreline has not recessed, a seawall parallel to the shoreline is required.

Exhibit 3 (Con't)



CONDITION THREE

If adjacent shoreline is recessed, a return wall is required.



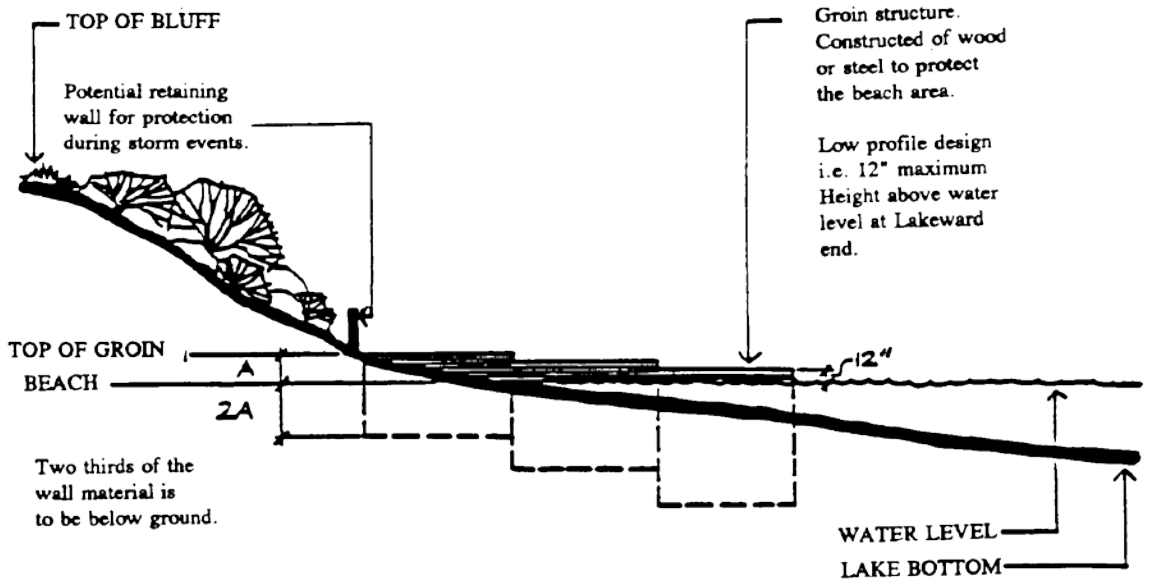
CONDITION FOUR

If adjacent shorelines have seawalls and existing shoreline has recessed significantly, a seawall with wingwalls is required.

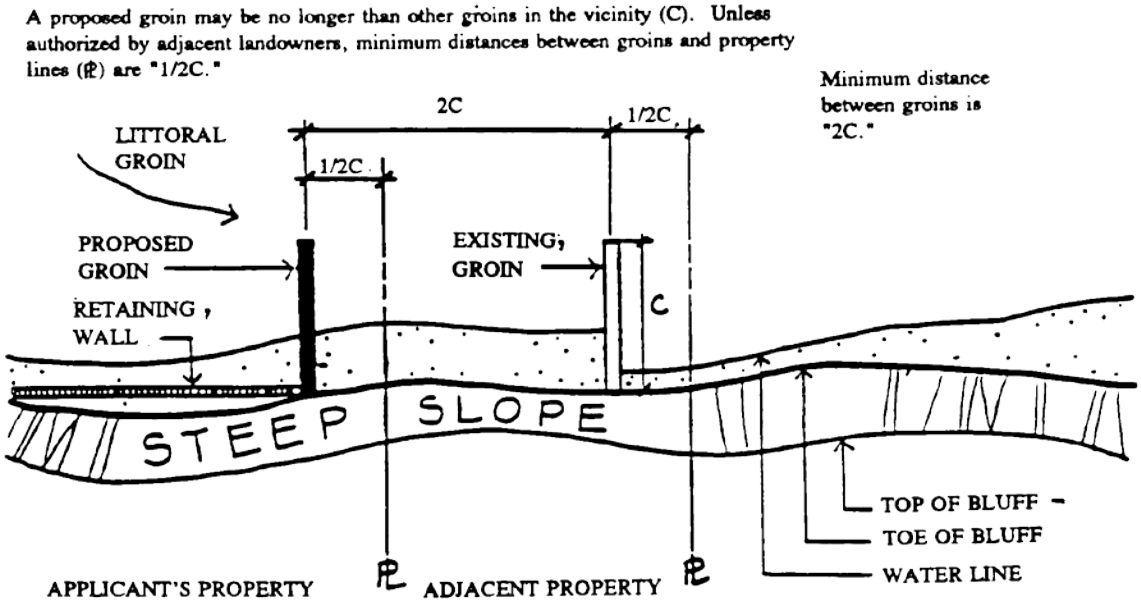
Source: Modified from the Construction Project Evaluation Manual, Michigan Department of Natural Resources, 1987.

Exhibit 4

Typical Groin



TYPICAL GROIN SECTION

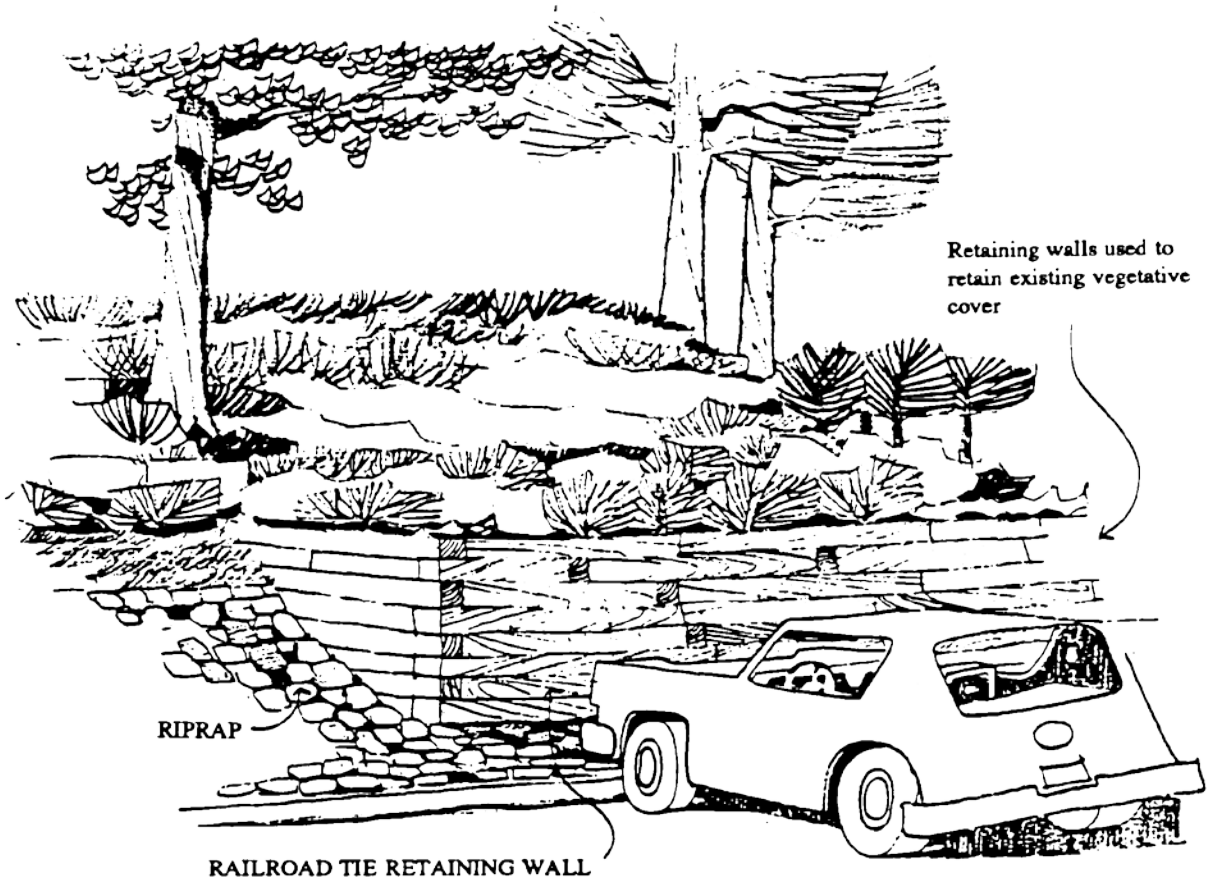


GROIN PLAN

Source: Construction Project Evaluation Manual, MDNR, Land and Water Management Division.

Exhibit 5

Retaining Wall



Source: Construction Project Evaluation Manual. MDNR, Land and Water Management Division.

Dec. 1, 1992

Street Sweeping

Description

Street sweeping involves the use of specialized equipment to remove litter, loose gravel, soil, pet waste, vehicle debris and pollutants, dust, de-icing chemicals, and industrial debris from road surfaces. Street sweeping equipment can consist of a truck or truck-like vehicle equipped with multiple brushes, pick-up deflector, holding bin, water sprayer, vacuum nozzle and filter, or a combination of some or all of these features.

Pollutants Controlled and Impacts

When done regularly, street sweeping can remove 50-90% of street pollutants that potentially can enter surface water through storm sewers. Street sweepers will also make road surfaces less slippery in light rains, improve aesthetics by removing litter, and control pollutants which can be captured by the equipment.

Application

Land Use
Transportation, urban

Soil/Topography/Climate
Street sweeping is not effective on snow covered roads.

When to Apply
Street sweeping is typically done in the early morning hours when traffic is light. It is sometimes necessary to control parking by placing signs which limit the hours or the side of the street in which parking is allowed.

Where to Apply
Street sweeping is applicable on urban streets with curb and gutter, or paved drainageways.

Relationship With Other BMPs

Sweeping is recommended at least four times per year on all Porous Asphalt Pavement. Street sweeping in some areas may decrease the frequency in which Catch Basins need to be cleaned.

Specifications

General Considerations:

1. Approximately 90% of the contaminants will accumulate within 12 inches of the curb, therefore, only one sweep is generally necessary to remove contaminants.

2. When replacing gutters or constructing new ones in urban areas, consider installing broader concrete gutters to increase street cleaning efficiency.

3. Damaged pavement is not possible to clean effectively and should be resurfaced in areas where street cleaning is done.

4. Use vacuum sweepers on dry pavement only.

Frequency of Sweeping:
The frequency in which street sweeping should be done is very controversial, and the schools of thought range from "not at all" to "every other day." Some studies have shown that street sweeping may have a negative effect by breaking down aggregated particles (clumps of particles) into fine particles which can be carried more easily by runoff. We feel that the goal of street sweeping should be to keep the larger-sized pollutants from entering storm sewers.

We recommend street sweeping:

-after heavy rain storms in which sediment is present on the streets; and

-adjacent to construction sites where sediment has left the site and entered the street; and

-at least once during the fall to collect leaves and keep them out of the sewer system; and

-at least once during the spring to collect garbage and coarse sediment left behind during snow melt.

The effectiveness of street sweeping appears to be primarily dependent upon the frequency of sweeping and the interval between storms. Additional considerations are operator skill and the number of cars parked at the curb. Other factors in order of importance are: total mass of the area to be swept and its relation to loadings on other areas not accessible to sweepers; the efficiency of sweepers compared to the storm runoff of the pollutant of interest; and local storm characteristics.

Types of Sweepers:
Street sweeping effectiveness is a function of sweeping frequency, number of passes per sweeping, equipment speed and pavement conditions. Below are two types of street sweepers. Keep in mind that street sweeping equipment is manufactured by more than one company and each company competes for design efficiency.

Mechanical broom street sweepers are effective in removing larger particles, but are not effective in removing fine, pollutant-laden dust and dirt (smaller than 400 microns). These small particles contain the majority of pollutants found on the streets (i.e. oxygen demanding substances, nutrients, metals, oils). The removal efficiency for these machines is 50%, assuming a smoothly paved surface, particles greater than 400 microns, and the absence of parked vehicles. These are less expensive to operate than vacuum sweepers.

Vacuum-type street sweepers are more efficient in removing dust and dirt particles (about 90%) than mechanical broom sweepers. However, vacuum sweepers are ineffective when the pavement is wet.

Maintenance

In order to increase the effectiveness of street sweeping, roads should be kept well-surfaced.

Dec. 1, 1992

Trees, Shrubs and Ground Covers

Description

This BMP addresses the selection and maintenance of woody plant materials, including trees, shrubs, and ground covers. Seed selection is discussed in the Seeding BMP, and sod selection in the Sodding BMP.

