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NOTICE OF FINAL GUIDANCE & CERTIFICATION

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DNR CERTIFICATION

I have reviewed this guidance document or proposed guidance document and I certify that it complies with sections 227.10 and 227.11 of the Wisconsin Statutes. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is not explicitly required or explicitly permitted by a statute or a rule that has been lawfully promulgated. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is more restrictive than a standard, requirement, or threshold contained in the Wisconsin Statutes.

10/08/2019

Signature Date

Storage Pile
Best Management Practices

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NATURAL RESOURCES BOARD

Wisconsin
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STORAGE PILE BEST MANAGEMENT PRACTICES

PURPOSE OF THIS MANUAL

This manual describes best management practices to control stormwater pollution from storage piles.

The production of this manual is funded through a grant from the Environmental Protection Agency (EPA). This manual is to be used by Wisconsin, Minnesota, and Michigan as guidance in writing stormwater discharge permit requirements for storage piles. The study focuses on storage piles found in the Lake Superior drainage basin. However, the best management practices described in this manual can be used for storage piles across the nation.

DEFINITION OF STORAGE PILE

For the purposes of this manual, a storage pile will be defined as any outside storage of raw or intermediate material or any final product or by-product of a manufacturing facility or type of facility covered by the EPA stormwater permit regulations. The definition also covers facilities similar to those included in the EPA regulations, but which may not be specifically listed in the Standard Industrial Classification (SIC) codes which EPA uses to identify industries required to obtain stormwater discharge permits.

The size of the storage piles will not be specifically defined as the range can vary tremendously. A small pile of one substance could have a much greater impact on water quality than a very large pile of another substance.

ARRANGEMENT OF MANUAL

This manual is arranged by type of material. Each chapter deals with a specific material and describes pollutants associated with the pile, how the pollutants are carried to surface waters, and suggested management practices to reduce stormwater pollutants associated with that type of material.

Appendices describe some types of best management practices in detail.

This manual reflects the EPA's approach in controlling stormwater pollutants; pollution prevention is the best and first line of defense. Source reduction and housekeeping practices are given first consideration as these are often times the most effective and most economical methods to control stormwater pollution. Structural or treatment practices are considered as alternatives when source reduction and/or housekeeping practices are not effective enough.

When this manual is used for permit guidance, the source reduction and housekeeping practices should be used as guidance for permit drafting. Structural or treatment should be considered as permit requirements if source controls and housekeeping practices do not result in significant reductions in pollution, i.e., water quality standards are not being met.

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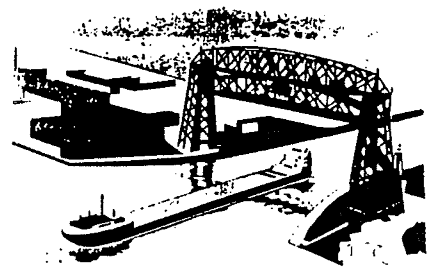
CHAPTER 1: TACONITE PELLETS



TYPICAL PILE CONFIGURATIONS AND LOCATIONS

Taconite pellets are a result of refining iron ore deposits found in taconite chert and slate. Taconite is crushed and ground so that 90 percent of the material is less than 325 mesh (material finer than flour). The crushing and grinding is done to separate out the iron from the silica. Iron grains are then separated from the silica by magnets.

Once separated, the iron ore concentrate is then mixed with bentonite or organic binding agents, and sometimes also with a fluxing agent (such as dolomite), and shaped into green balls. The green balls are fired in a furnace to harden into pellets approximately 1/2 inch in diameter. The heat of the furnace converts much of the magnetite in the green balls to hematite, which is much less magnetic. The pellets are stockpiled at the mine processing plant, and then transported to steel mills. The pellet size and shape is designed for optimum furnace characteristics at the steel mills.

Taconite pellets are transported by both rail and ore boat from the iron mine processing plants. The pellets are stockpiled at the mine processing plant sources, the steel mill destinations, and intermediate transportation points. These stockpile locations include a number of ore boat harbor facilities around the Great Lakes. Most of the harbor storage areas are unpaved, flat yards. At both harbor and non-harbor storage sites, the pellets are typically loaded and unloaded by various conveyor systems.

Taconite pellet stockpiles can be smaller than the size of a football field, particularly during periods of high pellet demand. During periods of lower demand, and at harbor sites during the non-navigation season, the piles can grow considerably in size.

Pellet transport, particularly at conveyor transfer points, can generate dust. Air quality protection efforts often involve water sprays, which can increase water movement from the pellet stockpiles. Chemical dust suppressants and freeze conditioning agents are sometimes applied to the pellets during transport and storage.

POLLUTANTS

There have been many papers and books written about the pollutants from taconite tailings - the remains of the taconite pellet making process. There has been little documentation regarding the potential pollutants from taconite pellets. For the purposes of this manual, a list of potential pollutants was developed using information on the chemical composition of taconite pellets. Runoff from a taconite storage pile was then monitored during four storm events for each of the pollutants potentially associated with taconite pellets. Samples were obtained from inside the pile (using a lysimeter), from an outfall into a detention pond and at the pond discharge point.

The storage pile sampled currently holds a National Pollutant Discharge Elimination System (NPDES) permit for the discharge from the basin. When the storage pile facility releases water from the pond it is monitored in accordance with its NPDES permit requirements. This study was designed to ascertain if there are any relationships between pollutant concentrations in the pile, at the pond inlet and at the pond outlet. Consequently, normal pond discharge times were altered for this study. The study results do not necessary reflect normal discharge values as normal pond retention times are longer than those used for this study.

The pollutants sampled included metals, total suspended solids, pH, alkalinity, and nitrate plus nitrate-N. The metals included aluminum, arsenic, barium, cadmium, copper, iron, lead, magnesium, manganese, molybdenum, and salts of chloride and sulfate. Total suspended solids and several of the metals were the pollutants that appeared to be of concern. Tables 1-1 through 1-7 show the results that had detects and appeared in quantifiable amounts. Other monitoring results from the taconite pellet study that did not show elevated levels of constituents are not reported here. pH results were between 6 - 9 standard units.

The taconite pellet storage site that was sampled is approximately 25 acres in size. At the time of the study, only one corner of the site was used for storage. Four lysimeters were inserted into a storage pile. The site is graded and sloped toward a detention pond which drains the entire storage site and several dozen acres of roads and buildings. The pond does not have an automatic discharge system. It is allowed to drain periodically during the year when pond levels get high. Samples were taken from the lysimeters and at the pond inlet. The pond was allowed to discharge after each storm event and samples were also taken from this discharge. During rain events three and five, two pond discharge samples were taken at time intervals of 13 to 54 hours after commencement of flow into the pond.

The sampling results from the study show that there tends to be lower concentrations of the pollutants in the pile and at the pond outlet as compared to pollutant concentrations at the pond inlet. The pond inlet location is draining the entire site. The pond outlet sample results appear to show the result of settling time in the basin. Arsenic was an exception to this, with much higher concentrations in the pile than at the two pond sampling points. It may be that this particular shipment of taconite had much higher levels of arsenic than previous shipments.

Pollutants of concern at the pond inlet appear to be iron, lead, aluminum, copper, and total suspended solids. The concentrations of all of these parameters at the pond outlet do not appear to be of concern. The results tend to show that a large taconite pellet storage area may generate enough pollutants from the entire site for there to be water quality concerns. The concentrations at the pond outlet show that allowing for settling of the yard runoff may result in a discharge that does not have water quality concerns.

It must be remembered that these sampling results are from one study and only one taconite storage pile. Other taconite pellets may differ in the amounts and types of contaminants that appear in the runoff.

Table 1-1

TACONITE PELLET SAMPLING RESULTS

Iron

Event	Lysimeter	Pond Inlet	Pond Outlet	Limits
2	720	12000	340	2000 ug Daily Maximum 1000 ug 30 Monthly Average (Federal limit for iron ore mining)
3	250	13000	90 - 500*	
4	140	890	890	
5	280	2500	460-370**	

All parameters are in ug/l. * For event #2, the first result reflects 13 hours detention and the second result reflects 30 hours detention time. ** For event # 5, the first result reflects 30 hours detention time and the second result reflects 54 hours detention time.

Table 1-2

TACONITE PELLET SAMPLING RESULTS

Aluminum

Event	Lysimeter	Pond Inlet	Pond Outlet	Limits
2	680	8000	130	1500 ATC Daily Maximum
3	310	9900	48 - 220	
4	140	4300	430	
5	99	1400	160-140	

All parameters are in ug/l. ATC = acute toxicity criteria. CTC = chronic toxicity criteria. HTC = human threshold criteria. HCC = human cancer criteria. TOC = taste and odor criteria.
Criteria selected for Great Lakes Communities as established in Wisconsin Administrative Code. These criteria may vary from state to state.

Table 1-3

TACONITE PELLET SAMPLING RESULTS

Cadmium

Event	Lysimeter	Pond Inlet	Pond Outlet	Limits
2	<0.2	0.2	<0.2	0.37 CTC Weekly Average 10 HTC Monthly Average 363.8 ATC Daily Maximum
3	<0.2	<0.2	<0.2 - <0.2	
4	<0.2	<0.2	2.1	
5	N/A	N/A	N/A	

All parameters in ug/l

Table 1-4

<table>
<tr><th colspan="5">TACONITE PELLET
SAMPLING RESULTS</th></tr>
<tr><th colspan="5">Arsenic</th></tr>
<tr><th>Event</th><th>Lysimeter</th><th>Pond Inlet</th><th>Pond Outlet</th><th>Limits</th></tr>
<tr><td>2</td><td>300</td><td>17</td><td>13</td><td rowspan="4">727.6 ATC
Maximum Daily

153 CTC
Weekly Average

50 HCC
Monthly Average</td></tr>
<tr><td>3</td><td>170</td><td>13</td><td>13 - 10</td></tr>
<tr><td>4</td><td>420</td><td>12</td><td>11</td></tr>
<tr><td>5</td><td>380</td><td>15</td><td>11 - <10</td></tr>
<tr><td colspan="5">All parameters in ug/l</td></tr>
</table>

Table 1-5

TACONITE PELLET SAMPLING RESULTS

Copper

Event	Lysimeter	Pond Inlet	Pond Outlet	Limits
2	7	41	7	9.33 CTC Weekly Average 99.2 ATC Daily Maximum 1000 TOC Monthly Average
3	5	32	<3 - 8	
4	<3	49	11	
5	<3	8	8 - 6	

All parameters in ug/l

Table 1-6

TACONITE PELLET SAMPLING RESULTS

Lead

Event	Lysimeter	Pond Inlet	Pond Outlet	Limits
2	<3	8	<3	7.59 CTC Weekly Average 50 HTC Monthly Average 1486 ATC Daily Maximum
3	<3	18	<3 - <3	
4	<3	10	<3	
5	<3	3	<3 - <3	

All parameters in ug/l

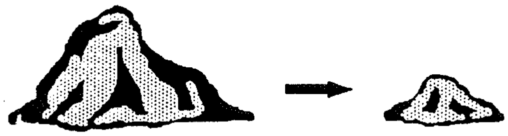
Table 1-7

TACONITE PELLET SAMPLING RESULTS

Total Suspended Solids

Event	Lysimeter	Pond Inlet	Pond Outlet	Limits
2	56	406	8	30 - 50 mg/l (Federal limits range for various types of facilities)
3	N/A	104	<2 - 15	
4	14	152	17	
5	4	29	6 - 5	

Parameters in mg/l



SOURCE AREA CONTROLS

Source area controls are those that prevent pollution from occurring at the source. They can range from elimination of use of a product to better control over the exposure of the product to stormwater. The following controls are suggestions for use if the storage pile is suspected to be a source of storm water contamination.

Reduce Amount of Taconite Stored at Harbor Sites

A method of reducing pollutants from taconite pellets at harbor storage locations is to reduce the amount of pellets being stored at these sites. This would require more storage at the mine or at the final destination point. Water quality concerns at the mine and final destination point storage areas should be compared with the water quality concerns at harbor storage sites. Sites should be compared for likelihood of impacts of concentrated runoff to a surface water, the ability to install detention basins and the potential for groundwater contamination.

Routing Uncontaminated Stormwater around Storage Piles

One method to reduce the amount of contaminated stormwater exiting a taconite pile is to reduce the amount entering the pile. This can be done by routing uncontaminated stormwater around the pile. Berms can be placed upslope of the pile in order to direct stormwater around the pile and into an infiltration area or off the site. The berm should be high enough to direct the flow of water around the taconite pile and safely away from the pile. Vegetated areas can also be used to infiltrate uncontaminated storm water upslope of the pile before the storm water reaches the pile.

Infiltration

Another source area control is to allow for as much infiltration as possible on the taconite storage site. It appears that the primary pollutants of concern are metals and total suspended solids. Many times metals will cling to suspended solids; therefore, if suspended solids can be controlled, metal levels can also be lowered. This should be done only if it can be assured that the level of metals in the runoff will not contaminate the groundwater. Many times metals can be trapped in the first several inches of soil if the soil is not too permeable. The soil must be permeable enough to allow for infiltration but not so permeable that metals will pass directly through to groundwater.

The soil at the storage site tends to become very compact due to the weight of the taconite pellets and the movement of heavy equipment across the site. There is probably very little potential for infiltration to occur on the storage pad itself. If infiltration would occur, it may be in the areas adjacent to the pad. Vegetated buffer strips could be used around the site to collect runoff and allow for infiltration. Again, this alternative should only be considered if there is no possibility of groundwater contamination in excess of groundwater standards.

The results from the taconite storage pile sampling at the pond inlet show that the levels of lead, cadmium, copper, iron, and arsenic are above groundwater standards in Wisconsin. Therefore, this runoff should not be allowed to infiltrate unless it can be shown that the metals would be trapped in the soils and not violate a groundwater standard. In addition, if depth to groundwater is shallow and groundwater is discharging into the surface water, there may be little or no attenuation of pollutants from the time water infiltrates beneath the pile until it discharges into the surface water.

TREATMENT PRACTICES

Detention Basins

When source area controls are not feasible or fail to reduce pollutants levels to the point where water quality standards are exceeded, treatment practices should be considered. The most feasible option, where land availability allows, is to install a detention basin. The basin should allow for enough settling time to bring pollutant levels to the point where water quality is not impaired. A goal to aim for is the weekly average effluent limit for chronic toxicity and the daily maximum effluent limit for acute toxicity. These vary from site to site and can be calculated by your state environmental protection agency. The tables in this chapter, showing monitoring results at a taconite storage pile, use effluent limits established for a Lake Superior discharge where it is assumed that no mixing will occur (as in a boat slip).

The detention basin should be designed to capture the 10-year, 24-hour storm event (generally used by EPA for detention basin design requirements in federal regulations) and allow for enough settling time to get total suspended sediment to approximately 30 to 50 milligrams/liter (EPA's range of limits for various types of facilities) or lower and to lower metal concentrations to below acute and/or chronic effluent limits. See Appendix 5 for information on designing detention basins.

Filter Devices

An alternative method to lower suspended solids and attached metals is to route the runoff through a screen filter. A screen, or series of screens, can be set up in a drainage ditch where runoff from the site has been directed. Appropriate screen size should be used to lower total suspended solids to approximately 40 mg/l. Again, the ditch and screen mechanism should be designed to treat the 10-year, 24-hour storm event.

The area behind the screens will have to be periodically cleaned to prevent the from building up high enough that it will be resuspended and potentially carrie during large storm events.

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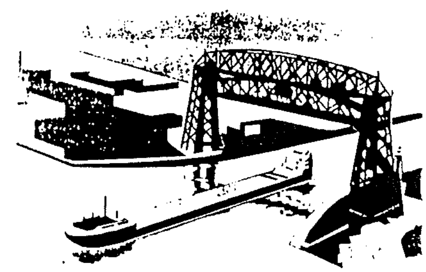
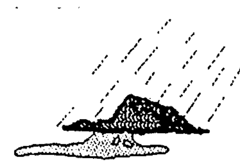
CHAPTER 2: COAL

TYPICAL PILE CONFIGURATIONS AND LOCATIONS



Coal is a fuel that is used by power companies and industries. It is stored at various locations in route from the mine and at the point of use. The size of these storage piles can range from several tons to hundreds of thousands of tons located on sites up to two to three times the size of a football field. It is often stored on harbor docks and near bays as it is transferred from one type of transportation to another. Coal is usually stored outside, as it is easier to load and unload in large areas and there is less danger of spontaneous combustion (Schueller, 1992).

POLLUTANTS



Contaminants from coal piles exit the pile either through runoff (stormwater running off the pile during a rainstorm), leachate (water trapped in the pile which infiltrates into the groundwater or is flushed out during rain storms), and airborne emissions. Runoff from the pile can also occur when the pile is sprayed to control dust emissions. Water pollution can also occur during loading and unloading of coal. Coal can be spilled directly into the water or dust can be generated during the transfer of coal between the rail car, storage pile and ship.

Monitoring results from coal pile leachate and runoff show varying levels of total suspended solids, metals, and polycyclic aromatic hydrocarbons (PAH's). The pH values of this runoff vary as well but are generally more acidic than the federal limit of 6 to 9 for coal pile discharges. In the majority of the samples, concentrations of these pollutants exceed water quality effluent limits set in Wisconsin for coal pile discharges into the Duluth - Superior Harbor.

Table 2-1 compares monitoring results from a number of studies to limits set for a coal storage facility located in Wisconsin on one of the Great Lakes. This facility is a coal transshipment facility which receives coal via railroad from several western states and stores it until it is shipped out by boat to a number of locations. Monitoring results taken from a detention basin at this facility show that discharge from the basin would meet all effluent limits set for the facility. However, the vast majority of the monitoring results obtained for this study either reach or exceed effluent limits for metals (including chromium, copper, lead, nickel, antimony, mercury, selenium, zinc, beryllium, arsenic, aluminum and cadmium), suspended solids, pH, and PAH's (including phenanthrene, pyrene, benzidine, benzo(ghi) perylene, flouranthene and acenapthene). A literature review done for the Pennsylvania Power and Light Company concluded that "many if not all constituents of coal pile seepage are far in exceedance of the water quality criteria" (Ripp, 1988).

Several studies have also concluded that coal pile leachate may be a source of groundwater contamination. A groundwater study at a utility site in New York led the New York State Department of Environmental Conservation to require collection and treatment of surface runoff and subsurface leachate (Mann, 1981). Mann's study showed increases in chemical concentrations in shallow groundwater wells down gradient from the coal pile. Overall increases in manganese, nickel, zinc, iron, and copper were noted with iron, copper, and manganese exceeding New York state groundwater standards. These same wells also had a significantly lower pH than background wells, indicating that coal pile runoff (pH 1.5 to 3) was percolating into the groundwater. The literature review done for Pennsylvania Power and Light Company concluded that leachate and runoff from coal storage areas may be a source for organic contamination of groundwater (Ripp, 1988).

Coal piles located adjacent to surface waters may be contributing pollutants to the surface water via runoff and groundwater infiltration. If depth to groundwater is shallow and groundwater is discharging into the surface water, there may be little or no attenuation of pollutants from the time water infiltrates beneath the pile until it discharges into the surface water.

The metals found in coal pile runoff and leachate are non-biodegradable and concentrate in the food chain. Possible effects of these metals include liver and kidney damage, tumors, birth defects, hemorrhages of the gastrointestinal tract, lung and other respiratory concerns, brain damage, bone defects, learning disabilities, and neurological damage (Schueller, 1992).

Low pH values in coal pile runoff and leachate can result in a release of higher concentrations of metals in the runoff (Davis, 1981, Chandler, 1985). Low pH values in a stream may also be detrimental to aquatic life. Suspended sediment can cover spawning beds and cause respiratory problems in some aquatic life. Suspended sediment and the dark color of some coal pile runoff is also an aesthetic problem.

Low levels of coal leachate that contain organic molecules may lead to enrichment of the receiving water body and interfere with the distribution of macro-invertebrates (Swift, 1985, Curran, 1980, Anderson, 1976).

SOURCE AREA CONTROLS

Source area controls are those that prevent pollution from occurring at the source. They can range from elimination of use of a product to better control over the exposure of the product to stormwater. The following controls are suggestions for use if the storage pile is suspected to be a source of stormwater contamination.

Reduce Amount of Coal Used

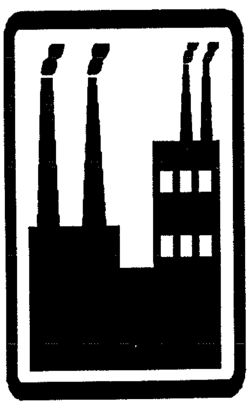
The first method of source reduction that should be considered is to reduce the amount of coal used. One of the ways to accomplish this is by lowering the demand for electricity, thereby reducing coal needed at electric generating facilities. Another method is to reduce the coal used at manufacturing industries. This can be done by installing more energy efficient furnaces or by switching to another type of fuel. Some coal burning facilities also burn wood, tire chips, and natural gas. Most coal boilers can be easily converted to natural gas fuel systems. Many alternative fuel types are cleaner burning than coal, thereby reducing the need for air emission controls. The use of high sulfur coal would also result in

the use of less coal as it has a higher BTU value. However, as explained in the following sections, higher sulfur coal has more contaminants associated with it, thereby increasing the water quality pollution potential.

Reduce Amount of Coal Stored at the Site

The second method of source reduction that should be considered is to reduce the amount of coal stored at the site. Some facilities store up to six months of coal at a time. At some sites this may be necessary if the method of delivery is by ship or barge. Winter conditions may prevent delivery of coal for a number of months at a time. However, at some sites, it may be possible to reduce the amount of coal stored.

Use of Lower Sulfur Coal



The sulfur content of coal plays a major role in the type and amount of contaminants in stormwater runoff and leachate. High sulfur coals tend to produce runoff and leachate which have lower pH's and higher concentrations of metals and organic compounds (Chandler, 1985, Davis, 1981, Hendershot, 1984, Stahl, 1984). High sulfur content is generally in the form of pyrite (FeS). The reaction of Fe sulfides with oxygen produces metal sulfates and acid. The acid dissolves many other complex sulfides and sulfosalts, releasing high concentrations of metals (Davis, 1981). Eastern coals tend to have higher sulfur content; therefore, runoff and leachate from these coals have lower pH's and higher metal content. Eastern coal runoff and leachate pH values tend to range from 2 to 3.8 while western coal runoff and leachate pH values range from 4.6 to 8.3 (Hendershot, 1984, Davis, 1981).

Over the past 10 years, more facilities have switched to lower sulfur coals in order to meet air emission standards. This should, therefore, result in a lower pollutant loading rate for metals and acidic runoff. Facilities that are not now using lower sulfur coal should explore this option to see if it is feasible for their site. There are, however, some problems associated with the use of lower sulfur coal. It has a lower BTU value per pound, thereby requiring more coal to achieve the same energy output. Lower sulfur coal is also more spontaneously combustible, thus increasing the likelihood of fires in the pile. Also, electrostatic precipitators, used for reducing air emissions, may not function as well with lower sulfur coal. (DNR personal correspondence).

Store Coal in Optimum Pile Configuration

There are conflicting opinions as to how much runoff exits the coal pile during a rain event. Estimates range from 10 to 95 percent (Davis, 1981 review, Stahl, 1984). Rainfall that does not immediately exit the pile either evaporates or infiltrates into the pile. The infiltrating water is removed via groundwater infiltration, flushing of the pile during subsequent rain events, or is absorbed by the coal.

Several studies point to the fact that direct runoff from a coal pile has lower pollutant levels than leachate (Anderson, 1976, ESEERCO, 1983). Moisture retained within the pile is dissolving minerals, thereby releasing metals (Anderson, 1976, Davis, 1981). Therefore, the less time there is for contact between moisture and coal, the lower the amount of contaminants generated.

There is also a direct relationship between coal surface area and amount of pollutants released. The smaller the coal particles, the larger the surface area available for reactions to take place; therefore, the higher the pollutant load in the runoff and leachate (Davis, 1981, review). By mixing grain sizes, compacting the coal, creating steep side slopes and a sloping top, a facility can minimize infiltration into the pile. However, by doing so, the facility is creating more surface runoff during rain events.

Which is the Best Configuration for Your Pile?

The coal pile owner or operator must evaluate whether the runoff and/or leachate could potentially contribute to a violation of a water quality standard. At many sites, neither direct runoff into a water body, or infiltration into the groundwater should be allowed.

If the runoff from a coal pile is monitored and results show that the runoff will not contribute to a water quality problem, the owner may wish to compact and slope the pile so that maximum runoff and minimum infiltration is achieved.

If the coal pile is on an impervious pad and runoff is collected and treated, more infiltration may be desired to reduce the amount of runoff immediately generated. This will allow for slower filling of the detention facility. This should only be done if the treatment facility can handle the higher pollutant levels from rainfall which infiltrates the pile and exits at a later time.

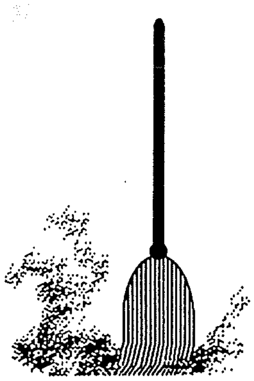
If the pile is not on an impervious pad, and the monitoring results show that the leachate will not violate groundwater standards, more infiltration may be preferred.

It should be remembered, however, that shaping the pile to either increase runoff or infiltration should only be done after monitoring of the runoff and leachate. Coal pile owners and operators should also remember that the longer the leachate stays in the pile before it exits, the higher the pollutant concentration will be. Coal pile studies to date show that most leachate has contaminants at levels that will violate both surface and groundwater standards.

Keeping the Pile Intact and Area Swept

Keeping the coal pile intact, or as small as possible, reduces the amount of coal that comes in contact with stormwater. This reduces the potential for contaminants to be dissolved or dislodged and washed into the nearby water body. The following actions will help keep the pile intact:

- Keep only one pile on site if possible.
- When adding to the pile, compact it and keep it as confined as possible to one spot.
- Regularly sweep the area and put the sweepings back onto the pile.
- Spray the pile and roads as needed to supress dust. However, do not spray to the extent that runoff from the site is created. The addition of 0.01 inches of water (either as rain or spray) will usually produce a dust free condition (Hesketh, 1983).



Loading and Unloading Concerns

A great deal of dust and spillage can be created as the coal is unloaded onto the pile and subsequently loaded onto vehicles to ship it off site or to move it to the boiler. The following practices should be followed when coal is being moved on, around, or off the site:

- If dust is being generated during loading, unloading, or transfer, the coal should be sprayed to control the dust. Many facilities are already required to do this as a requirement of their air permit. Spray should be controlled to avoid creating runoff from the site.

- Spillage into a water body during loading and unloading must be prevented. The use of covered chutes or booms should be considered to prevent spillage.

Vehicle Maintenance and Washing

Fluids from vehicle maintenance activities and broken hoses also contribute to stormwater contamination on a storage pile site. Any vehicle maintenance that has the potential to result in loss of fluids or solvents should be done indoors and on an impervious pad. Any spills should be immediately cleaned up. Properly dispose of all fluids and solvents.

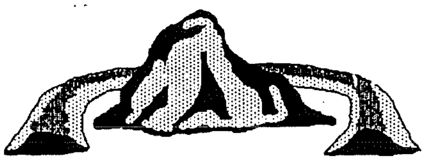
Routine maintenance of vehicles will prevent many accidental spills due to hose breaks. Hoses should be checked periodically and replaced when necessary.

Vehicle washing should be done in an area where the wash water can be treated or kept from discharging into a water body.

Berming

Berming is a practice which can serve several purposes. It can be used to prevent uncontaminated stormwater from washing across the exposed coal and becoming contaminated. It can also be used to keep storm water from carrying particulates off the site.

The coal pile should be carefully observed during a rain storm. Careful note should be made of areas where uncontaminated stormwater is moving across the storage pile area and coming in contact with the coal. Berming is one way to direct this uncontaminated storm water around the coal pile. (Filtration strips, discussed below, can also be used.) The berm should be high enough to direct the flow of water around the coal pile and toward an area where it can infiltrate without becoming contaminated.

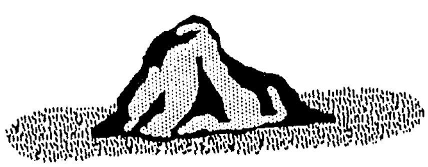


Berms can also be used to prevent storm water from washing particulates off the site. Many coal piles are located on docks where there is very little space between the coal pile and the edge of the dock. Rain storms can easily wash particulates off the dock into the water. The coal pile should be moved as far back from the dock edge as possible without interfering with loading and unloading operations. A berm can then be used to contain the coal pile and direct runoff away from the dock edge and back toward the pile or toward a treatment practice if one is used.

If water is directed back toward the pile, the owner or operator must remember that long-term contact of storm water on the coal pile can create higher pollutant concentrations. If the water cannot be evaporated, treated, or safely infiltrated, another option should be considered.

Vegetated Buffer Strips

Strips or areas of vegetation around the coal pile can be used to keep uncontaminated storm water from washing across the coal storage area and picking up contaminants. These types of areas can also allow infiltration of runoff from the pile.



Vegetated buffer areas can be designed as shallow depressions to capture stormwater and allow it to infiltrate over time. The amount of storm water moving towards the pile should be calculated. An infiltration area can then be designed to allow all of this water to infiltrate before it reaches the coal storage area. Large amounts of stormwater could also be directed around the coal pile through the use of berms. This excess water could be directed toward a vegetated area.