Trees, shrubs and ground covers can be used on steep or rocky slopes where mowing is not feasible. Once trees, shrubs and ground covers are well established they:

-help stabilize the soil, reducing both wind and water erosion
-reduce stormwater runoff by intercepting rainfall and promoting infiltration
-filter pollutants from the air and produce oxygen
-moderate temperature changes and provide shade
-provide some privacy
-improve aesthetic values and increase property values

In addition, ground covers can provide stabilization in areas which are heavily shaded.

Other Terms Used to Describe

Landscape Planting
Landscaping

Pollutants Controlled and Impacts

Tree, shrub and ground cover plantings: protect the soil from wind and water erosion, thereby reducing sedimentation in surface waters; utilize nutrients, thereby minimizing nutrient loading to surface water and nitrate leaching to groundwater; and filter soil that has eroded.

Application

Land Use
The BMP is applicable to all land uses.

Soil/Topography/Climate
Soils, topography and climate will all be considerations in selecting the appropriate trees, shrubs and ground covers for the site.

When to Apply
Plantings are usually done in the spring or fall, based on the following dates and depending on the type of vegetation.

Spring: April 15 - May 30
Fall: September 1 - October 30

Winter and summer plantings are generally not as successful.

Where to Apply
Apply at all sites where landscape planting will minimize soil erosion and/or enhance aesthetic values.

Relationships With Other BMPs

This BMP should also be used when trees, shrubs or ground covers are accidently damaged during Land Clearing operations. Trees, shrubs and ground covers are often incorporated into sites which need Critical Area Stabilization.

Specifications

Planning Considerations:
Wherever possible, **preserve existing woody vegetation.** Existing vegetation is more aesthetically pleasing, costs less than purchasing new species, and provides immediate shade, canopy and habitat. The identification of trees which should be preserved is discussed in the Tree Protection BMP.

For New Plantings:
1. Selection of appropriate species should be based on the following:

   Soil texture. Some species will grow best in certain soil textures. Information on soils for many counties is available from the local Soil Conservation District office. The Appendices include an update of the soils information that has been entered in the Department's land resources database.

   Soil tests may be needed to determine if nutrients or fertilizers need to be added to the site. All additions to the soil should be based on the results of soil tests. Follow the specifications in the Soil Management BMP.

   Exhibit 1 can be used as a starting point for selecting trees and shrubs based on soil conditions.

   Exhibit 2 can be used as a starting point for selecting ground covers based on soil conditions.

   Drainage classification. Drainage classification is reflective of the soil moisture condition of the soil. For example, species such as white birch will grow best if soil moisture is high. Other species such as Jack pines will "drown" and die in soils of high water content. Be sure to take the drainage classification of soils into consideration when selecting tress and shrubs.

   Native species. The type of vegetation which exists in the area is a good indicator of plants which will likely have good survival rates. These indicator species provide information on soil texture, drainage class, and fertility. Native vegetation or plant materials with similar

requirements can then be used.

Purpose (Use). The purpose for which the plant is being used should also be considered. If the plant is being added for shade, trees with fuller canopies should be selected. If the plant is being added to control soil erosion, then its rate of growth, type of root system, ground covering characteristics, and spacing between plants are important factors.

2. Because of the spacing required between many shrubs and trees, and because it takes time for most woody species to "take hold," soil erosion between plants may occur. To prevent erosion, mulch all sites which will be planted with woody species. See the Mulching BMP.

3. On steep slopes, stagger plantings and consider using erosion control mats or netting prior to placing to keep soil from eroding. Mats and netting should be slit to accommodate the shrubs. See the Filters BMP for information on the proper selection of nets and mats.

4. For areas in which trees or shrubs will be planted, any seeding that is done to help stabilize the area should consist of the least competitive plant species. Species such as tall fescue, which produces vigorous early growth, is highly competitive with tree seedlings and therefore should not be used. Species such as annual lespedezas, which starts growing relatively late in the spring, is much less competitive.

5. Any pruning that needs to be done should be completed before planting occurs and should be done by persons experienced in pruning.

   For deciduous trees: Prune to balance the loss of roots so as to retain the natural form of the plant type. The height ratio of the crown to the trunk after pruning should be approximately one-third crown to two-thirds trunk. The primary leader should not normally be cut back. Branches to be removed should be cut off flush with the trunk or main branch.

   For deciduous shrubs: Prune by removing all dead wood and broken branches, thinning out entire canes where they are too thick, cutting back or removing unsymmetrical branches and sufficient other growth to ensure healthy and symmetrical growth of new wood. Shrubs should be pruned so that they form a loose outline conforming to the general shape of the shrub type.

   Evergreen trees and shrubs: Evergreens should be pruned only to remove broken or damaged limbs.

6. In windy areas or where plantings will be done in stages, always begin planting on the windward side and progress across the area as it is being stabilized. Stagger trees in rows.

Trees:

Selecting Individual Trees:

Large nursery trees usually come with the roots and attached soil wrapped in burlap. As a rule of thumb, the soil ball of containerized and burlapped trees should be 12 inches in diameter for each inch of trunk diameter. Keep the soil around the roots moist until the tree is planted. Bind branches with soft rope to

prevent damage during transport.

Smaller nursery trees are usually sold in plastic containers as balled and burlapped stock, or as bare-root stock (seedlings):

Container-grown plants should have grown in the container for at least one growing season. If plants have been in the container too long they will show "pot-bound" root ends.

Balled and burlapped plants should be planted prior to "bud break." If planted in the fall, balling operations should not begin until after the plants have begun to "harden off." All plants should be dug and transported so that the ball is moist, and protected from rain or sudden changes in the weather.

Bare-root plants should only be handled in early spring, late fall or late winter. These plants should meet the following criteria to prevent a high rate of mortality:

Seedlings should be fresh smelling. Sour odor indicates that the seedlings have been stored too long and have begun to rot. Trees stored at correct temperatures will be free of mold.

The roots must be moist and glistening white when stripped of bark. Using a knife or fingernail, strip the bark off the root, working from base to tip. If the roots appear yellow, brown or have brown spots, the stock is badly damaged and has little chance of survival. Check the roots of several seedlings.

Buds must be firm, with no evidence of new growth.

Seedlings should be packed and shipped in wet moss or other medium, and kept cool (less than 34 degrees F) and moist prior to and throughout the planting process. Moss-packed seedlings should be kept in their container and kept moist. Clay-packed seedlings should not be watered, but should be covered with burlap if they are not to be planted soon after they are purchased.

Store packages of seedlings in a shaded location out of the wind.

Seedlings should be planted as soon as possible after they are received. If planting is delayed longer than four days after seedlings are received, "heel" the seedlings in a shaded area and keep moist. To heel in seedlings, dig a trench in soil that is shaded or in a well-ventilated enclosure. Place seedlings in the trench and cover the roots with soil. Replant when planting conditions allow.

Site Preparation:

Dig a hole at least deep enough and wide enough to hold the entire root ball. The final level of the root ball's top should be level with the ground surface. Keep topsoil separate from the subsoil. If the soils are clay, dig a deeper hole and backfill with some of the topsoil.

Planting:

Although the planting seasons for deciduous plants is between March 1 and October 1 or until the prepared soil becomes frozen, spring and fall are the best times to plant. Planting of evergreens should occur between March 1 and June 1, before new growth occurs.

Trees in containers and burlap will need to be planted individually. See Exhibit 3 and follow the steps below:

Trees in containers should be removed carefully so that all roots and soil remain attached. It may be easiest to cut the container. On balled and burlapped trees, loosen the twine and burlap at the top and check to make sure no other wrapping is present before planting.

Depending on the type of subsoil, it may be beneficial to mix a little peat moss into the soil. The

dug hole should be such that the plant is planted at the same depth as the original container.

Add water to settle the soil and eliminate air pockets. Once the water is drained off, lower the tree into the hole, backfill half way, and pat firm. Water again. Once the water is drained again, remove the burlap from ball and burlapped trees from around the trunk and the upper half of the ball. Fill the hole so that it is filled even with the ground line.

Backfill the hole and pat the soil firm. Leave a small depression around the tree so that water can run into the depression.

Add mulch around the tree to reduce competition from unwanted vegetation and to help prevent roots from drying out.

Bare-root seedlings should not be pruned prior to planting, except for broken or damaged roots. Plants can be planted either by hand or by machine. On large sites where slopes do not prohibit machinery, bare-root seedlings can be planted in furrows using a tree-planting machine.

A method of hand planting bare-root seedlings is shown in Exhibit 4. Plants should be set at a depth equal to the depth in their original location. The exposed roots should be held firmly in the proper position, with the roots spread out. The prepared soil should be watered around the roots and thoroughly firmed at intervals during the process of backfilling. Sufficient water should be used to ensure the soil is thoroughly saturated.

Spacing and Rates of Planting:
The proper spacing and rates of planting various tree species are shown in Exhibit 5.

Tree seedlings should *not* be fertilized during the first 12 months following planting because fertilizer tends to dehydrate newly planted trees.

Mulch between plants to prevent soil from eroding. Follow specifications in the Mulching BMP.

Plants Located on Slopes:
For plants located on slopes, a berm of prepared soil should be constructed halfway around each plant on the down-slope side. The berm of prepared soil should have an inside diameter equal to that of the planting hole, and a maximum height of 6 inches. Soil should not spill down-slope more than 18 inches.

Wrapping trees:
Trees should be wrapped within one week following planting. Trunks should be carefully wrapped beginning at the base of the trunk just above the roots and below the normal ground line, and should extend upward in a spiral with an overlap of one-half the width of the strip. The portion of the wrapping below the finished grade should be covered with soil. The paper should be held securely in place with masking tape.

Staking trees:
Newly planted trees often need to be staked for support. Trees which need to be staked should be secured with stakes and guy wires. Cushion the tree against the wire by placing old garden hose or equivalent between the tree and wire. See Exhibit 3.

Shrubs:

Selecting Shrubs:
For erosion control purposes, and when more than one species can be used, make the final species selection using the following characteristics:

-fast growing
-easy to establish
-have large lateral spread or prostrate growth (i.e. will grow outwardly to provide more cover)
-disease and insect resistant
-ability of the roots to fix nitrogen
-adaptation to a broad range of soil conditions

Like small trees, nursery shrubs usually come in plastic containers or as bare-root stock.

Site Preparation and Planting:
Follow the tree planting procedures for "Trees in containers and burlap," above. See Exhibit 3. Space shrubs approximately three feet apart.

It is important to mulch the entire area to keep other plants from competing with the desired plant and to cover exposed soil. See the Mulching BMP for mulching specifications.

Ground Covers:

Selecting Ground Covers:
When ground covers are to be used to help stabilize soils, select fast-growing, evergreens that require little maintenance.

Site Preparation:
The dense growth of ground covers requires that they have good soil. Well-drained soils high in organic matter work best. Make soil additions based on the results of soil tests. See the Soil Management BMP.

On steep slopes, till the soil in contour rows, or dig individual holes for each plant. Blend soil additions into the soil.

Planting:
Most ground covers are planted from container-grown nursery stock. Transplanting to the seedbed can be done using a small trowel or spade. Dig a hole large enough to accommodate the roots and soil. Backfill and firm the soil around the plant. Water immediately.

Space between plants based on how quickly full cover is achieved, usually between 1 and 3 feet apart.

Like with trees and shrubs, ground covers will be better protected from competitive species if the area is mulched. See the Mulching BMP for mulching specifications.

Maintenance

For New Plantings:

1. Check survival the first and second year and replant where survival is poor.

2. Where needed, control competing vegetation the first 2 or 3 years, preferably by mulching or cultivating.

3. Exclude livestock from all plantings.

For All Trees, Shrubs and Ground Covers:

Trees:
Seedlings are subject to competition with invading grasses and other vegetation. For hardwoods, vegetation must be controlled for at least three growing seasons. For conifers, vegetation must be controlled for at least two growing seasons. Mulch to prevent competition, or mow or clip competitive vegetation, where possible. Use herbicides only where mulching has failed and mowing and clipping are not possible. Follow guidelines in the Pesticide Management BMP.

Where soil tests indicate fertilizers are needed, fertilize in late fall or early spring before leaves emerge. For evergreens, use only 1/2 the recommended amount of fertilizer. Use a punchbar, crowbar or auger. Make holes about 18 inches deep and about 2 feet apart around the drip line of each tree. Distribute fertilizer evenly among the holes to bring it in contact with trees roots. Store and mix fertilizers following specifications in the Fertilizer Management BMP.

Ideally, newly planted trees should receive an inch of water each week for the first two years after planting. When rain does not supply this need, and where possible, the tree should be watered deeply but not more often than once per week.

Trees should be protected and unhealthy limbs cut following procedures in the Tree Protection BMP. Train and prune black walnut and other hardwoods to produce straight, single stemmed trees.

Christmas tree shearing should begin after the third year. Refer to the Soil Conservation Service Technical Guide, #660, Woodland Pruning.

Shrubs:
Maintenance of shrubs, including watering and fertilizing, depends upon the species. Maintain mulch around the base of each plant to reduce weed competition and retain moisture. See the Mulching BMP. Fertilizers are usually needed only once every 3 years or so, depending on the results of soil tests.

Pruning should be done as needed to remove dead limbs.

Ground Covers:
Most ground covers need yearly trimming to promote growth. Trim back from trees, flower beds, fences, and buildings. Add additional mulch as needed until the area is completely stabilized. Like shrubs, fertilizers may only be needed once every 3-4 years, depending on the results of soil tests.

Organic Debris Disposal:
Any organic debris which results from pruning, trimming or any other vegetative maintenance should be disposed of following specifications in the Organic Debris Disposal BMP.

Exhibits

Exhibit 1: Selecting Trees and Shrubs. USDA Soil Conservation Service Technical Guide, #342.

Exhibit 2: Selecting Ground Covers. USDA Soil Conservation Service Technical Guide, #342.

Exhibit 3: Planting Balled-and-Burlapped and Container-Grown Shrubs and Trees. North Carolina "Soil Erosion and Sediment Control Planning and Design Manual," as modified from the Virginia Division of Forestry.

Exhibit 4: A Method for Planting Bare-Root Seedlings and Sprigs of Grasses. Modified from the North Carolina "Erosion and Sediment Control Planning and Design Manual."

Exhibit 5: The Proper Spacing and Rates of Planting. USDA Soil Conservation Service Technical Guide, #612.

Exhibit 1
Selecting Trees and Shrubs

Soil Condition	Trees[1]	Shrubs[2]
1. Well and moderately well drained sand and loamy sand (coarse textured soils)	Austrian pine Jack pine* Red pine White pine* Black locust Cottonwood	Autumn olive Hawthorn Crabapple Tatarian honeysuckle Staghorn sumac Serviceberry
2. Well and moderately well drained, moderately coarse to moderately fine textured soils (sandy loam, loam, silt loam and clay loam)	Red pine White pine* Cottonwood Norway spruce* Jack pine* White spruce* Black locust Sugar maple*	Gray dogwood Autumn olive Crabapple
3. Well and moderately well drained clay and silty clay (fine textured soils)	White pine* Norway spruce* Black locust White spruce* Sugar maple* Red pine Cottonwood	Silky dogwood Tatarian honeysuckle Autumn olive Crabapple
4. Excessively wet (poorly drained) organic soils	Northern white cedar* White spruce* Red maple Silver maple Green ash Swamp white oak* Pin oak**	American cranberry bush Redosier dogwood Gray dogwood "Indigo" silty dogwood Nannyberry Viburnum
5. Excessively wet (poorly drained) mineral soils	Northern white cedar* Silver maple Green ash**	Nannyberry Viburnum "Indigo" silky dogwood Redosier dogwood American cranberry bush
6. Excessively wet (poorly drained) pH>7.4	Northern white cedar* White spruce* Green ash**	Nannyberry Viburnum

[1]For other species, refer to section II-H of the SCS Technical Guide, or the appropriate county soil survey, as available from the USDA Soil Conservation Service.
[2]Indicates species best suited for wildlife food or cover.
*Indicates species best suited for wildlife food or cover.
**Tamarack and willow may also be used, where available.

Source: USDA, Soil Conservation Service Technical Guide #342

EXHIBIT 2
SELECTING GROUND COVERS

Plant	Height (inches)	Sun	Partial Shade	Shade	Soil	
Buglewood (carpet bugle) (Ajuga reptans)	4 to 8	X	X	X	most soils	One of the best perrenials; spreads rapidly. Parent plant has deep deep green foliage, blue flowers. Gaiety and Metallica Crispa varieties have bronze-purple leaves. Silver Beauty's foliage is cream and light green. Alba is white-flowered.
English Ivy (Hedera helix)	6 to 8	X	X	X	rich, well-drained	Semievergreen to evergreen; covers large or small areas. Look for improved varieties: Baltic, Thornapple, Wilson and others.
Japanese Spurge (Pachysandra terminalis)	up to 6		X	X	fertile, moist	Universally popular evergreen herb. Some plants have small, spiked white flowers sometimes followed by white berries in the fall. Improved forms Green Carpet, Silver Edge.
Juniper* (Juniperus hortizontalis)	12 to 18	X	X		dry areas	Creeping, soft-textured plant; light green to steel blue needles frequently turn purple in winter. Waukegan variety is good. Japanese garden variety is very compact.
Juniper* (J. sabina tamariscifolia)	up to 24	X	X		dry areas	Sometimes called Tamarix Savin juniper. Needle-like silver-green leaves. A good spreader for slopes; use as foreground for deciduous trees or complete ground cover.
Lily-of-the-Valley (Convallaria majalis)	6 to 10		X	X	rich, moist	Fragrant white bell-like flowers; Rosea variety has purplish-pink flowers.
Periwinkle (myrtle) (Vinca minor)	up to 6		X	X	moist, well-drained	Almost universally used. Dislikes humid conditions. Good on slopes, level land or as a backdrop for bulbs. Bowles, a superior variety, has glossier leaves, larger blue flowers. Golden Bowles has gold and yellow foliage with white flowers.
Stonecrop, Goldmoss (Sedum acre)	up to 4	X	X		stony, sandy, dry	Mats of tiny foliage, good between stepping stones and in crevices. Spreads rapidly and can become a weed in grass. The sedum variety, Dragon's Blood, is known for its reddish-brown inch-high foliage and carmine flowers.
Sedum album	up to 4	X	X		sandy, well-drained	Forms mats of attractive dark-green to red foliage on creeping stems. Not as likely to invade grass areas as stonecrop.

* Indicates species best suited for wildlife cover.
Source: USDA, Soil Conservation Service Technical Guide #342.

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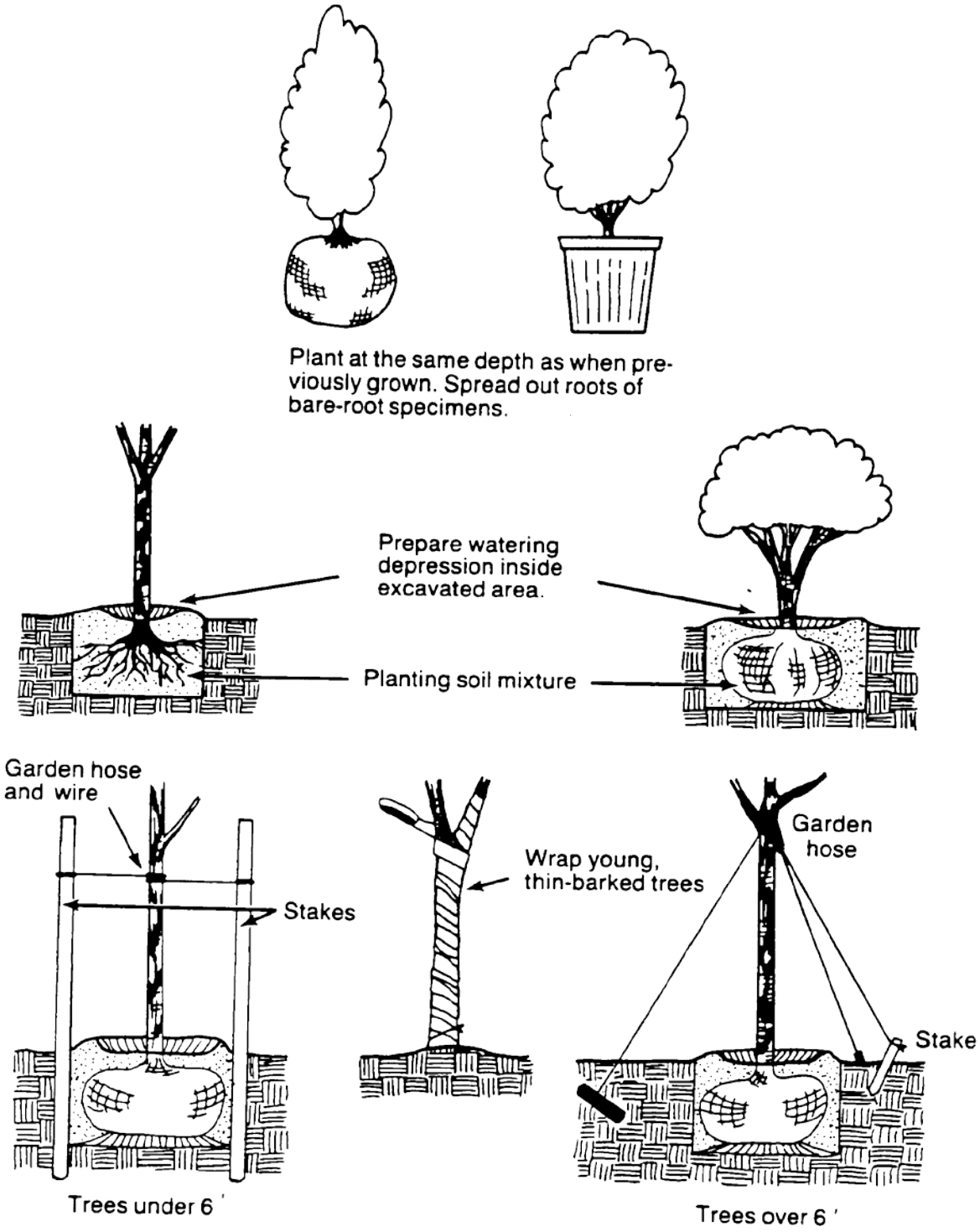
Exhibit 3

Planting Balled-and Burlapped and Container-Grown Shrubs and Trees

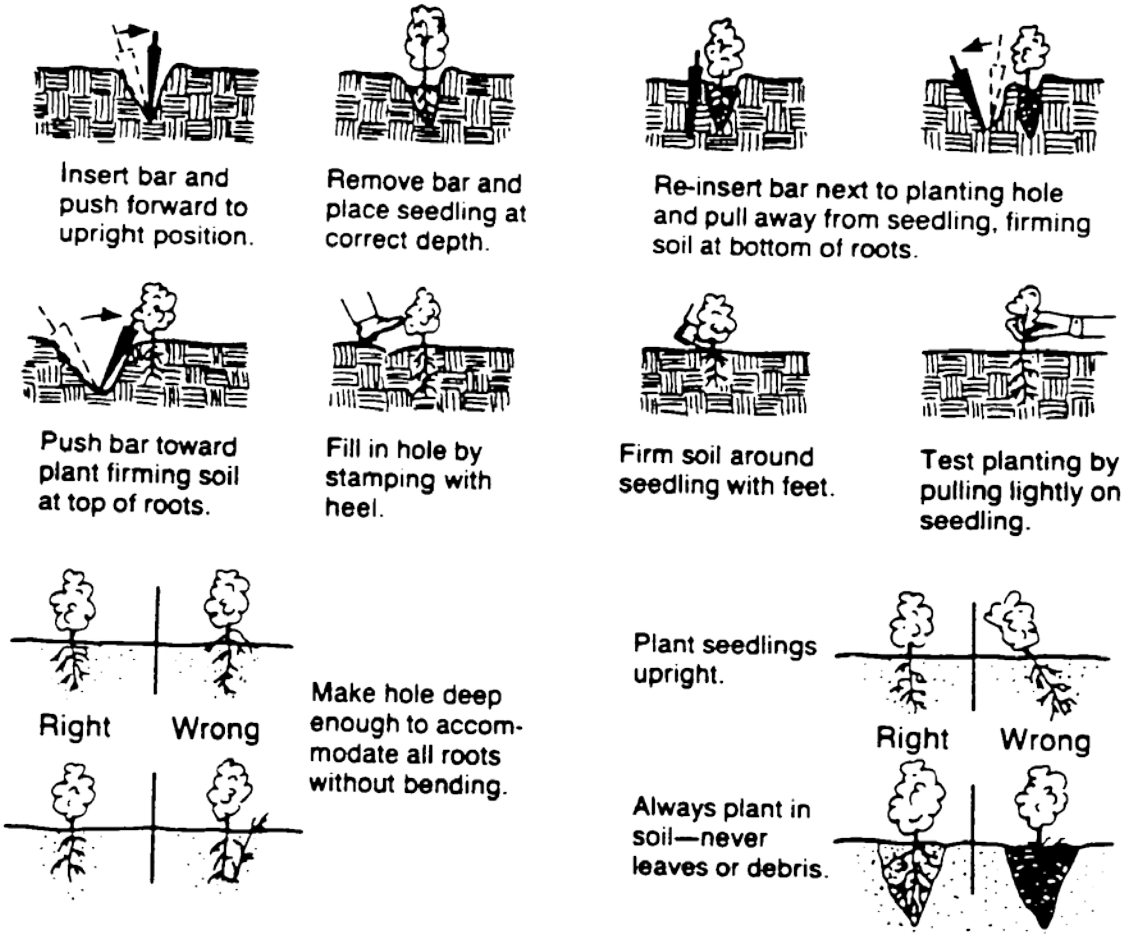


Source: North Carolina Erosion & Sediment Control Planning & Design Manual, as modified from the Virginia Division of Forestry.