Infiltration practices should not be used with contaminated stormwater unless approval has been obtained from the proper regulatory agency.

TREATMENT PRACTICES

When source area controls do not keep pollutant levels low enough to avoid violating a water quality standard or effluent limit, treatment of the coal pile runoff should considered.

One study concluded that most of the contaminants could potentially be flushed from the coal pile during the first portion of a rain event (Anderson, 1976). Anderson concluded that the completion of contaminant flushing was dependent on the volume and duration of rainfall. Therefore, only the first flush from a rain storm may need to be treated. This is consistent with monitoring requirements in many states' stormwater permits which require the sample to be collected during the first 30 minutes of the rain storm.

Therefore, when considering treatment, the owner or operator should monitor the runoff to evaluate whether only the initial runoff from some rain events should have to be treated. A detention system could be set up to allow for capture of the first 30 minutes of runoff. The remaining runoff could be diverted to another detention system, infiltration system, or allowed to discharge to a water body if pollutant levels are not of concern. Caution should be taken to do enough up-front monitoring to be able to determine when the runoff could be divided this way without causing a water quality concern.

When considering the following treatment options, the owner or operator may want to explore the option of treating only the initial runoff.

Pads

The pad under a coal pile has two main functions - to prevent infiltration to the groundwater and to allow the stormwater to run off from the coal pile area and be collected for treatment. Therefore, the pad should be impervious and should be sloped to facilitate runoff to the detention basin.

Since coal pile runoff can be very acidic, a material must be chosen that can withstand contact with the acidic discharge. Concrete is not recommended as this can crack, resulting in infiltration, and it will not hold up under exposure to acidic runoff.
Asphalt can also crack, thus resulting in infiltration into

groundwater. There may also be some contaminants associated with stormwater runoff from asphalt that are a water quality concern. Compacted clay pads are recommended. These can be expensive but hold up well under coal piles. The clay must be thick enough to render it impervious.

Recycling of Runoff Back Onto the Pile

When infiltration of contaminated stormwater is not a concern, the best treatment practice for contaminated stormwater from coal piles may be to spray the water back onto the pile. If the coal pile is not on an impervious pad, monitoring of the leachate should be done before the runoff is sprayed back onto the pile. Recycling of leachate may also concentrate pollutants. Care shold be taken to avoid violating groundwater standards.

The runoff from the coal pile can be collected in a detention ditch or basin. The runoff may need to be filtered before it can be recycled back onto the pile into order to avoid clogging the spray equipment. Evaporation from the detention area may also reduce the amount of water to be recycled. Recycling back onto the pile can be especially advantageous for coal piles that need to control dust.

Detention and Settling

In some instances, settling of the coal pile runoff may be enough to reduce pollutants to acceptable levels. Runoff sampled from the detention ditch at a coal storage facility in Wisconsin has been shown to be below the discharge limits set for the facility. The detention basin should be large enough to capture and treat the runoff from the ten year, twenty- four-hour storm event. In regions that receive small to moderate amounts of rainfall, there may be only a small amount of discharge from the settling basin due to evaporation.

The settling time needed will vary with the contaminant levels in the runoff. If suspended solids are the only pollutant of concern at a particular site, settling may be enough to reach acceptable levels of 50 mg/l. However, in many instances, settling time alone may not reduce pollutants to acceptable levels.

pH Adjustment

pH values of stormwater discharges from coal pile runoff need to be between 6 and 9 in order to meet federal water quality categorized limits for coal pile runoff at steam electric generating plants. Sampling results show that many times pH values in coal pile runoff are more acidic than the lower acceptable level of 6 standard units. If there is a direct discharge to surface water, the pH may need to be adjusted to meet water quality limits.

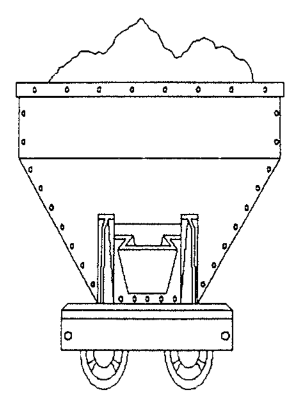
One method of pH adjustment is the addition of lime to the runoff. This requires an equalization basin for homogenous mixing of the runoff. Also needed would be a storage facility for the lime, a feed system, instrumentation, electrical connections, and piping. Liming may also help in the precipitation of metals.

Removal of Metals

A number of metals including chromium, copper, lead, nickel, antimony, mercury, selenium, zinc, beryllium, arsenic, aluminum, and cadmium, have been shown to be of concern in coal pile runoff. In some instances a long settling time may be enough to remove metals to the point that the discharge meets water quality limits. In other instances, metals will need to be removed via other treatment methods to prevent the coal pile discharge from causing a violation of a water quality standard.

Chemical precipitation, or flocculation, is a method to remove metals. A polymer can be added to the discharge to allow the metals to settle out. These are expensive options and may require special disposal of the collected solids as they may be considered hazardous waste.

pH adjustment can also be used to settle out some metals. Metals are less water soluble when the runoff has a higher pH level. Therefore, a pH adjustment like a lime feed system may also result in a lower metals content in the discharge. The metals will remain in particulates that have settled out. These accumulated solids will need proper disposal if they contain hazardous material.



A polymer feed system can include storage hoppers, chemical feeders, solution tanks, solution pumps, interconnecting piping, electrical connections, and instrumentation.

Subgrade Cutoff Walls to Prevent Groundwater Contamination

In those instances where coal pile infiltration or runoff is violating groundwater standards and an impervious pad is not an option, a subgrade cutoff wall may be an option. The cutoff wall can be a slurry or grout curtain. This wall is built around the coal pile and extended to relatively impermeable subsoil to prevent movement of groundwater under the slurry wall. The wall should have a permeability of less than 1 x 10 (-7) centimeter per second.

A drainpipe system is placed inside the slurry trench below the groundwater table. Collection pumps located at various points around the slurry wall keep the groundwater level inside the slurry wall slightly lower than outside the wall to prevent migration of coal pile leachate into the surrounding groundwater. This system also prevents an excessive migration of uncontaminated groundwater into the coal pile area. The sumps empty into an impervious basin (Mann, 1981). The collected water is then treated as necessary to remove any pollutants that could cause a violation of a water quality standard.

PAH Removal

When stormwater discharges from a coal storage area contain PAH's in levels that will cause a violation of a water quality standard, the PAH levels should be reduced. PAH's tend to cling to particulate matter. Therefore, solids removal may also reduce the level of PAH's.

A lined detention basin should be used to attempt PAH reduction in order to avoid groundwater contamination. At a minimum, the 10 year, 24-hour rain event should be captured and allowed to settle for at least 48 hours. Longer periods of settling should be considered, if possible, to allow for the maximum PAH reduction.

Table 2-1

COAL PILE RUNOFF AND LEACHATE ANALYSIS vs. DISCHARGE LIMITS

Water Quality Limits	Runoff and Leachate Sampling Results					
Water Quality Effluent Limits Established for a WI Coal Storage Facility	Fendinger 1989	Friedrick 1989	EPA Source Assessment 1978	Ripp 1988	EPA Development Document 1982	Midwest Energy 1993
Benzidine HCC 0.65 ng/1 mo. avg.			14,000 ng/1			<26,000 ng/1
Benzo(ghi) perylene HCC 0.023 ug/1			44 ug/1			<10 ug/1
Fluoranthene HTC 9.3 ug/1 mo. avg.			16 ug/1			<10 ug/1
Acenaphthene TOC 20 ug/1 mo. avg.	0.06 - 0.47 ug/1		15 ug/1			<10 ug/1
Arsenic ATC 727.6 ug/1 max. effl. CTC 153 ug/1 wkly. avg. HCC 50 ug/1 mo. avg.		Total recoverable 210 ug/1 AA Furn <10 ug/1 - 21,000 ug/1	<10 ug/1 - 146,000 ug/1	5 - 9050 ug/1	5 - 600 ug/1	<3 ug/1
Aluminum ATC 1500 ug/1 max. effl.				2750 ug/1 - 1,872,000 ug/1	66,000 - 440,000 ug/1	380 ug/1
Cadmium HTC 10 ug/1 mo. avg. CTC 0.37 ug/l wkly, avg. ATC 363.8 ug/1 max. effl.		Total recoverable <0.2 - 860 ug/1 ICP 160 - 3700 ug/1	875 ug/1	<0.001 ug/1 - 49 ug/1	<.001 ng/1	<0.2 ug/1

TABLE 2-1 continued

WI Coal Pile Discharge Limits	Fendinger 1989	Friedrick 1989	EPA Source Assessment 1978	Ripp 1988	EPA Development Document 1982	Midwest Energy 1993
Chromium +3 HTC 140,000 ug/1 mo. avg. CTC Chromium +6 50 ug/1 mo. avg. CTC Chromium +3 45.03 ug/1 wkly. avg. Chromium +6 9.74 ug/1 wkly. avg. ATC Chromium +3 9677 ug/1 max. effl. Chromium +6 28.4 ug/1 max. effl.		Total recoverable 280 ug/1 AA Furn <3 - 980 ug/1 (ICP)		<0.005 - 76,000 ug/1	<0.005 - 11 ug/1	<1 T ug/1 <1 T ug/1
Copper TOC 1000 ug/1 mo. avg. CTC 9.33 ug/1 wkly. avg. ATC 99.2 ug/1 max. effl.		ICP 5-21,000 ug/1	30 - 6750 ug/1	3400 ug/1	430 - 1400 ug/1	1 ug/1
Lead HTC 50 ug/1 mo. avg. CTC 7.59 ug/1 wkly . avg. 1486 ug/1 max. effl.		Total recoverable 3.2 - 140 ug/1 AA Furn <3 ug/1 - 150 ug/1	10 ug/1 - 530 ug/1	<0.01 - 505 ug/1		<3 ug/1

Table 2-1, continued

WI Coal Pile Discharge Limits	Fendinger 1989	Friedrick 1989	EPA Source Assessment 1978	Ripp 1988	EPA Development Document 1982	Midwest Energy 1993
Nickel HTC 170 ug/1 mo. avg. CTC 54.75 ug/l wkly. avg. ATC 5056 ug/1 max. effl.		Total recoverable 86,000 ug/1 TCP <100 - 91,000 ug/1	5 ug/1 - 33,200 ug/1		740 - 4500 ug/1	<10 ug/1
Antimony HTC 120 ug/1 mo. avg.			<1 ug/1 - 29,000 ug/1		8 - 2500 mg/1	<5 ug/1
Total Suspended Solids - 50 mg/1	1.3 - 14,900 mg/1		228 - 3384 mg/1			
PH 6-9	1.4 - 8.5		2.4 - 7.7	1.4 - 7.8	2.3 - 3.1	

HCC = Human Cancer Criteria, HTC = Human Threshold Criteria, TOC = Taste and Odor Criteria ATC = Acute Toxicity Criteria, CTC = Chronic Toxicity Criteria. Standards Established in Wisconsin Administrative Code. NDL = No Detect Level.

Table 2-1, continued

WI Coal Pile Discharge Limits	Fendinger 1989	Friedrick 1989	EPA Source Assessment	Ripp 1988	EPA Development Document 1982	Midwest Energy 1993
Mercury HTC 0.08 ug/1 mo. avg. ATC 3.06 ug/l max. effl.		.04 - 0.12 ug/1	NDL - 30.8 ug/1	0.01 ug/1 - 13,100 ug/1	2.5 ug/1	0.2 ug/1
Selenium HTC 10 ug/1 mo. avg. CTC 7.07 ug/1 wkly. avg. ATC 116 ug/1 max. effl.		Total recoverable <125 ug/1 AA Furn <5 - 2700 ug/1	<3 ug/1 - 83,000 ug/1	<0.001 - 829 ug/1	30 ug/1	<3 ug/1
Zinc TOC 5000 ug/1 mo. avg. CTC 41.05 ug/1 wkly. avg. ATC 553 ug/1 max. effl.		Total recoverable 2300 - 380,000 ug/1 ICP 22- 390,000 ug/1	75 ug/1 - 107,000 ug/1	6 - 194,000 ug/l	2.3 - 16 mg/1 2300 - 16,000 ug/1	<2 ug/1
Phenanthrene HCC 0.023 ug/1 mo. avg.	0.06 - 0.19 ug/1					<10 ug/1
Pyrene HCC 0.023 ug/1 mo. avg.	0.01 - 0.05 ug/l					<10 ug/1
Beryllium HCC 0.03 ug/1 mo. avg.		<1 - 750 ug/1 (ICP)			30 - 70 ug/1	<0.05 ug/1

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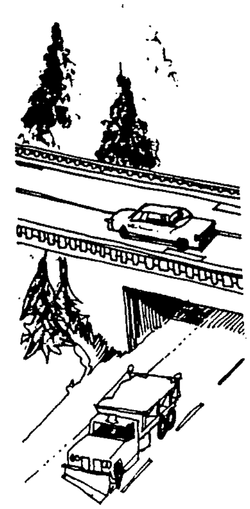
CHAPTER 3: SALT

TYPICAL PILE CONFIGURATION AND LOCATIONS

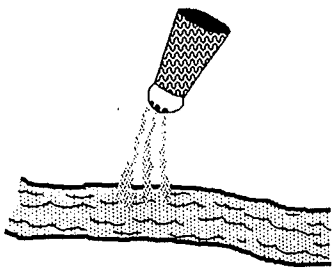
Salt is used for deicing, industrial activities, and chemical processing. Many storage piles are along the waterfront, as one of the major modes of transportation is by water. Smaller piles are created inland as the salt is trucked closer to points of use. Storage pile sizes can range from several tons to tens of thousands of tons. Approximately 30 million tons of dry salt is produced each year in the United States and Canada. The single largest use is road deicing salt which accounts for 13 million tons per year (Salt Institute, 1987). While the focus of this chapter will be on road deicing salt, some of the management practices may be used for outside storage of other types of salt where applicable.

POLLUTANTS

Salt used for highway deicing is composed of more than 95 percent sodium chloride (NaCl) as specified in ASTM D 632-94, Standard Specification for Sodium Chloride. Road or deicing salts are generally NaCl and calcium chloride (CaCl). (Other road deicing materials can contain up to 95 percent sand.) Deicing salt also may contain anticaking and freeze protectant additives such as ferric ferrocyanide (or prussian blue) and sodium ferrocyanide (yellow prussiate of soda or YPS). YPS is approved in food grade salt at 13 parts per million.. YPS is added to deicing salt at concentrations typically ranging from 20 to 100 parts per million..