Exhibit 4

A Method for Planting Bare-Root Seedlings and Sprigs of Grasses

A method of hand planting bare-root seedlings and sprigged grasses is shown below. With a planting bar/iron or shovel/spade, make a notch in the soil no less than 8 inches deep. Place the roots in the notch to the same depth as the plant was in its original growing container. Firm soil around the roots by pressing the notch closed. Water immediately, and mulch, where necessary, within 2 feet of the plant. Since fertilizers tend to dry out young seedlings, do not fertilize bare-root seedlings until the end of the first year.



Source: North Carolina Erosion and Sediment Control Planning and Design Manual, as modified from the Va. Div. of Forestry.

Exhibit 5

Spacing and Rates of Planting Several Tree Species

Species	Recommended Spacing (Open Planting)		Approx. No. Trees Needed	Acceptable Range
	Between Rows	In Rows	Per Acre	In Rate Per Acre
Jack Pine	8 feet	5 feet	1,050	900-1,200
Spruce & N. White-Cedar	8 feet	6 feet	900	800-1,000
Red Pine	8 feet	7 feet	800	700-950
White Pine	8 feet	7 feet	800	700-950[1]
Hardwood Trees (including black walnut)	10 feet	10 feet	430	400-500[2]
Hardwood Shrubs	6 feet	5 feet	1,450	1200-1800

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[1]Planting white pine is recommended primarily for understocked wooded areas from Jackson County north because of the white pine weevil. The number of seedlings required for interplanting on a per acre basis will usually be less in a wooded area. Most seedlings should be planted in the small openings where they will have significant amounts of sunlight. From Jackson County south, planting white pine in open fields is an acceptable practice, as well as interplanting.

[2]The spacing for hardwood trees depends upon several factors. Hardwood trees will not grow and develop well when spaced as closely together as conifers; however, competing vegetation is much more detrimental to hardwood plantations particularly in the establishment period. The closer spacing is recommended where the vegetation will only be controlled for approximately 3 years. The close spacing will enable the hardwood crowns to close more quickly and shade out the competing vegetation. Closer spacing will, however, require thinning at an earlier date. Wider spacing requires controlling the vegetation more than 3 years or until the crowns close, which may take up to 6 years. The closer spacing is an alternative to controlling the vegetation for longer periods of time.

Source: USDA Soil Conservation Service Technical Guide #612

Dec. 1, 1992

Winter Road Management

Description

This BMP addresses the proper use and storage of road salt, and discusses alternatives to road salt.

Road salt, also called rock salt, is known chemically as sodium chloride. Use of road salt has been implicated in the elevation of chloride and sodium levels in surface and groundwater as well as in the surrounding environment, and causes corrosion to roads, cars, and bridges. Sources of road salt runoff are roads and parking lots, drains, ditches, salt storage piles, loading areas, truck garages, truck washing areas, and sites where snow is piled. It is estimated that Michigan uses 0.5 million tons of road salt per year, and nationally, 10-11 million tons are used.

Salt can enter surface and ground waters due to the fact that it is soluble. Elevated levels of chlorides entering the Great Lakes and tributaries can have a negative impact on the fresh-water ecosystem. At high levels, salt is toxic to fresh-water organisms adapted to a narrow range of salinity. High levels of chloride can also lead to density stratification in ponds and lakes, which can result in oxygen depletion and fish kills. High sodium levels in ground water can cause health problems such as hypertension, and can aggravate cardiac-related diseases.

Other Terms Used to Describe

De-icing Chemical Use

Pollutants Controlled and Impacts

A reduction in the application rate of salt may result in an improvement of surface water quality by reducing chloride and sodium concentrations. Reductions in salt application will also help protect ground water supplies used for drinking water.

Other benefits that may occur by reducing salt application rates and encouraging proper salt storage include:

-reducing density stratification in ponds and lakes
-reducing corrosion of vehicles and bridges
-reducing damage to roadside vegetation, and
-reducing the deterioration of soil structure.

By properly storing road salt, runoff from salt storage piles can be prevented.

Application

Land Use
Urban, transportation

Soil/Topography/Climate
Winter precipitation comes in the form of sleet, hail, freezing rain and snow, each of which produces different road conditions. All maintenance personnel should know the basic kinds of weather conditions and how to adjust their application procedures to result in the desired road condition. Weather information should be carefully monitored using the most reliable sources available. Some maintenance departments hire private forecasters to get the most reliable local weather information.

When To Apply
Apply this BMP when weather and road conditions require salt spreading for road safety.

Where To Apply
Apply this BMP on any roads which require the application of salt to maintain safe driving conditions, or wherever salt is stored in storage piles.

Relationship With Other BMPs

Street Sweeping can be used to eliminate salt residues on street curbsides.

Specifications

Proper road salt management includes protecting sensitive areas, determining appropriate areas to dump snow, proper salt storage, exploring alternatives to road salt, using proper salt application practices, supervising and training staff, and maintaining equipment.

Protecting Sensitive Areas:
Planning should be made to protect sensitive areas. Sensitive areas include surface waters, drinking water wells and vegetation. Ideally, direct discharges of storm drains to lakes and streams should be avoided in areas where road salt is used in high quantities. Where possible, these drains should be directed to detention basins. Protect ground water supplies by locating salt storage piles away from wells.

Planting salt-resistant vegetation and diverting drainage away from important vegetative areas will help minimize the effect road salt may have on vegetation. Consider installing barriers to protect roadside vegetation from road splash.

Determining Areas to Dump Snow:
When piling snow, do not place directly in or immediately adjacent to surface waters (including wetlands), nor in the vicinity of wellheads. Ideally, snow piles should be directed to detention basins so that the soil and other debris attached to the snow can settle out before the water is discharged to surface waters.

Salt Storage:
Some of the basic elements of a good salt storage policy are as follows:

1. Salt should be covered, preferably in a permanent, roofed structure, to prevent rain and snow from reaching it. If this is not feasible, the next best solution is a waterproof covering weighted and tied down.

2. Salt should be stored on an impermeable pad, not on the ground. Asphalt is the most widely used material for pads, since salt has little effect on it. However, concrete is sometimes used. Concrete must be high quality, air-entrained and treated with linseed oil or asphalt-type coatings to reduce chloride penetration, and prevent scaling or spalling (i.e. flaking).

3. Any runoff that might occur should be contained within the storage site through an appropriate drainage design. Storage pads should slope to let water drain away, and the water channeled to a collection point via ditches, pipes or tile. This brine can then be reapplied to the stockpile during dry seasons, or applied to spreader loads prior to street applications.

4. Any salt storage areas existing in sensitive areas (i.e. zone of influence of water supply wells, significant recharge areas, lakes and wetlands) should be relocated.

Advantages of Using Salt:

Although the use of road salt has many drawbacks, the advantages of using it are:

-it is effective in increasing vehicle traction and achieving the "bare pavement" policy which is currently desired in various parts of the country
-transportation time delays and work time losses are minimized
-it facilitates emergency response in adverse weather
-it doesn't clog drains (like sand might)
-it is relatively inexpensive, costing between $25-50/ton

Application Rate:

It is important to use only the amount of salt necessary to result in safe driving conditions. Rates should be tailored to local conditions.

Application Pattern:

The proper spreading pattern is dependent upon the traffic density and highway design. The type of storm dictates frequency of application, the type of de-icing compound, and the total amount of de-icing compound necessary. The following is given for salt applications:

1. Windrow application is typical of two-lane pavements with low to medium traffic. A 4 to 8 foot application down the center line allows for good traction under at least two wheels.

2. Traffic flow will move the brine toward the shoulders, gradually melting the entire road width. Full-width spreading should be done on multiple-lane pavements with medium to high traffic volumes. Care must be used in the full width spreading not to waste salt.

3. A strong wind blowing across a street or highway can cause salt to drift into gutters or shoulders as it comes out of the spreader. Operators should be aware of wind conditions and spread accordingly on the upwind side.

4. Salt brine will flow down and across a banked curve. Spreading salt on the high side of the road will allow gravity to pull the brine to the low side of the road.

Proper calibration of spreading equipment should be done to accurately apply the proper amount of salt.

Alternatives to Salt:

Some reports have estimated that the damage done by salt ranges from 6-30 times the initial cost of the salt, with 90% of the damage due to corrosion. With the corrosive damage to bridges, highways, and vehicles factored in, one study concluded that the actual cost of salt may be closer to $775/ton. The total annual national cost of salt-related damage is estimated at approaching $5.5 million.

Alternatives to road salt include calcium magnesium acetate (CMA), calcium chloride, urea, sand, natural brines, potassium chloride, magnesium chloride (Freeze Guard), sodium formate, and regular salt such as Quik Salt, TCI, and CG-90.

CMA (ICE-B-GON) is manufactured from dolomitic limestone and acetic acid. The cost of this material ($650-700/ton) is related to the expense of producing acetic acid. At this time, CMA seems to be the alternative of choice. It is reported to be 10-15 times less corrosive than salt, with little or no effects on terrestrial vegetation or soil physical properties. However, it can result in significant organic loadings to receiving waters caused by chemical oxygen demand. During significant runoff events, this may deplete oxygen in surface waters, causing harmful effects to fish and other aquatic organisms. It can also cause increased organic loadings to wastewater treatment plants which serve combined sewers.

Four main obstacles to switching from salt to CMA are:

1. Inadequate understanding of the extent of salt damage

2. Subsidy of infrastructure repair by the federal government

3. Corrosion and environmental costs are external to the typical highway maintenance decision-process

4. Tendency by political decision-makers to heavily discount future cost savings when confronted by the need to increase current outlays in the near term

Other alternatives cause various types of environmental damage. Calcium chloride is an effective deicer but contains chloride and costs $250/ton. Urea costs $250/ton and may result in nitrogen contamination. Sand costs only $3/ton but can clog drains and settle out in streams. Alternatives such as ethylene glycol, diethylene glycol, methanol, and propylene glycol have a high chemical oxygen demand. The former two chemicals are also toxic to humans and wildlife if ingested, and methanol is toxic if ingested or absorbed through the skin.

Other proposed methods to remove snow are listed below. These may or may not be practical according to specific circumstances:

1. The use of external and/or in-slab melting systems

2. Mobile thermal "snow melters"

3. Use of compressed air in conjunction with snowplows or sweepers

4. Inclusion of snow and ice adhesion-reducing substances in the pavement itself (i.e hydrophobic materials such as silicone rubber or silicone resin)

5. Pavement substances that store and release solar energy for melting

6. Road and drainage design modifications to enhance runoff

7. Salt retrieval or treatment possibilities enhanced by the addition of chelating agents

8. Improved tire and/or vehicular design so as to reduce deicing requirements

Supervising and Training Staff:

The following principles should be included in staff training programs:

1. The application of salt and salt alternatives should not be substituted for plowing.

2. The best designed spreader equipment should be employed to avoid scatter and waste.

3. On and off ramps should be addressed as quickly as possible--safe roads are of little use if access ramps are hazardous.

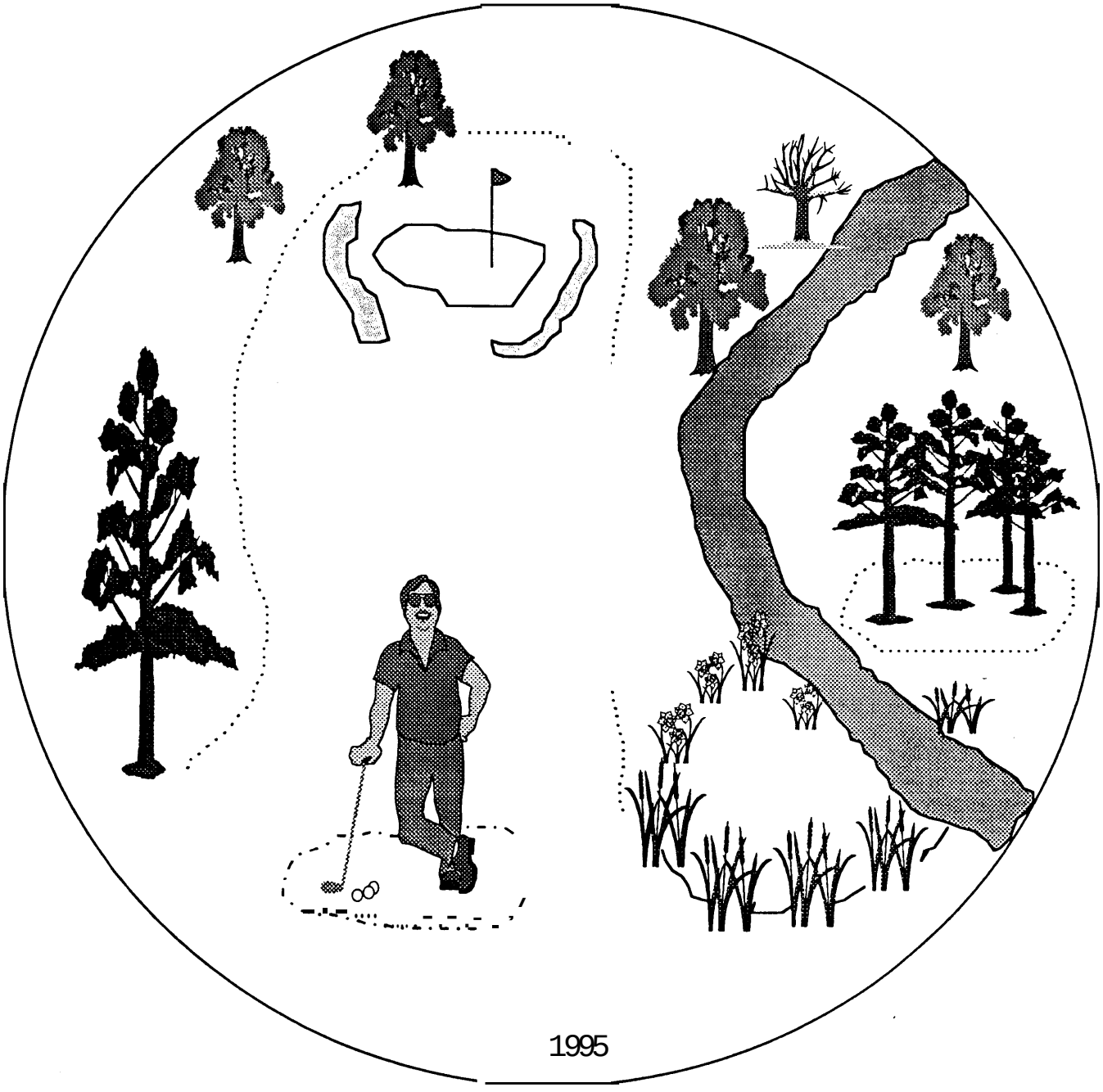
4. All equipment should be calibrated before use.

Ideally, the same crews should be assigned to the same road sections in each storm, and monitor the amounts dispersed from each spreader route.

Maintenance

Ongoing maintenance includes keeping equipment properly calibrated to ensure the salt or other substance is distributed at the proper rate and in the proper pattern. Another important part of the maintenance program is keeping good spare parts available.

Natural Resource Protection Strategy for Michigan Golf Courses



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DNR

Michigan Department of Natural Resources
Land and Water Management Division and
Surface Water Quality Division

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Michigan Department of Natural Resources

NATURAL RESOURCE PROTECTION STRATEGY FOR MICHIGAN GOLF COURSES

Michigan Department of Natural Resources
Land and Water Management Division
Surface Water Quality Division

INTRODUCTION AND BACKGROUND

Golf is an important industry in Michigan, and is one of the fastest growing sports in America today. The National Golf Foundation estimates that in order to keep up with demand, it will be necessary to add one new course per day--through the yea"r 2000. Michigan is the leading state in the number of existing public courses, and has been near the top in new golf course construction during the past several years. It is likely this growth will continue. A direct result of this growth has been a dramatic increase in public concern over the environmental impacts of golf courses. This concern has focused on the perceived impacts of development, operation and maintenance of golf courses to ground and surface water and other natural resources, and the overall quality of life for local communities and their residents.

In an attempt to address these concerns, improve the ability of golf course owners and developers to meet environmental standards, and enhance public understanding, Michigan Department of Natural Resources (MDNR}, has developed a number of assistance materials. These materials recognize that, while golf course development and operation has the potential for major environmental impacts, if properly sited, designed and constructed, such development impacts can be eliminated or minimized. Further, proper operation and maintenance of all golf courses can protect not only the quality of ground and surface water, public health and other natural resources, it can actually enhance water resource, open space and recreational values while providing needed economic growth to local communities in Michigan as well as the State as a whole. These publications do not set new standards, but serve to better communicate existing requirements and generally accepted best management practices. The publications include:

Guidebook of Best Management Practices for Michigan Watersheds: The Guidebook discusses nonpoint sources and impacts, and includes a step-by-step process for developing watershed plans and individual site plans. Its primary purpose is to provide guidance on how to use best management practices (BMPs} within the context of good watershed and site plans. It includes specific, detailed BMPs applicable to design, construction and operation of golf courses.

Natural Resource Protection Strategy for Michigan Golf Courses (this document): It will be available on its own and as an Appendix to the Guidebook.

A one-page Application Cover-sheet, with signature blocks, to be completed by MDNR staff and the applicant during or following the pre-application meeting. It will indicate what supplemental information is required to be submitted with the application. The applicant will file the Cover-sheet with the MDNR application, and Land and Water Management Division's Permit Consolidation Unit will use the Cover-sheet to determine if an application is "administratively complete."

A detailed Checklist (PR 2744), which is designed to assist the golf course developer in planning the project and preparing permit applications. It will also guide MDNR field staff in their permit reviews. It is not required to be turned in to the MDNR. The document consists of bullet statements directly reflecting the items discussed in detail within the Strategy, which the parties can use to double check that all items are appropriately addressed.

Land and Water Management Division also will prepare operating procedures and staff guidance memoranda for inclusion in its Division Guidance/Operating Procedures Manual.

These documents were developed with several uses in mind for those concerned with the proper location, design, construction, operation and maintenance of golf courses in Michigan. They aim to provide potential golf course developers with an easy-to-use list of items that MDNR staff look for in the permit application review process. They also strive to provide greater consistency in the permit application review process by MDNR staff and local units of government. And, they include management practices which should be used by golf course superintendents on both proposed and existing golf courses. Also, agencies and organizations which can provide assistance in the development of these plans are included at the end of the document.

It is in this spirit of voluntary compliance, and cooperative protection of our natural resources, that the Michigan Department of Natural Resources has developed these materials.

SITING AND GENERAL PLANNING CONSIDERATIONS

General Concepts - The most basic principle is to take advantage of what nature has already provided. By emphasizing the existing characteristics of the land and water resources, you can reduce the costs of development, retain the natural beauty of the area and minimize permit requirements. In that regard, examine your proposed development to ensure that:

1. development will follow the natural contours of the land as much as possible;
2. wetland and stream crossings are minimized;
3. any disturbance to wetlands has been avoided to the greatest extent possible;
4. land clearing along rivers, streams, ponds and wetlands is minimized;
5. natural buffers of vegetation have been left adjacent to ponds, streams and wetlands;

6. valuable trees will be preserved;
7. all regulated wetlands have been delineated;
8. the assessment of feasible and prudent alternatives to the use or alteration of wetlands and surface waters confirms that the proposal is justified;
9. endangered species habitat has been identified and the site plan will preserve this habitat; efforts were made to protect habitat for other desirable wildlife (see Audubon reference in "Available Assistance" section of this document);
10. the source of water to be used for irrigation has been identified, and construction and course operations will minimize impacts on the hydrologic condition of the surface and groundwaters so that existing uses of that water are not affected;
11. the pre-development hydrologic regime will be maintained as closely as possible;
12. there are adequate areas to accommodate long-term goals and future expansion;
13. pesticide storage/mixing-loading sites offer adequate well-head protection, either in the form of distance form the mix site or appropriate berming to safeguard the well; and
14. consideration has been given to placing a conservation easement on the undeveloped portion of the tract to ensure protection to natural resource values.

Site Plans - In general, development of golf courses should be similar to any other type of construction project. As described in the Guidebook of Best Management Practices for Michigan's Watersheds, a good site plan for any construction activity includes plan elements of: 1) soil erosion and sedimentation control, (as required under Act 347, the Michigan Soil Erosion and Sedimentation Control Act); 2) grading; and 3) stormwater management.

EARLY CONSULTATION

We cannot overemphasize the importance of discussing your initial thoughts, ideas and conceptual plans at the earliest possible date with the governmental decision makers and technical experts that will be helping you and dealing with your project from start to finish. You will need permits or other approvals from some of them, and others you may find to be of invaluable assistance as your project progresses. Discussing your ideas with these people BEFORE developing any actual plans can save you significant amounts of time and money. You should confer with the following:

Local Government - includes the city, township and county officials in at least the following areas:

1. planning and zoning;
2. public health;
3. county drain commissioner;

4. parks and recreation; and
5. public works, streets, roads and highways.

Local MDNR Office - includes staff of many divisions which may have an interest in your project. You should contact:

6. the District Supervisor of either the Land and Water Management or Surface Water Quality divisions, who will advise other appropriate field staff, and arrange for the Department's participation in the pre-application meeting discussed below. A map and phone numbers of MDNR district offices is included on pages 22 and 23.

Resource Specialists - include other governmental agencies, watershed councils, private consultants and citizens organizations.

7. You should discuss your concepts with the appropriate resource specialists, listed in the "Available Assistance" section of this document, pages 17 and 18.

PRE-APPLICATION, ON-SITE MEETING

A pre-application meeting on-site involving local MDNR staff and all other interested parties (e.g. consultants, local government officials, etc.) will reduce the amount of time required in the permit application and approval process. The following are guidelines for that meeting:

Stake Out the Site Before the Meeting - It is important to have the proposed course laid out so that all can visualize the design and the proximity to surface water, and other natural resources:

1. stake centerline and toe of fill slopes for fairways, greens, driving _ranges, tees and hazards in proximity to streams, ponds, lakes, wetlands, floodplains and other surface water resources;
2. stake all proposed excavations and fills, including ponds;
3. stake centerlines of proposed stream crossings; and
4. identify and stake wetlands boundaries in proximity to proposed construction areas and maintained facilities such as parking areas and roads, buildings, service area, etc;
5. identify and stake buffer areas; and
6. provide draft site plan which shows proposed course layout, related facilities and buildings in proximity to all surface water resources, including wetlands.

Meeting and Follow-Up Discussions - During these sessions, directly affected parties are able to mutually inspect the site and discuss the proposal, which should result in the following:

7. identification of issues, and discussion of concerns and alternatives to be further explored and evaluated;
8. completion of the one-page Application Cover-sheet, which confirms the following:
    i. MDNR and other agencies have indicated which permits are required for various development alternatives; and
    ii. MDNR has indicated which of the information discussed below (or additional information) MUST be submitted with the application.

MDNR PERMITS AND APPROVALS - REQUIRED SUBMITTALS

Early consultation, pre-application on-site meeting(s) and other local discussions should have identified and resolved the major issues which may either "make or break" the project. Upon resolution of such major issues, a detailed plan and proposal can be prepared and submitted for processing, review and consideration and possible approval under various local, state and federal statutes.

MDNR Permits Required - All activities which affect wetlands, streams or other water bodies will require a Land and Water Management Division construction permit. All development which exceeds five (5) acres also requires a Stormwater Permit by Rule from MDNR, Surface Water Quality Division. If there are unique resource areas involved, such as designated Natural Rivers or Great Lakes Environmental Areas, sand dunes, endangered or threatened species habitat, etc., there may be additional approvals required. MDNR staff and resource consultants can assist in identification of such areas.

Applications - The Land and Water Management Division's Permit Consolidation Unit (517-373-9244) will coordinate the Department review of permit applications for the majority of these activities. However, the Stormwater "Permit by Rule" coverage must come from the Surface Water Quality Division.

The best way to reduce delays in the MDNR regulatory process is to ensure that all items in this Strategy are followed. It is also critical that all portions of the MDNR application are filled out and addressed. NOTE: Most applications are returned because the applicant failed to fill out all portions of the permit application or submit the requested information. In addition to all information specifically requested in the application form and the information on the checklist, an application for a golf course construction or expansion permit may require an environmental assessment, along with construction plans and specifications.