The Salt Institute

Contaminants may be carried from the salt piles via wind or stormwater which can dislodge or dissolve the salt. These contaminants may be carried to surface waters or infiltrate into the groundwater. It is possible for rainfall to reduce an uncovered salt storage pile at a rate of 1/4 percent per annual inch of precipitation. That equates to the loss of up to 25 tons per year from 500 tons of exposed salt. This amount could contaminate 15 million gallons of water to the suggested 250 mg/liter chloride level set for drinking water and can raise the sodium levels to the threshold level of 20 mg/l in 120 million gallons of water (the maximum concentration recommended by the American Heart Association for patients on low sodium diets) (Schueller, 1992 and Salt Institute, 1995). Chlorides can also harm freshwater organisms and vegetation by increasing the level of salinity in surface water.



Salt leachate is very soluble and therefore easily carried from the salt pile. An estimated 20 percent of the rise in chloride levels in the Great Lakes is due to the use of salt as a deicing agent; eight percent of the annual sodium input into the Cambridge Reservoir in Massachusetts is attributed to salt leaching from salt storage facilities (Schueller, 1992, Fritsche, 1992).

SOURCE AREA CONTROLS

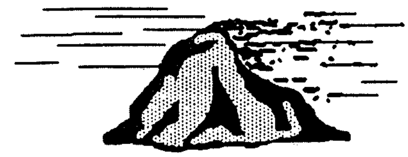
Source area controls are those that prevent pollution from occurring at the source. They can range from elimination of use of a product to better control over the exposure of the product from rainfall. The following controls are suggestions for use if the storage pile is a source of stormwater contamination.

Reduce Amount of Salt Used

Reducing the amount of salt used should obviously reduce the amount of salt that is potentially exposed to stormwater. This would require industries to find alternative substances or reduce the amount used in manufacturing, chemical processing and food preparation. Reducing the amount of road salt used would entail putting less on roads for deicing or finding a substitute deicer. Electronic applicator controls on trucks have been shown to be more efficient for deicing salt application than mechanical systems.

Substitute deicers include calcium magnesium acetate. The calcium and magnesium ions' mobility in soil are limited, and the acetate anion is much less mobile in soil than the chlorine ion, thereby reducing the potential for groundwater contamination. There may, however, be biological oxygen demand associated with acetate breakdown. Calcium magnesium acetate works best as a deicer if applied before snow accumulates in any amount. CaCl or NaCl work better on packed snow and ice, (Fritzsche, 1992). However, more of the substitute deicers may be needed to achieve the same level of melting action as NaCl provides.

Reduce Amount of Salt Stored



The amount of salt potentially exposed to stormwater can be reduced by keeping inventories as low as possible without reducing the pile to below needed levels. Delivery by water transportation may require that the pile be built up enough to supply salt when water routes are impassable and to have enough on hand for an unusually severe winter. Proper planning will help keep inventories at an adequate level without stockpiling unneeded amounts.

Enclosing the Salt Pile

The State of Wisconsin requires that all salt piles must be covered or enclosed and placed on an impervious pad so that neither precipitation, stormwater runoff, nor wind comes in contact with the stored salt and carries it away. In addition, the salt pile may not be any closer than 50 feet (laterally) from any surface water. These are requirements of the Wisconsin Department of Transportation (WI Chap. Trans 277) and the Wisconsin Department of Natural Resources (WI Chap. NR 216). Chloride and sand mixtures that are 95 percent or more untreated sand by weight are exempt from these requirements.

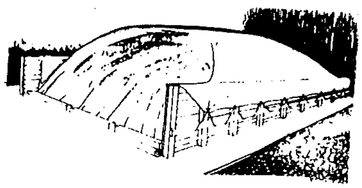
Prompt and effective covering of the stockpile as well as proper cover system management and maintenance prevents salt loss due to precipitation. These factors also minimize material handling problems resulting from wet or caked salt. The following guidelines for pads, berms, buildings and tarps should be considered when designing a cover system for a salt pile.

Pads and Berms

- Impervious pads should be at least 2 1/2 inches thick and set on a compacted gravel base (Richardson, 1974). Asphalt or concrete pads can be used.

Asphalt pads should have a surface sealant applied to prevent infiltration.

- Concrete pads should be high quality, air entrained, and should have the concrete coated with linseed oil, asphaltic type coatings, or other coatings to make them impermeable (Schueller, 1992).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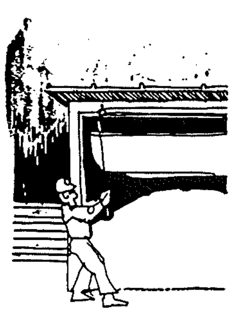
- The pad should have adequate slope to allow water to drain away from the center (Salt Institute, 1987). Placement of salt on the stockpile should begin at the high end of the sloped pad and proceed toward the low end. When removing salt from the stockpile, equipment should work from the low end toward the high end. Any precipitation or brine runoff from the site should be disposed or discharged according to applicable regulatory requirements. (Salt Institute, 1995)

- The salt storage area should be designed to prevent stormwater from flowing onto the pile. This can be accomplished by placing walls or berms on the upslope sides of the salt pile area in order to direct stormwater around the storage area. The downgradient side can also be constructed with a berm which allows vehicle access to the pile.

- The surface sealant applied to the pad should also be applied to the junction of the pad and berm. A seal should also be placed between any walls and the pad to prevent water from entering the pile below the bottom of the wall.

Salt Storage Buildings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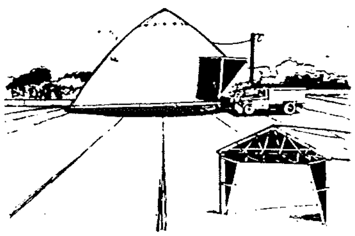
The Salt Institute feels that small stockpiles of salt (a few tons up to 3,000 tons - typically used by winter maintenance agencies) are best protected by ground level sheds or buildings. If the ends of the building do not have doors, a cover should be placed over the exposed salt or a tarp hung over the opening. Door openings should be a minimum of 20 feet wide. Buildings range from domes with conveyor systems to simple pole buildings. Many facilities are converted garages or were sheds originally used for another purpose. The Salt Institute encourages looking around for an existing building which will suit your needs before building a new structure.

Tarps

If a tarp is used to cover the salt it should meet the following requirements:

- The tarp should be impermeable or water resistant.
- The ends should be secured with tie downs.
- The seams should be watertight.
- The tarp should completely cover the salt and be brought over the top of the berm or wall surrounding the salt pile.
- The salt pile should only be exposed at the working face - i.e., uncovered only while salt is being added or removed and open only to minimum dimensions necessary.
- The covering should be regularly inspected, repaired, and maintained to conform to the above requirements.
- Tarp ends should be tied down or anchored to secure them against wind and to completely cover the salt pile. Suggested tie downs include timbers, railroad ties, sand bags, tires or polycord nets. The anchors should be lashed together and placed uniformly over the pile.
- Tarp seams should be sewn together as adhesive tape does not always hold well.
- Tarps can be made of polyethylene, polypropylene, hypalon, polyurethane foam or water resistant canvas. Typically polyethylene used for covering



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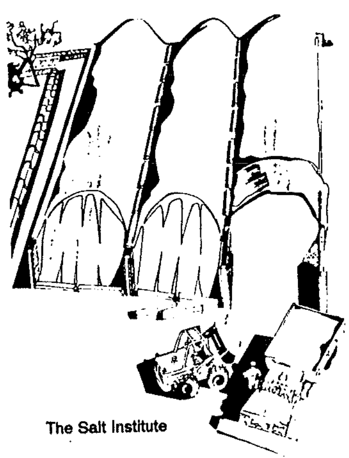
salt stockpiles is 12 millimetersl or greater in thickness (NASC, 1993).

Costs to cover salt stockpiles depend on economies of scale and local site specific conditions. Estimates used by Salt Institute member-companies in 1991 suggest nonstructural, temporary covering costs as high $1.00 per ton for stockpiles of 2500 tons and $0.70 to $1.00 per ton for stockpiles of 5,000 tons. The cost of domes as estimated by EPA in 1991 (Federal Regulations, August 16, 1991) ranged from $30,000 for a small dome to $100,000 for a large dome. (Large domes are categorized by EPA as those holding up to 5,000 tons of salt). This placed EPA's estimated price for storage per ton between $70 to $80 for the small domes and approximately $18 per ton for the larger domes. However, the Salt Institute estimated the costs of a 5,000 ton structural salt dome can exceed $175,000 or about a minimum of $34 per ton of salt.

Pile Configuration



The Salt Institute

Salt piles built in windrow or sugarloaf shapes enhance tarp stability. These shape also facilitates tarp covering and uncovering (NASC, 1993). Where applicable, the crown at the top of the pile should be between 4 - 10 feet in width. This crown should be sloped down gradient about 1% to 2 % toward the working face so that stormwater is not allowed to accumulate on the crown. The slope of the stockpile sides and ends should be maintained to preserve the 32 degree natural angle of repose for bulk salt. (Salt Institute, personal correspondence, 1995).

Keeping the Pile Intact and the Area Swept

Keeping the pile intact and the area swept reduces the amount of salt that is exposed to stormwater. The area should be inspected every time the pile is added to or reduced. All spilled salt should be cleaned up immediately and the pile recovered if a tarp is used.

In addition to inspections after loading, the site should be regularly inspected and cleaned as necessary.

Loading and Unloading Concerns

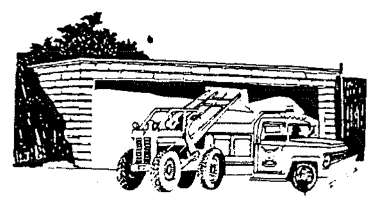
Operators should take care during loading and unloading to avoid spilling salt as it is being transferred onto the pile or into the truck. Salt unloaded from a boat or ship can easily be spilled into the water. Conveyor systems and buckets should be set up to eliminate this spillage.

Conveyors should be designed to prevent salt spillage. The speed of conveyors can also be controlled to reduce dust.

Chutes or booms can be used at the end of the conveyor to direct salt onto the pile and to reduce dust generation. The boom should be placed as close to the pile as possible as salt is being unloaded.

If a bucket is used, the bucket should be as close to the top of the pile as possible before the salt is emptied onto the pile.

All loading and unloading should be done within the pad area when possible (NASC, 1993).



The Salt Institute

Trucks beds should be covered with a tarp prior to departure from the salt storage area (NASC, 1993).

The working face of the storage pile should be maintained perpendicular to the long axis of the pile by loading alternately left/right and right/left. (Salt Institute, 1995).

Chunks of salt formed as the crust of the pile breaks up should be crushed and blended into the pile daily and not allowed to accumulate. (Salt Institute, 1995).

Vehicle Maintenance

Fluids from equipment operation and maintenance activities also contribute to stormwater contamination on a salt storage site. Any vehicle maintenance that has the potential to result in loss of fluids or solvents should be done indoors and on an impervious pad. Any spills should be immediately cleaned up. Properly dispose of all fluids and solvents.

Routine maintenance of vehicles will minimize many accidental spills of fluid due to hose breaks and related leaks.

Vehicle washing should be done in an area where the wash water can be treated or kept from discharging into a water body.

TREATMENT PRACTICES

Brine Collection and Control

Stormwater runoff or brine from salt storage activities should be disposed or discharged in accordance with state and local regulatory requirements. One option is to spray it back onto the pile during dry seasons. It may also be applied to spreader loads prior to street application (Salt Institute, 1987 and 1995).

If the brine cannot be recycled or reused, proper disposal methods should be followed. In Wisconsin, interim chloride toxicity values recommended for use are 788 milligrams/liter for acute toxicity and 399 milligrams/liter for chronic toxicity.

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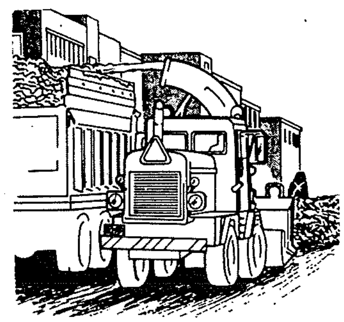
CHAPTER 4: SNOW DISPOSAL

TYPICAL PILE CONFIGURATIONS AND LOCATIONS

As snow accumulates throughout the winter in urban areas, it is at times collected and deposited at sites away from high traffic and congested areas. The snow is dumped on open land sites or occasionally into surface waters.



Environment Canada

The size of snow storage piles will vary with the size of the urban area and the amount of snowfall received. The disposal sites are normally located as close as possible to the areas from which the snow is removed in order to keep transportation costs low. Open lots, parks, unused parking lots, rivers, lakes, streams, wetlands, and ponds have all been used as disposal sites.

POLLUTANTS

Plowed or dumped snow may contain chlorides, sodium, lead, cadmium, zinc, chromium, oil and grease, sediments, bacteria, nitrates, litter and debris. The amount and types of pollutants will vary with traffic density and will depend on how quickly snow is removed from the streets.

Chlorides, sodium, and sediments are contributed to snow by the use of road salt and sand on streets in order to reduce traffic accidents. It has been estimated that after each snow storm, 1,000 pounds of road salt is applied to each mile of two lane road. Oil and grease, lead, cadmium, zinc and chromium are from automobiles. Pet wastes contribute bacteria and nitrates, and litter and debris originate from a number of sources. Snow left on city streets for any length of time takes on a gritty black appearance which is evidence of the many types of pollutants it contains.

Chloride levels in dumped snow have been found to range from 6 mg/l to 2250 mg/l. Interim chloride toxicity values recommended for use in Wisconsin are 788 milligrams/liter and 399 milligrams/liter for acute and chronic toxicity, respectively. Chlorides form a saline layer along the bottom of lakes that can prevent normal mixing. This can lead to reduced oxygen levels in the bottom waters and increased nutrient release from the sediments. These added nutrients may stimulate plant growth. Increased chloride levels may also result in the release of mercury from contaminated sediments (Schreiber, 1986).

Chlorides readily move through the soil and can enter the groundwater as stockpiled snow melts. The groundwater enforcement standard for chlorides in Wisconsin is 250 mg/l. Some wells in Wisconsin have become contaminated above the drinking water standard for chlorides with the source documented as road salt use (Schreiber, 1986).

Sodium levels in stock piled and dumped snow have ranged from 7 mg/l to 220 mg/l (Seaway Port Authority). Increased sodium concentrations may prevent mixing of waters in lakes (as do increased chloride concentrations) and result in increased nutrient release from sediments. High concentrations of sodium and chloride lead to deterioration of soil structure, resulting in decreased permeability, loss of vegetation, and increased erosion (Schreiber, 1986).

Sediment, primarily sand from road salt and sand mixtures, is also a contaminant of concern in snow. One New England state found that an average of 358 cubic yards of sand was deposited every year on a snow dumping site (Vermont ECD). One study measured total suspended sediments (TSS) at concentrations as high as 2,250 mg/l (Pierstorff). Wisconsin state effluent limits set maximum levels of TSS at 50 mg/l at a number of facilities. Sand can have a blanketing effect on lakes and streams, smothering fish spawning areas, and vegetation. Snow dumping in surface waters in Ontario has been curtailed because of the amount of sediment in snow (O'Brien).