Submittals Required With All Applications -

Complete application - You need to ensure that:

1. the application forms are completely filled out;
2. all information requested by the application has been provided;
3. application was filed with MDNR, Land and Water Management Division;

4. the Stormwater Permit-by-Rule was filed with MDNR Surface Water Quality Division; and
5. all local governmental applications have been filed.

Site plans - In general, development of golf courses should be similar to any other type of construction project. As stated in the Guidebook, a good site plan for any construction activity includes plan elements of: 1) soil erosion and sedimentation control, (as required under Act 347, the Michigan Soil Erosion and Sedimentation Control Act); 2) grading; and 3) stormwater management. The site plan needs to contain the following:

6. Site map, consisting of a topographic map, with a two-foot contour interval, showing:
   a. all surface water resources, wetland boundaries and the type and function of all affected wetland areas;
   b. location of pesticide/fertilizer storage and mix/load sites in relation to water resources;
   c. stationed centerlines and toe of fill slopes for fairways, greens, driving ranges and tees which correspond to the actual staked areas on-site;
   d. location of all existing and proposed buildings, drain tiles, sewers, stream crossings, and other permanent structures and their proximity to surface waters, including wetlands;
   e. existing contours, direction of drainage and proposed grade changes, with cut and fill areas depicted in both plan and cross section view; where possible, water from heavily treated areas like tees and greens is directed away from water resources;
   f. location of all facilities, structures, treatments and measures used for soil erosion and sedimentation control, grading practices and long-term stormwater management; and
   g. location of significant stands of existing trees and shrubs, and proposed buffer areas.

7. A written portion of the site plan which includes:
   a. a justification for use or alteration of surface water resources, including an analysis of feasible and prudent alternatives to use of wetlands;
   b. description and specifications of the soil erosion and sedimentation control mechanisms to be employed during construction;
   c. maintenance schedule for all soil erosion and sedimentation control practices;
   d. explanation of how dewatering will be done such that water is filtered or discharged into a poperly designed sediment basin;
   e. description of the construction sequence - how the project will be developed in stages so that small areas are developed and stabilized one at a time, as opposed to developing the entire site at one time;
   f. measures to be used to control dust;

g. description of how the "treatment train" concept, as discussed in the Guidebook, will be used;
h. a description of the stormwater component of the plan; and
i. proposed cutting schemes of vegetation within buffer areas.

8. For ponds, basins and other water storage structures, you must provide:
   a. assurance that water will be released at a controlled rate to a stabilized outlet;
   b. assurance that water treated with chemicals which produce an un-natural color is not released to surface waters
   c. elevation before and after development, along with contours and maximum depths;
   d. that there has been consideration to creating irregular shaped sides and varying bottom contours for wildlife habitat;
   e. design criteria, including storm design, location of the emergency spillway, etc;
   f. assurance that such structures are designed so that they fit into the natural setting; and
   g. the person responsible for the long-term maintenance of the structure has been identified (For golf courses this will usually be the golf course owner) .

Submittals Required as a Result of Pre-Application Discussions -

9. Turf Management Plan. This should contain the types and amounts of fertilizers and pesticides that will be used for each of the turf grasses and ornamentals chosen for the site. Fertilizer and pesticide use should be coordinated such that irrigation is done at times which will neither carry nutrients or pesticides off the ground and into surface waters, nor result in leaching to groundwater. Information on fertilizers, including storage, handling, mixing, disposing and various types of fertilizers, is included in the Fertilizer Management BMP. Information on pesticides, including storage, handling, mixing, disposing and integrated pest management principles, is included in the Pesticide Management BMP.
   a. Turf selection
      1. the first principle of integrated pest management, identifying disease-resistant species, has been followed;
      2. turf species selection takes into consideration the intended use and location, and its tolerance to shade;
      3. trees, shrubs and ground covers selected are the most disease-resistant species to the site conditions; and
      4. for areas that need to be kept short (tees and greens), grasses selected are those with lower preferred cutting heights - cutting grasses lower than their preferred height reduces the root system and otherwise makes the plants more susceptible to disease.

b. Fertilizers - See the Fertilizer Management BMP for details - the plan should include:
   1. results of soil tests;
   2. type, amount and frequency of fertilizer applications to greens, tees and fairways;
   3. notation of circumstances where nutrients will be applied in excess of soil test recommendations, along with sound justification;
   4. method of application and calibration schedule;
   5. notation of areas other than greens, tees and fairways where fertilizers will be applied - application of fertilizers directly in or adjacent to streams, rivers, lakes or wetlands should be avoided;
   6. location of fertilizer storage, mixing and loading - pesticides, fertilizers and hazardous materials must be stored at least 200 feet from surface water resources, and in separate areas or buildings so that they cannot be confused with one another;
   7. mixing areas are on impervious surfaces;
   8. liquid fertilizers are provided with secondary containment;
   9. a plan to address potential fertilizer spills; and
   10. fertilizers will be disposed of in a manner consistent with the label.

c. Basic Integrated Pest Management principles - As discussed in the BMP Pesticide Management for Turfgrass and Ornamentals, IPM is a pest management system that uses all suitable techniques in a total management system to prevent pests from reaching unacceptable levels, or to reduce existing pest populations. The Pesticide Management BMP includes the basics of integrated pest management, and discusses the concept of degree days to determine pest activity and to ensure management practices are implemented when action thresholds are reached. The turf management plan includes:
   1. an integrated pest management (IPM) that will be used to control the most common types of pests - this includes the use of pest scouting techniques, biological controls, baits, traps and other non-chemical pest control methods before pesticides are considered;
   2. identification of the action threshold for each pest, and the pesticides that will be used if biological or other non-chemical methods are not successful;
   3. pests will be spot treated, wherever possible;
   4. buffer/filter strips will be treated with pesticides only when it is documented that all other non-chemical controls prove to be ineffective. The plan must identify the circumstances in which pesticides will be used in the natural or created buffer areas;
   5. pest populations will be monitored by scouting, baits and traps or other collection methods;

6. pesticide storage areas, separate from fertilizer storage, are indicated;
7. the applicant has identified where pesticides will be mixed, loaded and rinsed. All such activities will be done on impervious areas. Where possible, the design of such areas has been included;
8. the method of application is as target-specific as possible;
9. routine calibration should be done following the calibration procedures in Appendix 4 of the Guidebook;
10. all equipment designed to draw water should have a properly functioning anti-siphoning device;
11. all pesticides are provided with secondary containment;
12. the conditions in which the public will be notified of pesticide applications is included; and
13. restricted use pesticides will only be applied by certified/registered applicators.

d. Irrigation principles include the following:
   1. irrigation needs were determined and are consistent with the hydrologic information;
   2. an irrigation schedule has been determined, based upon actual rainfall, plant needs, and soil water holding capacity;
   3. description of how irrigation will be monitored to ensure that the irrigation schedule was coordinated with the fertilizer management plan above;
   4. The design of an irrigation system should take into consideration the potential fate of the irrigated water. Where possible, irrigated water will be recycled by directing runoff to the ponds used as the water source. This would also recycle nutrients or chemicals which were not absorbed by the plants. Irrigated water could also be directed to infiltration practices if pollutant levels are such that groundwater won't be impacted. Direct discharges of runoff to surface waters is the least preferred fate of irrigated water; and
   5. back-flow prevention devices (anti-siphon valves) should be installed to prevent back-flow of fertilizers into wells.

e. Mowing:
   1. mowing will be done at the preferred height of the grasses selected;
   2. if grass clippings and leaves are removed from the greens, tees or fairways, they will be mulched or composted and disposed of in a manner which will not affect surface waters or wetlands; and
   3. compost piles are not located in or immediately next to surface waters, wetlands or flood plains, nor on steep slopes or in areas with high water tables.

10. Water Quality Monitoring Plan. Certain sites contain high quality surface waters that are particularly susceptible to pollutant sources which may come from golf course construction, operations and maintenance. Typically, citizens and local governmental units are concerned with these possible impacts. All parties can protect themselves, as well as the water resources involved, by establishing baseline water quality before course construction, and monitoring that water quality over a period of time. If problems are encountered, they can be corrected immediately. If no problems are encountered through the monitoring, that information can also be invaluable. The plan needs to be developed such that:
    a. the goals and objectives of the monitoring plan are clearly explained. In many cases, the goals and objectives may include determining trends in water quality over a given period of time to evaluate the effectiveness of the implemented best management practices;
    b. it is clear how the data will be used. There's no sense collecting data if the manager doesn't know what he/she is going to do with it;
    c. baseline survey data is collected, so that comparisons can be drawn between existing and future conditions. Data collected at a later date, using the same methodology, can then be compared to this baseline data. Baseline surveys can include:
        1. physical characteristics including: the lengths, widths, depth and cross sections of the stream; bottom substrate (type and percentage); and habitat. Record observed characteristics and any physical characteristics and take photographs, where possible;
        2. chemical properties, including water sampling. Parameters of interest may include pH, temperature, and total suspended solids (especially during the development of new golf courses), and phosphorus, nitrates and pesticides, before and after development and throughout the life of the course;
        3. biological communities, including fish, invertebrates, plants and mammals. Standard procedures for macro-invertebrate surveys are available from the MDNR, Surface Water Quality Division; and
        4. hydrologic information, including volume and rate of flow. This will help designers to select properly sized culverts ,. and similar structures, and design practices which will limit hydrologic inputs to within the pre-development hydrologic regime, and to determine changes in hydrology over the life of the golf course. Note that hydrologic information was discussed as part of the basic site planning process.

For most plans, this data will likely be collected both upstream and downstream of the proposed development. Sampling should be done

at least monthly, as well as some done during dry weather and some done during storm events (all storm events should be recorded). There should be a minimum of three of each type of sample {seven is ideal). Work with consultants or MDNR staff to identify the best upstream and downstream locations and to determine site-specific parameters. Private consultants can also conduct the actual monitoring. Further:

d. the appropriate parameters have been identified and they correspond with the goals and objectives. If, for example, the goals of the plan are to evaluate the effectiveness of the fertilizer management program, then the parameters should include nutrients;
e. locations where samples will be taken are included, either on a map or in written form;
f. the method and frequency of sample collection has been determined. This should include how the samples will be taken and the numbers of samples which will be collected per each location. This information should be as specific as possible. Data should be collected using standardized collection procedures. Proper procedures will vary depending on the type of data collected;
g. the laboratory that will be used for analysis and the method of analysis have been submitted. The applicant should be using analytical laboratories with approved quality assurance/quality control plans. There should be some indication that the lab will be using standard methods of analysis;
h. sample results will be analyzed by professionals familiar with sampling methodology, chemical parameters, and DNR specified detection levels for all parameters analyzed. The applicant will use reputable consultants or MDNR staff (when available) to help analyze the results; and
i. the analyzed data will be used to determine a plan of action when problems are indicated. If problems are indicated, the management practices being used on the golf course will be re-evaluated. For example, if nitrate concentrations are elevated, the applicant will modify the turf management plan after reviewing the checklist above and the specifications of the Pesticide Management and Fertilizer Management BMP's.

11. Soil Management Plan. Soil management is managing soil to provide the best growing conditions for turf and other vegetation. It may include adding lime, fertilizer or other constituents to the existing soil to address fertility problems, abnormal moisture content or inappropriate pH. It also includes cultivation and drainage techniques. The soil management plan should include:

a. the results of on-site soil samples, showing all the soil textures on the site. Soil textures will help determine the BMPs necessary to meet the goals of the site plan. Soil textures

should be determined for the maximum depth in which a structure is proposed;

b. soil sampling results for nutrient and organic content. Soil tests for nutrient management purposes should be collected from the top three inches of soil. Enough samples should be taken and the samples mixed together, in order to get a representative sample from the course;

c. soil samples for turf areas that differ significantly in grass type, use or growing conditions are analyzed separately;

d. soil analyses for pH;

e. statement that soil test results were used to determine the amount of nutrients to be applied; and

f. statement that soil samples will be collected and analyzed every three years for nutrients, organic content and pH so lime, fertilizers and other soil amendments will be applied correctly.

12. Woody Vegetation Management Plan. Protection of existing trees and shrubs and select planting of new woody vegetation can greatly enhance the aesthetics of a golf course, while providing for infiltration of surface water runoff, erosion control, and absorption of nutrients, chemicals and other pollutants. A woody buffer strip along water bodies can also shade the water body, thereby reducing thermal pollution, and make an important contribution to the aquatic food chain. The plan needs to be such that:

a. it will protect and maintain the existing woody vegetation as natural buffers, to the extent possible;

b. woody vegetation will be maintained by regular monitoring of the health of the vegetation, by disease and pest management using the IPM plan, and by limited pruning and cutting when absolutely necessary;

c. all pruned branches will be disposed of following the Organic Debris Disposal BMP; and

d. woody vegetation is protected from root damage caused by heavy equipment during construction and by fill (fill should not be placed within the drip line).

13. Equipment Maintenance and Storage Area Plan. The Eauioment Maintenance and Storage Area BMP includes the types of practices which should be followed for equipment maintenance and storage, both during construction and for the ongoing maintenance of existing courses. Note that the storage, handling and disposal of hazardous wastes are carefully regulated by the MDNR, Waste Management Division (WMD) and applicants are encouraged to contact WMD for specific requirements. The equipment maintenance and storage area plan should ensure that:

a. wastes such as empty hydraulic fluids canisters and other non-hazardous waste and litter are disposed of in trash cans, dumpsters or other appropriate receptacles - receptacles are properly maintained;

b. vehicles and equipment are stored and maintained on sealed, impervious areas;
c. floor drains are designed to drain to sanitary sewers. If floor drains drain to storm sewers, the drains have been plugged;
d. the golf course manager is familiar with the location of all underground storage tanks, septic fields and any other underground structures;
e. materials are on hand for the containment and cleanup of spills;
f. secondary containment is provided for all hazardous materials;
g. hazardous materials are stored in sealed, locked areas or buildings and are such that they cannot be confused with one another. All materials are registered with the fire marshal. Storage locations for these materials are located on the site plan. Posting of these areas is required; and
h. Material Safety Data Sheets (MSDSs) are available for all hazardous materials.

14. Spill Response Plan. This plan includes the steps to be followed in case chemical materials are spilled. The remainder of the information below primarily deals with spills of gas and motor oil. If other materials are used, a response similar to that outlined below MAY be appropriate, but because other materials may have specific hazards all potential hazards should be identified, safe handling measures developed, and appropriate spill response procedures added to this plan. The spill response plan includes at a minimum the following:
    a. Clearly identify the appropriate responding authorities. They may be the MDNR district office, state police or local emergency response. If no other phone number is available, the Pollution Emergency Alerting System (PEAS), 1-800-292-4706, can be used. This number is in use 24 hours a day;
    b. in the event of a spill of gasoline, fuel oil or motor oil, follow the steps below:
        1. Insure the safety of yourself and anyone else on site. In areas where you can smell spilled material, do not smoke or use open flame or devices which produce a spark (such as internal combustion engines). Evacuate any area where the danger of explosion is high. Tend to any injuries;
        2. Contain the spill. Build dikes or pits or use absorbent pads to keep the spill from spreading until it can be retrieved. If the spill is in water, contact the appropriate authority (see above) and either use absorbent booms, logs or earth dams. Keep in mind that containing spilled material on porous soils may contaminate underlying groundwater. On porous soils, either consider another way to contain the spill or retrieve the spilled material as soon as possible;
        3. Retrieve the spilled material. Collect and dispose of the material at an approved disposal sight as soon as

possible. If you do not have the necessary equipment or the amount of spilled material is very large a contractor should be called to perform the cleanup. A list of potential spill response firms is attached at the end of this document. Phone numbers for other local spill response firms or a company response team should be added to this spill response plan for easy access; and

4. If material is lost to the ground or a surface water the appropriate authority must be contacted immediately. For smaller spills easily contained and cleaned up, authorities will be contacted after all cleanup activities are completed;

c. the job site and vehicles used to transport materials contain equipment needed to deal with a spill;

d. the plan has been made available and reviewed by everyone who will handle this material, as well as persons hauling materials and wastes into and out of the golf course; and

e. a written pesticide spill response/cleanup plan for the golf course--based on the turf management plan--is a component of this plan.

15. Waste Management Plan. This item needs to ensure that:

a. on-site sewage treatment systems include a clean-out schedule, monitoring plan, reporting plan and schedule for replacement and/or upgrading, in accordance with local county health department regulations and requirements; and

b. after construction, trash collection, storage and removal will continue to be addressed. Ideally, a recycling program should be established. (Note: waste management during construction was discussed under the Equipment Maintenance and Storage Areas Plan).

PROCESSING AND EVALUATION OF APPLICATIONS, AND PERMIT ISSUANCE

1. Land and Water Management Division Permit

a. Land and Water Management Division construction permit applications, along with the appropriate fee, and the Application Cover Sheet and required submittals, must be filed with the Division's Permit Consolidation Unit (PCU) in Lansing. PCU will: log in the application; deposit the fee with the State Treasurer's office; determine the exact laws under which the project falls; conduct a computer search to determine if there are special natural resource values associated with the site; and review the application to determine if it is "administratively complete". "Administratively complete" means that all of the following has been submitted: all information on the application form; the proper fee; and all other information noted during the pre-application discussions. In making this determination, PCU staff will use the Application Cover Sheet (PR 2743) and the

Checklist (PR 2744), in conjunction with the application submitted by L&WMD (PR 2731). Once the application is determined to be administratively complete, the entire file is assigned to a L&WMD field person. NOTE: In Michigan, the Land and Water Management Division administers Section 404 of the Federal Clean Water Act, for fills within "waters of the United States". Except in very limited cases along the Great Lakes shoreline and on federally navigable rivers, no separate federal filing is necessary.

b. Public Notice Requirements - An application for a new golf course, expansion of an existing course, and many other activities associated with a golf course, will normally require a "public notice" to be issued: This means that local governmental units, nearby landowners, and other citizens are notified of the application, and given an opportunity to comment on it. They have the right to ask that a public hearing be held to discuss the merits of the proposal. If a hearing is held, the applicant will be given an opportunity to explain the proposal and answer questions. Conduct of a public hearing increases the processing time for permits.

c. MDNR Field Review - Normally, the MDNR staff person assigned the file is the one that conducted the pre-application, on-site meeting. They should be very familiar with the proposal and the issues. It is now their job to evaluate the proposal in light of the criteria in the applicable laws, and all of the comments offered by the adjacent landowners, local governmental units, state and federal resource agency officials and other citizens. They must attempt to balance the desires of the applicant with the concerns of the public and the environmental constraints of the site. Hopefully, this Strategy and its associated documents have been used during the planning phase, and been found useful. If so, resource impacts should be minimal, and a permit can be issued in a short time period. If problems do exist, the L&WMD staff person must resolve those before a permit can be issued. While the specific criteria varies from law to law, generally the Department will issue a permit if it finds that the structure or project will not adversely affect the public trust or riparian rights, and that no other feasible alternative exists which would lessen the impact to surface water and wetland resources. A permit will not be issued if the proposed project or structure will unlawfully impair or destroy any of the waters or other natural resources of the state.

d. Permit Conditions and Responsibility of Permittee - In issuing the permit, staff may include such conditions as are necessary to ensure protection of the waters of the state and other natural resources. It shall specify that the project will not cause unlawful pollution. The applicant, both during construction, and in the operations and maintenance of the facility, has the responsibility to meet the conditions of the permit, and

otherwise ensure against unlawful pollution to the waters or other natural resources of the state.

2. Surface Water Quality Division (SWOD) Stormwater Permit by Rule
   a. Construction activities which disturb 5 or more acres must be covered by a National Pollution Discharge Elimination System (NPDES) stormwater permit. SWQD provides NPDES coverage under a Permit by Rule. The applicant must first obtain an Act 347 Soil Erosion and Sedimentation permit from the appropriate local enforcing agent. The applicant then completes a "Notice of Coverage" (NOC) form, and submits that, along with the appropriate fee, to the SWQD Permits Section. If the Act 347 permit is valid, Permit by Rule coverage is granted immediately upon receipt of a complete NOC. The permittee should understand the following: 1) that approval by an Act 347 agency of an inadequate soil erosion plan does not release the permittee from liability under the Stormwater Permit by Rule; 2) violation of any condition of the Act 347 permit also constitutes a violation under the Stormwater Permit by Rule; 3) coverage is valid only if the Act 347 Permit remains valid; and 4) Permit by Rule coverage also requires that a certified stormwater operator perform weekly inspections of soil erosion control measures being used at the site, and maintain a log of those inspections.

AVAILABLE ASSISTANCE

The National Golf Foundation will provide information on the feasibility, costs, equipment needs and facilities required in the development of a golf course A representative will visit the site on request. The following publications are available from the National Golf Foundation at 1150 South US Highway One, Jupiter, FL, or call: 1-800-733-6006, FAX 407- 744-9085.

- Planning and Building the Golf Course
- Planning Information for Private Golf Courses
- Organizing and Operating Public Golf Courses
- The Professional Golf Shop
- Planning the Golf Clubhouse
- information sheets on design, construction and operation
- listing of golf course architects

Universities:
Michigan State University (MSU). Local county offices of the MSU Extension can get you information and put you in touch with resource experts at Michigan State University. The primary resource contact at Michigan State is the Department of Crop and Soil Science. They can provide information on soils, fertilizers and turfgrass establishment and maintenance under Michigan conditions. They offer the following publications:

- Lawn Establishment (Extension Bulletin E-673)
- Lawn Care (Extension Bulletin E-646) ·
- Lawn Weed Control (Extension Bulletin E-653)
- Turfgrass Varieties and Seeding Rates (# 1353)
- Bentgrass Varieties (# 1352.2)
- Planting Bentgrass Greens (# 1352)
- Management of Bentgrass Putting Greens (# 1354)
- Selecting the Level_ of Turfgrass Maintenance (# 1351)

The Water Resources Institute at Grand Valley State University has experience in the design, construction, maintenance and monitoring of golf courses built to minimize environmental impacts. The following services are available through the Institute:

Wetland and stream enhancement practices that reduce excess nutrient and sediment loading;
Pesticide and metals analysis of soils, sediments and surface waters;
Nutrient budgets for turfgrass maintenance; .
Best Management Practices for nutrient and sediment control during golf course construction;
Biological assessment and monitoring of wetlands associated with golf courses;
Environmental compliance assistance; and
Database management.

For iilformation, contact the Water Resources Institute at Grand Valley State University, One Campus Drive, Allendale, Michigan 49401, or call: 616-895-3271.

Ferris State University in Big Rapids offers a Bachelor of Science program in Professional Golf Management. Staff of that Department can assist in placement of general managers and PGA professionals, as well as assistant professionals and student interns. For information, contact: Professional Golf Management, Ferris State University, 1506 Knollview Drive, Big Rapids, Michigan 49307-2290, or call: 616-592-2839.

United States Department of Agriculture, Natural Resources Conservation Service, along with the local Soil and Water Conservation Districts, can provide soil survey information, limited soil testing and expertise in best management practices - located in most county seats.

Department of Natural Resources District Offices - map and phone numbers attached

Surface Water Quality Division
Land and Water Management Division
Fisheries Division
Wildlife Division
Forest Management Division
Lansing Permit Consolidation Unit (517) 373-9244

Local river watershed councils (list attached) and County Drain Commissioners both can provide assistance on water resources and management activities within the watershed and the county where your golf course is planned.

The Audubon Cooperative Sanctuary Program (ACSP) for Golf Courses. This program was designed to enhance wildlife habitat on existing and future golf courses, encourage active participation in conservation programs by the golf industry, recognize golf course as an important open space, and educate the public on the benefits of golf courses. It also aims to increase awareness about positive golf course contributions to the environment. The program is sponsored by the Audubon Society of New York State, Inc. and the U.S. Golf Association. For further information call or write:

Audubon Society of New York State, Inc. USGA
Hollyhock Hollow Sanctuary Golf House
Route 2, Box 131 P.O. Box 708
Selkirk, NY 12158 Far Hills, NJ 07931-0708
(518) 767-9051 (908) 234-2300

Private environmental and permitting consultants can assist you in understanding environmental regulations, delineating wetlands, completing necessary studies and applying for required permits.

Golf Associations:

American Society of Golf Course Architects
221 N. LaSalle Street
Chicago, Illinois 60601
312-372- 7090

Golf Association of America
31800 Northwestern Highway, Suite 130
Farmington Hills, Michigan 48018
313-855-4653

Golf Course Builders of America
920 Airport Road, Suite 210
Chapel Hill, NC 27514
919-942-8922

Golf Course Superintendents Association of America
1617 St. Andrews Drive
Lawrence, Kansas 66049
800-472-7878

Michiana Irrigation Association
4109 S. Pine Dell Drive
Lansing, Michigan 48911

Michigan Border Cities Golf Course Superintendents Association
23640 E. Lobost
Novi, Michigan

Michigan Turfgrass Foundation
P.O. Box 80071
Lansing, Michigan 48908

Mid-Michigan Turf Association
1103 Eastman
Midland, Michigan 48640

National Golf Course Owners Association
14 Exchange St., P.O. Box 1061
Charleston, SC
803-577-5239

National Golf Foundation
1150 South U.S. Highway One
Jupiter, Florida 33477
407-744-6006

Northern Michigan Turf Managers Association
3733 Apollo Drive
Traverse City, Michigan 49684
616-943-8343

United States Golf Association
Golf Journal P.O. Box 708
Far Hills, New Jersey 07931
201-234-2300

Western Michigan Golf Course Superintendents Association
15784 Pruin
Spring Lake, Michigan 49456
616-842-4840

REFERENCES

Balogh, James C. and William J. Walker, editors, 1992, Golf Course Management and Construction: Environmental Issues, Lewis Publishers.