Lead levels have ranged from 0.9 mg/l to 9.8 mg/l in dumped snow, cadmium levels from 0.01 to 0.14 mg/l, and chromium levels from 0.05 to 16 mg/l. (Pierstorff, 1980). These amounts would exceed Wisconsin groundwater standards and the lead and chromium levels would exceed acute toxicity criteria effluent discharge limits for some surface waters in Wisconsin. Lead is usually found in an insoluble form in snow and is attached to particulate matter; therefore, there is little potential for groundwater contamination. It can however, accumulate in the soil, thus impairing the structure and changing soil fertility (Schreiber, 1986). Heavy metals can also build up in the tissues of aquatic plants and animals and subsequently accumulate in animals that consume them. Possible effects of heavy metals include liver and kidney damage, tumors, birth defects, brain damage, lung and respiratory concerns, learning disabilities, and neurological damage (Schueller, 1992).

Oil and grease concentrations in dumped snow have ranged from 1.3 mg/l to 28 mg/l. (Pierstorff, 1980). Daily maximum effluent standards established at some facilities in Wisconsin have limits for oil and grease at 20 mg/l. Oil and grease can contribute polycyclic aromatic hydrocarbons to surface waters and cause an oil sheen to appear on the surface of the water.

The visual impression of snow dumping is also a problem. No one likes to see a truckload of dirty snow being dumped into the local river or stream. The general public associates this with pollutants being added to the stream (Vermont ECD).

SOURCE AREA CONTROLS

Reduce Contaminants in Snow

The first source area control which should be considered is to reduce the amount of contaminants in snow. This can be done by plowing more frequently and reducing the amount of road salt used, reducing vehicle miles traveled by encouraging the use of public transportation and ride sharing, and removing snow from roadways within 48 hours to reduce the contaminant load in the collected snow. Decreasing plowing and reducing the amount of salt used should never be done at the risk of public safety.

Vermont's "smart salting" program calculates salt application rates using infrared sensors on trucks to measure winter pavement temperatures, which are typically 7 to 40 degrees F warmer than the air. When the pavement is so cold (about -6 degrees F) that salt would be inefficient, crews apply sand or other abrasives. Sand is frequently mixed with salt to help embed the sand into colder surfaces and increase friction. Overall, state transportation crews have found that applying salt and sand in frequent doses during a snowfall, versus "waiting out the storm" achieves the best results. They are using 25 percent less salt and sand than in previous years (WNDR brochure, 1995).

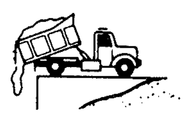
Once these source area reduction practices are put into place, the next step to consider is how best to dispose of the snow that will be collected. Land disposal is the preferred option over direct dumping into surface waters. Direct disposal of snow into surface waters should only be done in emergency situations.

Land Disposal

Land disposal of snow offers a number of options over snow dumping directly into a surface water.

- Refuse and litter can easily be collected after the snow has melted.

- Sediments build up on land rather than in lakes and streams.



Environment Canada

- Contaminants that tend to cling to soil can be filtered out.

- There is less potential for a concentrated dose of contaminants entering lakes and streams. The contaminants gradually seep into the soil or are carried downslope as the snow melts (Schreiber, 1986).

The land disposal site must be carefully chosen. The best disposal sites are those that drain to a detention basin which captures meltwater pollutants. The potential for surface and groundwater contamination must be evaluated at each disposal site. The soil texture should be fine grained to allow for the capture of metals and prevent chlorides from seeping into the groundwater. Fine grained soils will allow for more overland flow vs. infiltration as the snow gradually melts.

Areas of fractured bedrock should also be avoided as these areas can serve as direct conduits of pollutants to the groundwater.

The site should also be located at least 1,000 feet from any private well and down gradient from any wells or groundwater recharge areas (such as gravel pits) and preferably near groundwater discharge areas (Schreiber,, 1986 and Vermont ECD).

Wetland areas should also be avoided to prevent surface water contamination and damage to wildlife and wetland vegetation.

Sanitary landfills should not be used for snow disposal as the added moisture can accelerate the movement of leachate from the landfill (Schreiber, 1986 and WDNR Brochure, 1995).

Site Selection Criteria

The following factors should be considered when selecting a site:

- The site should be far enough away from surface waters to allow for slow dispersal of snow as it melts. This will allow for capture of most sediments and pollutants and result in a gradual release of any remaining contaminants to the surface waters. A minimum setback of 150 feet is recommended.
- If the site is located in a floodplain, it should not contribute to the potential for flooding.
- Runoff rates should be estimated and a site selected that allows for the receiving water's ability to absorb the amount of runoff and pollutants entering it at any given time. Site selection should also take into account downstream uses of the surface water.
- The alternate and future uses of the site should be known. Human exposure to contaminants remaining on the site after the snow melts should be avoided. Therefore, recreation areas should not be used for snow disposal.

- The site should be easily accessible to the trucks hauling the snow. This will reduce the potential for haulers to dispose of snow at sites other than the approved sites.

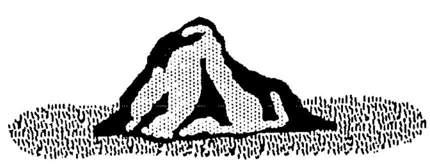
- Noise should also be considered. Residents do not appreciate numerous trucks driving up and down residential streets.

- Visual impacts should also be considered and consequently residential areas avoided (Schreiber, 1986).

Site Maintenance

Once a site is selected, the runoff needs to be controlled and the site maintained. The following site preparation and maintenance practices should be followed:

- A sediment barrier or trap should be constructed. This could consist of a detention basin, berm, silt fence or staked hay bales. For example, a coarse gravel berm down gradient of the dumped snow will slow and disperse flow and trap sediments and debris.



- Vegetation should be well established and maintained at the site during the growing season. This will help capture pollutants and prevent soil erosion.

- All litter and debris should be removed from the site after the snow melts. A fence should also be erected to capture windblown litter if this is a problem during the period when snow is melting.

- Sediment should also be removed or evenly dispersed over the site to allow for capture by the vegetation. This will also prevent heavy sediment buildup from smothering vegetation (Schreiber, 1986, Vermont ECD).

Surface Water Disposal

Surface water disposal should only be done in emergency situations or when a suitable land disposal site is not available. All attempts should be made to find a proper land disposal site before surface water disposal is considered. If surface water disposal is considered, only major rivers should be used and water quality standards should be maintained.

Before dumping snow into surface waters, state laws should be checked. Most states require permits to discharge waste material, pollutants or any substance into waters of the state. Most states do allow for surface water disposal of snow on a case-by-case basis during emergency situations. Permission must be obtained from the state.

If surface water disposal is chosen, only clean snow should be dumped. Clean snow is that which has been removed from streets within 48 hours after the snowfall.

The Vermont ECD describes heavily contaminated snow as snow that is:

- Subject to moderate to large traffic volumes
- From downtown areas
- Heavily or frequently sanded or salted
- From large parking lots (> 25 spaces or 1/2 acre)

Snow from such areas should not be dumped directly into surface waters even if collected within 48 hours after the snow fall.

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CHAPTER 5: WOOD

(INCLUDES LOG STORAGE, SAWDUST, BARK, AND WOOD PROCESSING FACILITIES)

TYPICAL PILE CONFIGURATION AND LOCATIONS

As logs are removed from the forest, they are stored in piles in the forest or placed in intermediate storage locations. The logs are eventually transported to wood processing facilities. At the wood processing facilities (sawmills and pulp and paper manufactures), the logs are again stored for short periods of time. Often times the logs are sprayed with water while in storage at the sawmill. This spraying reduces the likelihood of checking and cracking and softens the bark for easier removal. Checking and cracking can reduce the shear strength of the wood, results in product wastage, and also provides access to insects. At times, insecticides are added to the spray water if there is an insect problem on site.

Once on site at the wood processing facility, the logs are eventually debarked and then cut or chipped, depending upon the eventual use of the wood. The debarking process results in large amounts of bark debris. The cutting and chipping processes leave behind piles of sawdust. The bark and sawdust is either stored at the wood processing facility, burned for fuel or placed in trucks and sold to other facilities. Bark chips and sawdust are also occasionally sold or given away for landscaping purposes.

POLLUTANTS

Logs, bark, and sawdust stored outside have been shown to contribute a number of pollutants to surface waters and groundwater. These pollutants include biochemical oxygen demand (BOD), chemical oxygen demand (COD), fecal coliform bacteria, phenols, tannic acid, total suspended solids (TSS) , and hydrogen sulfide.

BOD and COD are associated with decaying organic materials. These types of materials lower the oxygen available in surface waters, making less available for aquatic life. Wood chips, bark, and sawdust are all materials that contribute to increased BOD and COD. BOD values reaching 500 and 800 mg/l have been measured in stormwater at wood processing facilities and at 2600 mg/l in lab leachate experiments (personal correspondence, MPCA, and Goudey, 1992).

Fecal coliform bacteria levels as high as 23,000 counts/ml have been measured at wood processing sites (personal correspondence, WDNR). Treatment plant limits are set at between 200 and 400 counts/ml. Fecal coliform bacteria are indicators of fecal matter present and can be associated with disease carrying bacteria and viruses.

Phenols are a skin irritant and can cause toxicity via ingestion, inhalation, or absorption. Phenols have been found in concentrations up to 30 mg/l in aspen leachate. This concentration is considered toxic by one author (Goudey, 1992). Human threshold criteria (the maximum concentration set to protect humans and aquatic life from adverse effects) for phenols are set at 2.7 mg/l by the Wisconsin Department of Natural Resources. Phenols are mainly associated with poplar and willow. The sapwood and heartwood appear to be the major sources of the phenols, with the bark and rootwood containing smaller amounts (Sharif, 1989).

Hydrogen sulfide was also found in log leachate at levels of 5 mg/l. This was considered toxic by the author of one study (Pacific Northwest Pollution Control Council, 1971). Hydrogen sulfide is toxic by inhalation and is an irritant to eyes and mucous membranes.

Laboratory leachate studies have produced various results in terms of log leachate toxicity. Schaumburg (1970 and 1973) found that ponderosa pine, hemlock, and older Douglas fir leachate was not acutely toxic to salmon and trout fry. Schaumburg, along with Schuytina (1976), also concluded that leachate from log sections without bark were more toxic than comparable sections with bark intact. Schuytina's studies in 1976 also found that 96-hour bioassay tests of Douglas fir, hemlock, and ponderosa pine log leachate did not result in mortalities to trout fry in 100 percent solutions.

Schuytina and Atkinson (1971) found, however, that younger Douglas fir (< 50 years) leachate was somewhat toxic to salmon fry. The Pacific Northwest Pollution Control Council (1971) and Atkinson (1971) concluded that leachate from older fir logs and ponderosa pine produced no toxicity during a 96-hour bioassay test, but that serious water quality problems could result if runoff from log storage facilities is discharged into small streams.

Power (1988) concluded that log leachate from pine and spruce can be acutely toxic to salmon eggs and fry, caddis fly larvae, and mayfly nymphs. Power also concluded that log leachate resulted in decreased zooplankton density in surface waters and therefore, a reduction in food availability for fry. Goudey (1992) concluded that aspen leachate was very toxic to all forms of aquatic life. Goudey's lab test showed that aspen log leachate concentrations of one to two percent of full strength were median acutely toxic for rainbow trout and daphnia. Goudey states in his 1992 study that one ton of aspen wood can potentially release enough leachate to render one million liters of water acutely toxic to trout. Sproul (1969), concluded that COD values he observed in leached organic matter from logs were high enough to render receiving water useless as a fish habitat. He observed COD values between 180 and 3700 mg/l.

Sproul also observed pH values of 3.5 to 4.6 standard units(s.u.) in log leachates. These are below generally accepted discharge limits of between 6 to 9. Suspended solids values from log leachate in Sproul's studies ranged between 5 to 120 mg/l. Sproul also concluded that groundwater supplies should not be developed in areas where bark has been placed on pervious ground.

Several studies concluded that log leachate results in decreased numbers of benthic organisms (O'Claire, 1988 and Pacific Northwest Pollution Control Council, 1971). These studies also concluded that bottom deposits of wood debris create physical barriers to the healthy development of benthic communities

Aesthetics are also a concern of log leachate and storage pile runoff. Some log leachate produces a dark brown color (associated with tannic acid) in surface waters. Although many surface waters are naturally brown in color, runoff from log storage facilities, which is noticeably darker than the surface water, is not aesthetically pleasing to citizens who notice the discharge. There may also be floatables associated with discharge from some log and wood storage facilities. Most states do not allow any floatables or any noticeable color in discharges from permitted facilities.

Logs with bark intact tend to release less soluble organic matter and color than those with bark removed, although it appears that bark contributes most of the color producing substances (Sproul, 1968 and Graham, 1969).

EPA has set water quality discharge limits for various logging operations. These limits presently do not apply to material storage area runoff. These limits are included in this discussion however, as they give an indication of the quality of discharge EPA is requiring of some log yard operations. Discharges from wet storage areas and hydraulic barking operations have a limit of zero discharge of debris and a pH range of 6 to 9 s.u.. Wet storage areas are defined as the storage of logs or roundwood before or after removal of bark in self-contained bodies of water or storage of logs or roundwood on land where water is sprayed or deposited intentionally on the logs. Debris is defined by EPA as woody material such as bark, twigs, branches, heart wood, or sap wood that will not pass through a 2.54 cm (1.0 inch) diameter round opening and is present in the discharge from a wet storage facility. Debris is defined in this manual as any waste left from logs, logging operations or wood processing activities.

Log washing operations (where water is applied under pressure to remove dirt) have a federal limit of 50 mg/l suspended solids, and a pH of 6 to 9 s.u. Performance standards for new sources (new operations after 1983) have a zero discharge limit.

Federal effluent limitations from mechanical barking operations are set at the following:

	Maximum Daily	30-Day Average
BOD_5	0.09 pd/cu. ft. of product	0.03 pd/cu. ft. of product
TSS	0.431 pd/cu. ft. of product	0.144 pd/cu. ft. of product
pH	6 - 9 s. u.	6 - 9 s. u.

Insecticides

Insecticides and fungicides are, at times, sprayed on the logs to prevent damage to the wood. It is unknown if they are used in large enough amounts to cause water quality problems.

SOURCE AREA CONTROLS

Source area controls are those that prevent pollution from occurring at the source. They can range from elimination of the use of a product to better control over the exposure of the product to stormwater. Many of the pollutants associated with log storage and wood processing facilities can be controlled with source area controls. Sediment and debris control can go a long way toward reducing total suspended solids, BOD, COD, floatables and other pollutants associated with wood chips, bark and sawdust. The following source area controls are suggested for use if the wood processing facility needs to control stormwater pollutants.

Proper Disposal of Wood Waste

Control of log processing material (bark, chips, and sawdust) can eliminate most of the storm water pollutants associated with these materials. If these types of materials do not come in contact with storm water, they will not contribute pollutants to storm water discharges. Many wood processing facilities are able to keep bark, sawdust, and wood chips to a minimum at their site by selling or giving away the waste material. There are many markets for various types of wood waste. Keeping the yard clear of wood debris by properly disposing of the waste material can really help to reduce stormwater pollutant loading. See Appendix Four for a list of facilities in Wisconsin which take or buy wood waste.

Sediment Control in the Yard

Log storage yards generally have exposed soil. The yards are usually cleared and leveled to create easy access for unloading and moving of logs. Heavy equipment moving around the yards creates ruts and can track sediment from the yard. If the logs are sprayed, the soil is generally kept moist and can even be washed away if the spray is heavy. Rain can also easily wash away exposed sediment in heavily used yards.

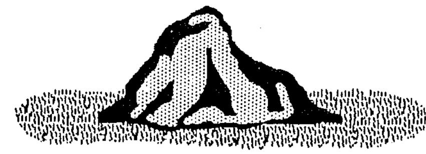
The following practices will help control sediment loss from log yards:

- The log storage area can be kept graveled to prevent sediment from being discharged and tracked off the storage yard site.
- A pervious base will allow the spray water to infiltrate to some extent and the gravel will help control sediment loss.
- In some areas in the yard, an impervious base will help control sediment. This practice does, however, create more runoff and can be broken up by the use of heavy of machinery.
- Geotextile fabric can be placed under gravel in heavy traffic areas to help keep a firm base and control sediment loss.

Vegetated Buffer Strips

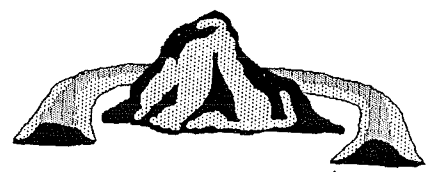
Strips or areas of vegetation around the storage yards can also be used to infiltrate uncontaminated stormwater before it reaches the e yard or storage area. A vegetated strip will also slow down water flowing from the yard and material storage areas and capture some of the sediment and debris. Sediment controls in the yard, such as spreading gravel to stabilize the soil, should also be used, as most vegetated buffer strips will not be able to handle large sediment loads.

Facilities that have heavy loads of debris and sediment being washed off site may need to consider the use of two filter strips to capture these loads. Heavy sediment and debris loads may build up and eventually smother the vegetation. If two filter strips are used, one can be scraped and rebuilt when it is no longer capturing sediment and debris and the second one can be used while the first one is getting re-established.



Berms or Diversion Structures

A berm around the yard or material storage areas can be used to keep uncontaminated stormwater from flowing into the log and material storage areas. The upslope sides of such areas should be bermed in order to direct uncontaminated stormwater safely off site or to infiltration areas. Berms placed downslope of the yard or material storage areas can also be used to help slow down and capture yard runoff. Downslope berms can be graded with a ramp for machinery access.. If soil is used for the berm, it should be covered in vegetation to keep it intact and prevent the berm from eroding.



Collection of Debris and Yard Material

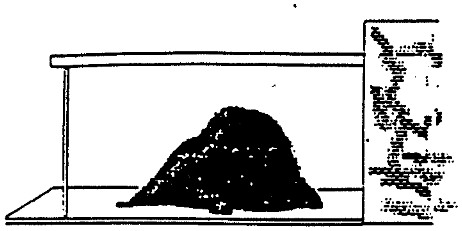
As logs are removed from the yard for processing, the areas on which they were stored can be cleaned. Loose bark and wood should be picked up. A small tractor with a blade can be used to lightly scrape the site. If the wood debris and bark has very little soil in it, it can be chipped and included in other bark debris. If there is a significant amount of soil, the material may be composted. A state permit may be required for the compost pile. The compost pile should be constructed and operated so as to avoid groundwater and surface water contamination. The compost pile can be placed on a pad with runoff collected and sprayed back onto the compost pile. Compost material can also be used for residential and commercial landscape purposes. Potential users are local forestry personnel or garden clubs.

Larger log yards may choose to use debris sorters. These are machines that use screens of varying sizes to sift the log yard debris and sort it into piles for various uses. The woody debris can be used for fuel or for landscaping purposes. The grit and rocky material can be placed back in the yard. These types of sorting mechanisms can get very expensive. Some facilities rent them from local contractors or hire a contractor to come to the site periodically.

Detention Basins

A combination of a basin with a screen and a filter strip can also be used to capture heavy sediment and debris loads. Runoff can be directed into the basin, and debris and sediment removed via settling or screening. The discharge is then directed to a filter strip for infiltration. The basin must be periodically cleaned. The captured material can be composted or screen sorted. Recovered wood debris can be used as fuel and the soil placed back in the log yard and stabilized with gravel. The excess water can be recycled and used for log spraying operations or sprayed on vegetated areas. The spray should be applied at a rate which prevents runoff.

Collection of Bark



Each wood processing facility should have a plan to properly dispose of bark. Bark can then either be chipped or left in strips to be used for fuel or sold to other wood processing facilities. The bark should be placed directly in trucks for transportation to the facility which is buying the bark or utilized

If used on site, the bark can be moved by covered conveyors to the appropriate point on site or placed in trucks and transported to an indoor or covered facility on site. If it is necessary to store bark or bark chips uncovered outside, the storage site should be appropriately bermed. Berms should be placed to keep uncontaminated stormwater from flowing across the bark storage area. Stormwater that comes in contact with the bark can be collected and the debris and sediment removed before it is allowed to discharge off the site. This can be done using infiltration areas or a settling pond. The runoff can also be recycled and used for site spraying operations.

Collection of Sawdust

As sawdust is generated, it should be bagged or placed under cover. Sawdust can be used as a fuel on site. If used on site it should be transported under cover to the appropriate location. This can be done using covered conveyors or trucks. If sold to another facility, it should be bagged indoors or placed in a covered truck for transportation.

Stormwater discharge permit requirements generally do not allow a discharge of floatables from the site. It is difficult and expensive to remove sawdust from runoff and it is difficult to remove finely spread sawdust from the yard. The best solution is to keep it from coming in contact with stormwater.

Proper Storage of Wood Chips

At some facilities wood chips are brought on site and used as the main material in the facility's operation. At other sites, wood chips are generated in the facility's operation and subsequently sold. At either type of facility, wood chips should be properly handled to avoid contamination of stormwater. As with sawdust, it is recommended that wood chips be kept under cover or indoors. Stormwater discharge permits do not allow any discharge of floatables. If wood chips get into the stormwater, they should be removed before the stormwater can be discharged from site.

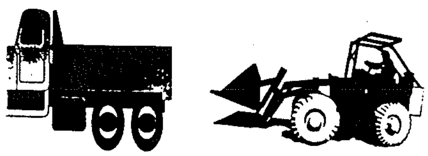
Following are several methods for covering wood chips:

- Placing a roof over the wood chip pile and placing berms around the pile. This prevents rain from falling on the pile and prevents uncontaminated stormwater from flowing onto the pile.

- Containing the wood chips in a building such as a pole shed or dome. Covered conveyors could be used to move the wood chips to the appropriate location.

- Placing the wood chips directly into a covered truck for later use on site or to be sold to another facility

Loading and Unloading Concerns



A great deal of dust and spillage can take place when sawdust or chips are bagged, conveyed, or loaded onto a truck. The following practices should be considered when sawdust or wood chips are processed or loaded:

- Sawdust should be bagged indoors in order for dust to be contained. After bagging operations, the dust should be swept up and proper disposal methods followed.

- If dust is generated when loading trucks, the truck should be tarped and a chute or boom used to place the sawdust or chips in the truck.

- The area should be swept after the truck is loaded in order to clean up any spilled debris.

Minimizing Use of Insecticides

If insecticides are sprayed on the logs to prevent insect damage, the amount use should be kept to the minimum possible. Care should be taken to spray only the areas necessary and to prevent spillage and excess spraying. When insecticides are used, an analysis of runoff should be done to determine the amounts that are in stormwater as it leaves the site

Vehicle Maintenance and Washing

Fluids from vehicle maintenance activities and broken hoses also contribute to stormwater contamination on site. Any vehicle maintenance that has the potential to result in the loss of fluids or solvents should be done indoors and on an impervious pad. Any spills should be immediately cleaned up. Properly dispose of all fluids and solvents.

Routine maintenance of vehicles will prevent many accidental spills due to hose breaks and fluid loss. Hoses should be checked routinely and replaced when necessary.

Vehicle washing should be done in an area where the wash water can be treated or kept from discharging into a water body.

See Appendix One for proper disposal of vehicle wash water.

Log Yard Debris Sorters

The following are several contacts for information on log yard debris sorters. The listing is not an endorsement for these firms or individuals, but simply several sources the author was able to collect.

RECOVERY SYSTEMS TECHNOLOGY INC.
BOTHWELL, WA
1-800-75WASTE

MARK DOTY
BEAVERTOWN, OR
503-643-9023

CLARKS SHEET METAL
EUGENE, OR
503-343-3395

PHIL MITCHELL
WEYERHAUSER
TACOMA, WA
206-924-2555

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Atkinson, Sheridan William, BOD and Toxicity of Log Leachates, thesis submitted to Oregon State University for Master of Science, June 1971.

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Goudey, Dr. J., Stephen and Dr. Barry R. Taylor, "Toxicity of Aspen Wood Leachate to Aquatic Life, Part 1: Laboratory Studies, Prepared for: Environmental Protection Branch, Northern Interior Region, BC Environment, Ministry of Environment, Lands and Parks, September, 1992.

Graham, John L. and Frank D. Schaumburg, "Pollutants Leached from Selected Species of Wood in Log Storage Wagers. Proceedings of the 24th Industrial Waste Conference, May 1969, Purdue University, Lafayette, Indiana.

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O'Claire, Charles E., and Lincoln Freese, "Reproductive Condition of Dungeress Crabs, Cancer Magister, at or near Log Transfer Facilities in Southeastern Alaska. Marina Environmental Research 26 (1988) 57-81.

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Schaumburg, Frank D., and Sheridan Atkinson, "Biochemical Oxygen Demand and Toxicity Associated with Log Leachates", Dept. of Civil Engineering, Oregon State University, Coevally, Oregon, presented at Western Division of American Fisheries Society meeting, August 1970.

Schuytina, Gerald S., and Robert D. Shaubland, "Effects of Log Handling and Storage on Water Quality", Industrial Environmental Research Lap, USEPA EPA-600/2-76-262, Sept. 1976

Sproul, Otis J., and Clifford A. Sharpe, "Water Quality Degradation by Wood Bark Pollutants", Water Resources Center Publications #5, June 1968. OWRR Project No. A-009-Me Technology Experiment Station, University of Maine, Orono.

Toews, D. A. A., and M. J. Brownlee, A Handbook for Fish Habitat Protection on Forest Lands in British Columbia. Field Services Branch, Dept. of Fisheries and Oceans, Vancouver, B.C., May 1981.

Toxicological Profile for Phenol, Agency for Toxic Substances and Disease Registry U.S. Public Health Service. Prepared by Syracuse Research Corporation under subcontract to Clement Associated, Inc., under contract # 205-88-0608, Dec. 1989.

APPENDIX ONE

VEHICLE WASHING

Pollutants In Vehicle Wash Water

Vehicle wash water usually contains cleaners which include phosphorus, degreasers, surfactants or soaps as one or more of their ingredients. Phosphorus is an element that is essential for algae growth; small amounts of phosphorus contribute to algae growth in surface water. Surfactants can be toxic to sensitive stream organisms in small concentrations. They may also cause unsightly foaming in the receiving water and in smaller streams. In addition, surfactants may reduce levels of dissolved oxygen (necessary for survival of aquatic life) in surface waters.

Cleaners that are labeled biodegradable may also have negative impacts on surface waters. Biodegradable means that the product will eventually break down through the action of microorganisms. It does not necessarily mean that the product is not a pollutant or that it is safe to discharge into the environment.

Other miscellaneous chemicals are also used in the cleaning process. For example, hydrofluoric acid has been used for vehicle washing in order to give stainless steel tanks a nice shine. Any cleaner may have the potential to contaminate surface waters and impair aquatic life. Even if no chemicals are used, vehicle wash water can still be of concern. In winter, salt washed from vehicles can become concentrated at levels that are harmful to surface waters. Dirt, oil, and grease are washed off the vehicle. Dirt settles out in the bottom of the stream and may cover fish spawning beds. Oil and grease cause an unsightly sheen on the surface of the water and cling to aquatic plants.

Proper Disposal of Vehicle Wash Waters

The preferred solution is to discharge all vehicle wash water to a waste water treatment plant. The treatment plant will remove suspended solids, oil and grease will be skimmed off, biodegradable detergents will be broken down, and chlorides should be diluted to an acceptable concentration. The wash water can be pumped or hauled to a sanitary sewer with permission.

If you are currently washing in an outside lot, here are some suggestions:

1. Direct discharge to a sanitary sewer from a wash station.

   An existing building could be used or a concrete or asphalt pad constructed that is large enough for at least one truck to be washed. The pad should have a collection sump and the wastewater would flow by gravity or be pumped from the collection point to an existing sanitary sewer line. It is preferable to have a roof over the washing area to keep clean stormwater out. If a roof is not practical, one may consider a valve system which diverts truck washwater to the sanitary sewer and clean stormwater to the storm sewer.

2. Hauling to a sanitary sewer from a wash station.

   In areas not served by a sanitary sewer, a holding tank should be constructed to collect truck washwater from the wash station. The holding tank contents should then be hauled to a treatment plant. To minimize the volume hauled, clean stormwater should be kept out as explained above.

3. Collection of washwater with no wash station.

In situations where a fleet of parked trucks is washed by a mobile washer, collecting the wastewater is more difficult. If the parking lot has a catch basin connected to a stormsewer, this can be used as a collection point. The storm sewer could be temporarily blocked or plugged so that a temporary pump could send the washwater to a sanitary sewer, if it's available, or to a holding tank.

4. Washing on gravel or dirt lots.

Washing on porous soil will probably not create a surface water discharge, but there is still a concern about groundwater impacts. As mentioned earlier, there could be impacts from the chloride ions in road salt. Also, the cleaning chemicals and any fuel oil, antifreeze, or hauled product washed onto the ground could pollute groundwater. Due to these potential threats to groundwater, it is best to avoid washing trucks on porous soil. If there are no alternatives, the impacts on groundwater should be minimized as follows:

a. There should be at least five feet of moderately permeable soil (loam) on top of groundwater or bedrock, so that the unsaturated soil can treat the wastewater. Highly permeable soils such as gravel or coarse sand provide no treatment.

b. Use only high-pressure hot water and no chemicals to wash the trucks.

c. Wash only the outside of the truck. Under no circumstances should the inside of tankers or trailers be washed out. Avoid washing oil and grease from the undercarriage.

d. Limit the number of trucks washed at the site, especially in winter when road salt is being used.