Golf Course Development in Hawaii: Impacts and Policy Recommendations, 1992, Hawaii Office of State Planning, Honolulu, Hawaii.

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Impacts of Golf Courses on Groundwater and Surface Water in Michigan, by the Regional Groundwater Center at the University of Michigan Biological Station.

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Klein, Richard D, 1990, Protecting the Aquatic Environment From the Effects of Golf Courses,
Community and Environmental Defense Associates, Maryland Line, Maryland.

Love, William R, 1992, An Environmental Approach to Golf Course Development, the American Society of Golf Course Architects, Chicago, Illinois.

Otsego County Water Quality Committee, 1992, Policy Guidelines for Minimizing Environmental Impacts from Golf Course Development in Otsego County, Northeast Michigan Council of Governments, Gaylord, Michigan.

Petrovic, A. Martin, 1991, "Golf Course Management and Nitrates in Groundwater: the Real Story", Cornell University, Cornell, New York.

60th. Annual Michigan Turfgrass Conference Proceedings, 1990, Michigan Turfgrass Foundation, Lansing, Michigan.

Turfgrass Pest Management: a Training Manual for Commercial Pesticide Applicators, 1992, Extension Bulletin E-2327, Michigan State University Cooperative Extension Service, East Lansing, Michigan.

Watschke, Thomas L., Scott Harrison and G.W. Hamilton, 1989, "Does Fertilizer/Pesticide Use on a Golf Course Put Water Resources in Peril?", Pennsylvania State University, University Park, Pennsylvania.

MICHIGAN SPILL RESPONSE FIRMS

The following are listed according to their location. However, most will travel to wherever needed.

BARK RIVER
Stenberg Brothers, Inc.
P.O. Box 127
Bark River, MI 49807
906-466-9908

MT. PLEASANT

Moravy Trucking Company
1934 Commercial Drive
P.O. Box 530
Mt. Pleasant, MI 48864-0530
517-773-6971

SAGINAW
Bierlein Environmental Services, Inc.
2903 S. Graham Road
Saginaw, MI 48603
517-781-1810

FLINT AREA
Drury Brothers, Inc.
11950 E. Newberry Road
Durand, MI 48429
517-288-2611

Youngs Environmental Cleanup
5305 North Dort Highway
Flint, MI 48505
313-789-7155

SOUTHEAST MICHIGAN
Great Lakes Environmental
22077 Mound Rd.
Warren, MI 48091-1208
313-758-0400

K & D Industrial Services
6470 Beverly Plaza
Romulus, MI 48174
313-729-3350

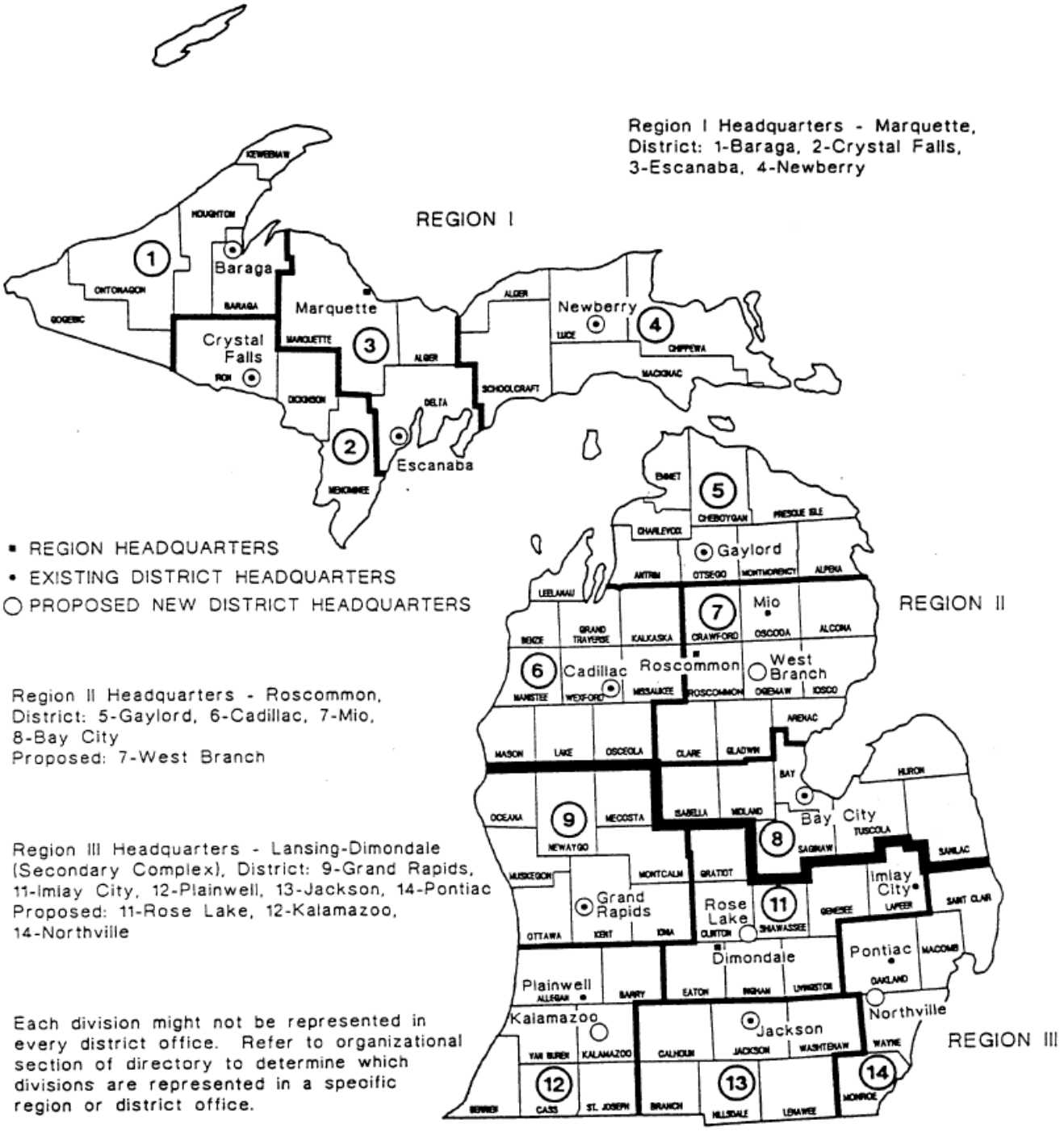
Inland Waters Pollution Control
2021 Schaefer
Detroit, MI 48217
313-841-5800

Marine Pollution Control (MPC)
8631 West Jefferson
Detroit MI 48217
313-849-2332

TRAVERSE CITY
Egeler Industrial Waste, Inc.
9246 Cedar Run Road
Traverse City MI 49684
616-946-6801

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

REGIONS AND DISTRICTS



DISTRICT OFFICES

REGION I

BARAGA
427 US-41 North
Baraga MI 49908
906-353-6651
906-353-7464 FAX

CRYSTAL FALLS
1420 US-2 West
Crystal Falls MI 49920
906-875-6622
906-875-3336 FAX

ESCANABA
6833 Highway 2,41 & M-35
Gladstone MI 49837
906-786-2351
906-786-1300 FAX

ISHPEMING FIELD OFFICE
1985 US-41 West
Ishpeming MI 49849
906-485-1031

MARQUETTE
1990 US-41 South
Marquette MI 49855-9131
906-228-6561
906-228-5245 FAX

NEWBERRY
PO Box 77
RR #1, S-123
Newberry MI 49868
906-293-5131
906-293-8728 FAX

REGION II

BAY CITY
503 North Euclid
Bay City MI 48706
517-684-9141
517-684-4482 FAX

CADILLAC
8015 Mackinaw Trail
Cadillac MI 49601
616-775-9727
616-775-9671 FAX

GAYLORD
PO Box 667
Gaylord MI 49735
517-732-3541
517-732-0794 FAX

MIO
PO Box 939
191 South Mount Tom Road
Mio MI 48647
517-826-3211
517-826-3509 FAX

ROSCOMMON
8717 North Roscommon Rd
PO Box 128
Roscommon MI 48653
517-275-5151
517-275-5167 FAX

REGION III

SECONDARY COMPLEX
PO Box 30028
Lansing MI 48909
517-322-1300
517-322-6311 FAX

GRAND RAPIDS
350 Ottawa Northwest
Grand Rapids MI 49503
616-456-5071
616-456-1239 FAX

JACKSON
301 East Louis Glick Hwy
Jackson MI 49201
517 780-7900
517-780-7855 FAX

LIVONIA
38980 7 Mile
Livonia MI 48152
313-953-0241
313-953-0243 FAX

SHIAWASSEE
10650 South Bennett Drive
Morrice MI 48857
517-625-4600
517-625-5000 FAX

PLAINWELL
PO Box 355
Plainwell MI 49080
616-685-6851
616-685-1362 FAX

Road Salt Application and Storage

Minimum Measure: Pollution Prevention/Good Housekeeping for Municipal Operations

Subcategory: Municipal Activities

During storage, road salt should be covered to prevent salt from lumping together or being lost with storm water runoff

Description

The application and storage of deicing materials, most commonly salts such as sodium chloride, can lead to water quality problems for surrounding areas (Koppelman et al., 1984). Salts, gravel, sand, and other materials are applied to highways and roads to reduce the amount of ice during winter storm events. Salts lower the melting point of ice, allowing roadways to stay free of ice buildup during cold winters. Sand and gravel increase traction on the road, making travel safer.

Applicability

This practice occurs in areas that receive snowfall in winter months and require deicing materials. Municipalities in these areas must ensure proper storage and application for equipment and materials.

Siting and Design Considerations

Many of the problems associated with contamination of local waterways stem from the improper storage of deicing materials (Koppelman et al., 1984). Salts are very soluble when they come into contact with stormwater. They can migrate into ground water used for public water supplies and also contaminate surface waters.

More information about road deicing materials can be found at the American Association of State Highway and Transportation Officials EXIT Disclaimer website.

Limitations

Road salt is the least expensive material for deicing operations; however, once the full social costs are taken into account, alternative products and better management and application of salts become increasingly attractive options.

Table 1. Deicing Alternatives (Keating, 2004)

Substance	Cost	Characteristics
Calcium Chloride ($CaCl_2$)	Flake $290/ton, pellet $340/ton	• Melts ice at temperatures of -25 ° F • If used as recommended, will not harm vegetation
Magnesium Chloride ($MgCl_2$)	Flake $260/ton, pellet $300/ton	• Lowest practical temperature: 5 ° F • If used as recommended, will not harm vegetation; however, $MgCl_2$, on a percentage basis, contains 17-56% more chloride ion than other salt-type deicers
Potassium Chloride (KCl)	$240/ton	• Lowest practical temperature: 12 ° F • Will not harm vegetation
Urea	$280/ton	• Lowest practical temperature: 15 ° F • Will not harm vegetation
Calcium Magnesium Acetate (CMA)	$2,000/ton	• Will work below 0 ° F • Low toxicity and biodegradable

Maintenance Considerations

Covering stored road salts may be costly; however, the benefits are greater than the perceived costs. Properly storing road salts prevents the salt from lumping together, which makes it easier to load and apply. In addition, covering salt storage piles reduces salt loss from stormwater runoff and potential contamination to streams, aquifers, and estuarine areas. Salt storage piles should be located outside the 100-year floodplain for further protection against surface water contamination.

If used during road salt application, certain best management practices can produce significant environmental benefits. The amount of road salt applied should be regulated to prevent oversalting of roadways and increasing runoff concentrations. The amount of salt applied should be varied to reflect site-specific characteristics, such as road width and design, traffic concentration, and proximity to surface waters. Calibration devices mounted in the cabs of spreader-trucks help maintenance workers apply the proper amount of road salt. Alternative materials, such as sand or gravel, should be used in especially sensitive areas.

Cost Considerations See Table 1 for the costs of different deicing alternative substances.

References

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