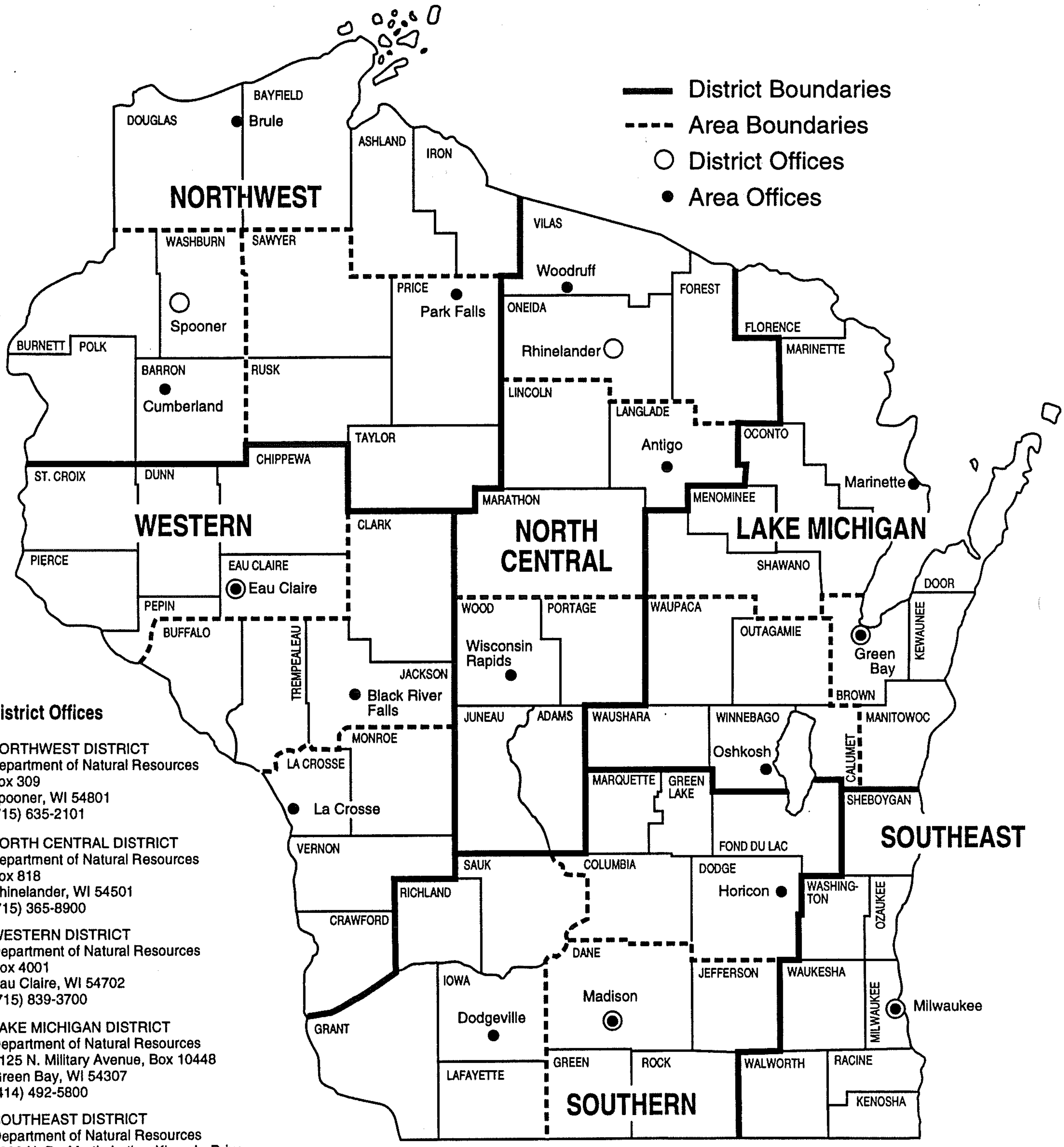
At the present time, it is Wisconsin Department of Natural Resources policy that grit and sludge collected during vehicle washing cannot be landspread. It is considered a solid waste and must be taken to a sanitary landfill. This is because analysis of this waste at some sites has found high concentrations of metals and other pollutants.

There is a tendency in commercial carwash operations to construct a three-foot diameter sump to settle out the grit and allow the oil and grease to float to the surface. One of the problems when using a small-diameter wastewater sump is that the solids are at the bottom, the water is in the middle, and the oil is floating on the top. When the sump is emptied by pumping out the contents, the liquids and solids are mixed together and the load is too wet to be accepted in a landfill as a solid waste. It then becomes necessary for the operator to dewater these solids prior to disposal in a landfill. It is recommended that whenever possible, the grit be settled in a long, shallow, floor-drain trench so that it can be dewatered in place and shoveled into standard, solid waste containers. This settling trench should then be followed by a sump that would allow the oil and grease to float to the top where it can be skimmed off.

APPENDIX TWO

GENERAL POLLUTION PREVENTION INFORMATION

DNR Field Districts and Areas



District Offices

NORTHWEST DISTRICT
Department of Natural Resources
Box 309
Spooner, WI 54801
(715) 635-2101

NORTH CENTRAL DISTRICT
Department of Natural Resources
Box 818
Rhinelander, WI 54501
(715) 365-8900

WESTERN DISTRICT
Department of Natural Resources
Box 4001
Eau Claire, WI 54702
(715) 839-3700

LAKE MICHIGAN DISTRICT
Department of Natural Resources
1125 N. Military Avenue, Box 10448
Green Bay, WI 54307
(414) 492-5800

SOUTHEAST DISTRICT
Department of Natural Resources
2300 N. Dr. Martin Luther King, Jr. Drive
Box 12436
Milwaukee, WI 53212
(414) 263-8500

SOUTHERN DISTRICT
Department of Natural Resources
3911 Fish Hatchery Road
Fitchburg, WI 53711
(608) 275-3266

REV 7/95

Wisconsin's Pollution Prevention Information Clearinghouse
Publications Order Form

WI Department of Natural Resources
Hazardous Waste Minimization Program
P.O. Box 7921; Madison, WI 53707
FAX Number 608/267-2768

Jay Prakash 608/264-8981
Lauranne Bailey 608/264-8852
Sam Essak 608/267-9523
Lynn Persson, Coordinator 608/267-3763

We're glad to provide your company/organization with the publications that you check off on the list below. All publications are free to Wisconsin businesses, local government and others interested in promoting pollution prevention and good management of hazardous waste. Our funding is limited, so please, **restrict your total request to 300 pages or 15 publications.** Waste minimization publications from other states are included, too. Please note that each state has slightly different hazardous waste regulations, so refer to Wisconsin's regulations, handbooks and fact sheets for information specific to Wisconsin's hazardous waste programs.

Return this original form to the attention of the Clearinghouse Specialist at the above address. Your name will be added to our mailing list to receive *Waste•Less•News*, our quarterly publication which gives updates on hazardous waste management, miniziation, workshops and other activities. Give us a call if you have comments on the publications or suggestions for additional publications to include in the Pollution Prevention Clearinghouse.

** Recently added publication*

*** Recently revised publication*

General Pollution Prevention

Wisconsin Programs

- ☐ Hazardous Waste Minimization Program Description (DNR 2 pp) PUBL-SW-152 92
- ☐ Pollution Prevention Program Summary (DNR, DOD, SHWEC 1 p) PUBL-TS-013 8/93
- ☐ Technical Assistance & Waste Reduction Resources UW-Extension (SHWEC brochure) 94
- ☐ Hazardous Pollution Prevention Assessment Grant Program (DOD 1 p) 11/93
- ☐ Act 325, Legislation establishing Wisconsin's Pollution Prevention Program (5 pp) 90
- ☐ ** *Waste • Less • News*, most recent newsletter from DNR's Hazardous Waste Minimization Program (8 pp)
- ☐ * Industrial Environmental Training Programs Offered by Wisconsin Technical Colleges (SHWEC 6pp) 93

Pollution Prevention Successes

- ☐ Annual Governor's Award for Excellence in Hazardous Waste Reduction (brochure) 93
- ☐ * The Bottom Line Solution, summary of 12 case studies (WI DNR 8 pp) PUBL-TS-009 94

Check under Waste and Process Specific categories for copies of complete case studies.

Information Clearinghouses

- ☐ ** Wisconsin Pollution Prevention Information Clearinghouse Publications Order Form (6 pp) PUBL-SW-199 5/94
- ☐ * Pollution Prevention Information Resources (4 pp) PUBL-SW-156 94

Wisconsin Management Reports

- ☐ Research Report I: A National Literature Reivew and Bibliography on the Barriers and Incentives for Reducing Hazardous Waste (50 pp) PUBL-MB-003 91
- ☐ Research Report II: Personal Interviews with Hazardous Waste Generators: Summary and Analysis (25 pp) PUBL-MB-004 92
- ☐ Research Report III: Information: Sources, Desired Types and Formats (19 pp) PUBL-MB-005 8/92
- ☐ Research Report IV: Hazardous Waste Generator Contacts with the DNR (19 pp) PUBL-MB-006 8/92
- ☐ Research Report V: Barriers and Incentives to Hazardous Waste Reduction (56 pp) PUBL-MB-007 8/92
- ☐ Report to the Legislature on Pollution Prevention Activities in Wisconsin (DOD 18 pp) 9/93
- ☐ Wisconsin Hazardous Waste Minimization Chapter, Hazardous Waste Capacity Assurance Plan (9 pp) PUBL-SW-107 89

Setting Up a Company Program

- ☐ Draft Guidance to Haz Waste Generators on the Elements of a Waste Minimization Program (EPA 6 pp) Federal Register Vol. 58 No. 102 May 28 93

☐ Pollution Prevention: A Guide to Program Implementation (UWEX SHWEC 48 pp) 93

☐ Facility Pollution Prevention Guide (EPA 143 pp) 600/R-92/088 92
  ☐ Supplemental Software Order Form (EPA 1 p) 93

☐ Understanding Pollution Prevention Assessments (UWEX SHWEC 2 pp) 4/93

☐ * Design for the Environment: Environmental Accounting and Capital Budget Project Update #1 EPA/742/F-93/007 10/93 (10 pp)

☐ The 33/50 Program: Forging an Alliance For Pollution Prevention (EPA brochure) 741-K-92-001 92

☐ Operating Procedures, Waste Reduction Opportunity Checklist (WI DNR 3 pp) 89

☐ Pollution Prevention: Make it Work for You-Model Policy (WI DNR 2 pp) PUBL-TS-004 90

☐ Pollution Prevention: Make it Work for You-Checklist (WI DNR 2 pp) PUBL-TS-005 90

☐ Profiting from Waste Reduction in Your Small Business, (AK Health Project 46 pp) 88

☐ Waste Minimization: Environmental Quality with Economic Benefits, (EPA 34 pp) 90

Waste Prevention & Recycling Services

Equipment Manufacturers & Consultants

Many of these fact sheets include an explanation of the equipment, purchasing guidelines and a list of manufacturers.

☐ Activated Carbon Adsorbers for On-Site Recovery (WI DNR 5 pp) PUBL-SW-145 91

☐ Agitated Thin Film Evaporators for On-Site Recovery (WI DNR 4 pp) PUBL-SW-146 91

☐ ** Aqueous Industrial Cleaning Chemicals (WI DNR 8 pp) PUBL-SW-147 4/94

☐ ** Aqueous Parts Washing Equipment (WI DNR 7 pp) PUBL-SW-148 4/94

☐ High Volume Low Pressure Equipment (WI DNR 4 pp) PUBL-SW-149 93

☐ Membrane Filtration: Microfiltration, Ultrafiltration and Rev. Osmosis. (MnTap 5 pp) 91

☐ On-Site Anti-freeze Recycling and Reconditioning (WI DNR 2 pp) 9/93

☐ On-Site Solvent Recovery Stills (WI DNR 7 pp) PUBL-SW-150 91

☐ Used Oil Filter Crushing Machines (WI DNR 1 p) 7/93

☐ Environmental Consultants with Hazardous Waste Minimization Services (WI DNR 2 pp) 90

☐ Industrial and Environmental Consultants (UWEX SHWEC 2 pp) 10/93

Waste Exchanges & Recycling Markets

☐ Waste Exchanges (WI DNR 2 pp) PUBL-SW-138 93

☐ ** Waste exchange newsletter: *Industrial Material Exchange Service*, most recent copy (Illinois EPA 28 pp)

☐ Markets for Wisconsin's Recycled Materials Software and Hard Copy Order Form (WI DNR 2 pp) 92

** Markets for Wisconsin's Recycled Materials - Excerpts
  ☐ Barrels and Drums (4 pp) 4/94
  ☐ Oil (4 pp) 4/94
  ☐ Oil Filters (2 pp) 4/94
  ☐ Precious Metals (7 pp) 4/94
  ☐ Solvents (1 p) 4/94

Solid Waste Recycling

☐ Recycling and Waste Reduction Information and Education Publ. Order Form (WI DNR 2 pp) PUBL-IE-138 93

☐ Recycling and Waste Reduction Tech Assistance Publ. Order Form (WI DNR 2 pp) PUBL-SW-334 4/93

☐ ** Solid Waste Reduction and Recycling Demonstration Grants (WI DNR 2 pp) 3/93

☐ Video and Handbook on Recycling in the Workplace, how to order (WI DNR 6 pp) PUBL-IE-115-91 6/91

WI DNR Waste Management

Industrial Hazardous Waste Management Requirements

☐ Managing Your Haz. Waste: A Guide for WI Small Quantity Generators (110 pp) PUBL-SW-071 93

☐ What is Hazardous Waste? (4 pp) PUBL-SW-106 93

☐ Hazardous Waste Determination: A Guide Through NR 605, Wis. Adm. Code (13 pp) PUBL-SW-204 93

☐ EPA Identification Number (4 pp) PUBL-SW-101 89

☐ Hazardous Waste Manifest (4 pp) PUBL-SW-102 89

☐ Hazardous Waste Inspection Logs (2 pp) PUBL-SW-098 89

☐ Hazardous Waste Training Records (2 pp) PUBL-SW-099 89

☐ Land Disposal Restrictions (6 pp) PUBL-SW-105 89

☐ Transporting Hazardous Waste (2 pp) PUBL-SW-137

☐ Toxicity Characteristic Leaching Procedure TCLP (EPA 7 pp) 90

☐ Recycling Hazardous Waste: DNR Requirements in Brief (2 pp) PUBL-SW-191 93

☐ Recycling Hazardous Waste: Guide to NR 625 Recycling Provisions (12 pp) PUBL-SW-189 93

☐ Wisconsin's Hazardous Waste Laws & Regulations: How to Order your Copy (1 p) 92

Special Waste Guidance

☐ Dry-Cell Battery Recycling (4 pp) PUBL-SW-203 8/93

☐ ** Fluorescent Lamps and Incandescent Bulbs (2 pp) PUBL-SW-195 2/94

☐ PCB Management for the Appliance Demanufacturer: Capacitors and Ballasts (8 pp) PUBL-SW-194 10/93

☐ * Recycle Waste Antifreeze; a Fact Sheet For Businesses and Institutions (4 pp) PUBL-SW-??? 4/94

Used Oil Management Requirements

☐ Used Oil Management (12 pp) 93

☐ Recycle Used Oil (4 pp) PUBL-IE-105 2/91

☐ Used Oil Burning (4 pp) PUBL-SW-104 89

☐ Used Oil Filters: Businesses (4 pp) PUBL-SW-135 10/93

☐ Used Oil Filters: Households (1 pp) PUBL-SW-134 8/91

☐ Control Potential Risks from Recycled Used Oil, Management Standards Issued--No Hazardous Waste Listing (EPA 3 pp) 530/F-92/018 92

Hazardous Waste Management Information & Services

☐ ** Hazardous Waste Specialists (DNR 2 pp) PUBL-SW-202 2/94

☐ Wisconsin Licensed Commercial Transporters for Hazardous Waste List Expires '94 (6 pp) 1/94

☐ Wisconsin Licensed Commercial TSD's List Expires '94 (1 p) 1/94

Household Hazardous Waste

☐ ** Clean Sweep Grant Program Requirements (WI DNR 4 pp) PUBL-SW-036 92

☐ Haz. Waste in Your Home: Here's what you should do! (WI DNR 2 pp) PUBL-WW-003 89

☐ * Houshold Hazardous Waste Management: A Manual for One-Day Comunity Collection Programs (EPA 80 pp) 530/R-92/026 93

☐ * Household Hazardous Waste: Steps to Safe Management (EPA 530-F-92-031 brochure) 92

☐ Safe at Home: rediscovering cleaning solutions from a bygone era (DNR, UWEX & CBE 4 pp) 91

☐ Household Hazardous Waste Collection: Bibliography in Brief (UWEX 3 pp) 89

Other Environmental Regulations

☐ Air Management Regulations Publications Order Form (2 pp) 10/93

☐ Emergency Remedial Response Publications Order Form: LUST, Spills, Env Repair, Superfund (2 pp) 9/93

☐ Managing Industry Stormwater Discharges: Preparing a Pollution Prevention Plan (5 pp) PUBL-WW-016 92

☐ Wastewater Treatment Plant Discharges - General Prohibitions NR 211.10, WI Adm. Code (2 pp) 92

For regulations relating to labeling products made with ozone depleting substances, see Parts Cleaning under the next category.

Waste & Process Specific

Coating & Painting

☐ Coating and Painting, Waste Reduction Opportunity Checklist (WI DNR 3 pp) 89

☐ In Living Color: Painting Challenges for the '90s (Univ of TN 80 pp) 91

☐ Metal Parts Coating Plant (EPA Waste Minimization Assessment Brief 4 pp) 600/M-91/015 91

Wisconsin DNR/SHWEC Case Studies:

☐ Alternative Coating to Reduce VOC Emissions From Lacquer Coating Operations (UWEX SHWEC 3 pp) 93

Electroplating

☐ Plating and Metal Finishing, Waste Reduction Opportunity Checklist (WI DNR 5 pp) 89

☐ Electroplating and Metal Finishing Hazardous Waste Minimization Demonstration Project (WI DNR 75 pp) PUBL-SW-193 92

Formulating

☐ Formulating, Waste Reduction Opportunity Checklist (WI DNR 3 pp) 89

Machining & Cooling

☐ Machining Waste Reduction Opportunity Checklist (WI DNR 2 pp) 89

☐ The Cool Facts on Recycling Metalworking Coolants (MA OTA 4 pp)

☐ * Mobile Onsite Recycling of Metalworking Fluids (EPA Project Summary 6 pp) 600/SR-93/114 93

Parts Cleaning

☐ Cleaning, Opportunity Checklist (WI DNR 4 pp) 89

CFC Alternatives newsletter: City of Irvine, CA.
☐ Aqueous Cleaning (2/91)
☐ Semi-Aqueous Cleaning (7/91)

☐ Labeling for Products Made with Ozone Depleting Substances (UWEX SHWEC 2 pp) 93

☐ Metal Parts Cleaning--Waste Minimization (EPA 50 pp) 530/SW-89/049 89

☐ Reduction of Total Toxic Organic Discharges and VOC Emissions from Using Plastic Media Blasting (EPA Project Summary 8 pp) 87

Wisconsin DNR/SHWEC Case Studies:
☐ Apply Total Quality Management techniques to reduce solvent usage (UWEX SHWEC 3 pp) 93

☐ Replace 1,1,1-Trichloroethane with Citrus-Based Solvents (WI DNR 4 pp) PUBL-SW-168 92

☐ Replace 1,1,1-Trichloroethane with Citrus-Based Solvents (WI DNR 4 pp) PUBL-SW-161 92

☐ Replace CFCs with Aqueous Cleaners (WI DNR 4 pp) PUBL-SW-169 92

☐ Replace Chlorinated Solvents with Aqueous Cleaners; Parts Cleaning (WI DNR 4 pp) PUBL-SW-162 92

☐ Substituting Less Toxic Solvents for Hazardous Solvents (WI DNR 4 pp) PUBL-TS-017 93

☐ Use Plastic Media Blasting to Strip Paint from Parts (WI DNR 4 pp) PUBL-SW-165 92

Solvent Reduction

☐ The Good, the Bad and the Banned: Solvent Reduction. (Univ of TN 80 pp) 91

☐ Guidelines for Waste Reduction and Recycling: Solvents. (OR 44 pp) 1991

☐ * Industrial Cleaning Source Book (UWEX SHWEC 54 pp) 93

SIC Code Specific

SIC 2000: Food Products Industry

Wisconsin DNR/SHWEC Case Studies:
☐ Salt Whey Recovery/Reuse by Evaporation (WI DNR 4 pp) PUBL-SW-167 92

SIC 2400: Furniture Industry

☐ Application of Low Solvent Coatings to Wood Furniture, Summary Evaluation of Associated Problems (EPA 4 pp) 600/S2-87/007 87

SIC 2500: Wood Products Industry

☐ Wood Preserving Industry (EPA Pollution Prevention Guide 48 pp) 625/R-93/014 93

SIC 2700: Printing and Publishing Industry

☐ The Commercial Printing Industry (EPA Pollution Prevention Guide 45 pp) 625/7-90/008 90

☐ Commercial Sheet-Fed Printing Industry, Reduction of VOC Emissions Via Product Substitution and Recycling of Solid Waste, Terry Printing, Inc., Janesville, WI (EPA 3 pp) 600/2-91/051 91

☐ Manufacturer of Printed Labels (EPA Waste Minimization Assessment Brief 4 pp) 600/M-91/047 91

☐ Printing (NJ EPA 12 pp) 91

☐ The Printing Industry, Waste Reduction Guidebook (OR 35 pp) 91

☐ Roll the Presses but Hold the Wastes: P2 and the Printing Industry (UWEX SHWEC 21 pp) 93

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☐ Mercury-Bearing Waste Minimization, Mercury Cell Chloralkali Plant (EPA Waste Min Audit 4 pp) 88

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☐ Printed Plastic Bags Manufacturer (EPA Waste Minimization Assessment 4 pp) 600/M-91/017 91

SIC 3300: Primary Metals Industry

☐ Generators of Corrosive and Heavy Metal Wastes (EPA Waste Minimization Audit Sum. 6 pp) 600/S2-87/055 87

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☐ Aluminum Cans Manufacturer (EPA Waste Minimization Assessment Brief 4 pp) 600/M-91/025 91

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☐ Metal Casting and Heat Treating Industry (EPA Pollution Prevention Guide 70 pp) 625/R-92/009 9/92

☐ Metal Finishing, Electroplating, Printed Circuit Board Manufacturing, excerpt (OR 35 pp) 91

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☐ Printed Circuit Board Manufacturer (EPA Waste Minimization Assessment Brief 5 pp) 600/M-91/022 91

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☐ The Dry Cleaning Industry, Hazardous Waste Regulations of (OR 6 pp) 91

Wisconsin DNR/SHWEC Case Studies:

☐ Equipment Improvement Cuts Drycleaning VOC Emissions by 80% (WI DNR 4 pp) PUBL-SW-163 92

SIC 7300: Photoprocessing Industry

☐ Photofinishing Facility (EPA Waste Minimization Assessment 4 pp) 600/S2-91/039 91

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SIC 7500: Vehicle Maintenance Industry

☐ The Green Machine (WI DNR Booklet on how car owners minimize their cars' impact on the environment 16 pp) 91

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☐ Institutions, Colleges and Universities (Hazardous Waste Minimization 8 pp) 92

☐ Madison Area Technical College (WI Waste Minimization Opportunity Assessment 22 pp) 91

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See SIC 8000 for additional references.

SIC 9100: Local Government

☐ Communities Controlling Toxics, Publications Order Form (Local Government Commission 1 pp)

☐ Opportunities for Local Government to Promote Pollution Prevention (EPA 6 pp) 90

☐ Waste Reduction Tips for Local Government (AK 10 pp)

☐ * Urban Runoff Pollution Prevention and Control Planning (EPA Handbook 178 pp) 625/R-93/004 93

☐ References: Pollution Prevention and Local Government (2 pp) 93

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Hazardous Waste Minimization Program
PO Box 7921
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TO:

APPENDIX THREE

VEGETATED AREAS AND PLANTING GUIDES

SOIL CONSERVATION SERVICE

FILTER STRIP

Definition

A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and waste water.

Scope

This standard establishes the minimally acceptable requirements for design and operation and maintenance of filter strips for removing sediment, organic matter, and other pollutants from runoff or waste water. It does not apply to field borders (386).

This standard does not apply to filter strips used for industrial or human wastes.

Purpose

To remove sediment and other pollutants from runoff or waste water by filtration, deposition, infiltration, absorption, decomposition, and volatilization, thereby reducing pollution and protecting the environment.

Conditions Where Practice Applies

This practice applies: (1) on cropland at the lower edge of fields or above conservation practices such as terraces or diversions, or on fields adjacent to streams, ponds, and lakes; (2) in areas requiring filter strips as part of a waste management system to treat polluted runoff or waste water when bedrock and/or ground water are more than two feet below the ground surface; and (3) on forest land where filter strips are needed as part of a forestry operation to reduce delivery of sediment into waterways.

Planning Considerations

Evaluate type and quantity of pollutant, slopes and soils, adapted vegetative species, time of year for proper establishment of vegetation, necessity for irrigation, visual aspects, fire hazards, and other special needs. Prevent erosion where filters outlet into streams or channels. If filter strips are to be used in treating waste water or polluted runoff from concentrated livestock areas, the following must be considered:

1. Adequate soil drainage to ensure satisfactory performance.
2. Provisions for preventing continuous or daily discharge of liquid waste unless the area is adequate for infiltrating all daily applied effluent. Temporary storage should be considered to prevent discharge to the filter strip more frequently than once every 3 days.
3. Enough rest periods to maintain an aerobic soil profile. Storage or alternating filter strips may be desirable.
4. Reduced effectiveness of filter strips under snow or frozen conditions.
5. An adequate filter area and length of flow to provide the desired reduction of pollutants. A serpentine or switchback channel can be used to provide greater length of flow.
6. Provisions for excluding roof water and unpolluted surface runoff.
7. Slopes less than 5 percent are more effective; steeper slopes require a greater area and length of flow.
8. Provisions for mowing and removing vegetation to maintain the effectiveness of the filter area. While not generally recommended, controlled grazing may be satisfactory when the filter area is dry and firm.
9. The need for a level-lip weir, gated pipe, sprinklers, or other facilities to distribute flow uniformly across the top of the filter strip and maintain sheet flow through the strip.

Filter strips by themselves will not meet the "no discharge" requirement applicable to livestock operations requiring permits under the National Pollutant Discharge Elimination System. More stringent pollution abatement measures may also be necessary where receiving waters must be highly protected.

Design Criteria

Filter strips for sediment and related pollutants.
These criteria apply to filter strips on cropland at the lower edge of fields, on fields, on pastures, or in manure spreading areas adjacent to streams, ponds, and lakes, and above conservation practices such as terraces or diversions.

The length of flow through vigorous vegetation shall be at least 10 feet for slopes of less than one percent and proportionately up to at least 25 feet for 30 percent slopes.

Filter strips for runoff from concentrated livestock areas.
These criteria apply to filter strips for feedlot and barnyard runoff.

Runoff estimates will be based on the 10-year, 24-hour rainfall. The following values of rainfall and runoff may be used:

Rainfall = 4.0 inches

Runoff Curve No.	Runoff (inches)
85	2.5
90	2.9
95	3.4
98	3.8

The suggested runoff curve numbers are 90 for unpaved lots and 95 for paved lots.

The peak discharge from the lot area can be determined from Table 5-3, Tabular Discharges for Type II Storm Distribution (csm/in), Technical Release No. 55, (TR-55) Urban Hydrology for Small Watersheds, or by using other approved hydrology methods. Peak discharges in table WI-1 in the Agricultural Waste Management Field Manual (AWMFM), Chapter 12, may be used for the respective lot sizes and runoff curve numbers.

Flood routing procedures described in the Engineering Field Manual, pages 11-55b and 11-55c or TR-55 may be used when applicable.

A settling basin or low velocity channel shall be provided between the waste source and filter strip when more than fifty 1,000-pound animal units are confined. Such facilities should be considered for use with all filter strips.

Sediment and/or manure storage must be considered for all settling basins. The additional storage capacity, based on frequency of cleaning, shall be provided for manure and other solids settled within the basin. The solids storage volume shall be based on the number of head, percent of time on the lot, and a minimum of 10 days between cleanings. The minimum daily volume of solids per animal shall be: (1) 1,400# dairy cow--1.85 cubic feet; (2) young dairy stock--1.0 cubic foot; (3) 1,000# beef cattle--1.2 cubic feet. The stock shall be considered to be on the lot at least 25 percent of the time.

A constructed settling basin, if needed, shall have sufficient capacity, as a minimum, to store 65 percent of the peak inflow rate from a 10-year, 24-hour storm for a duration of 15 minutes. Any basin outflow shall be disregarded in computing minimum storage.

A low velocity channel may be used as a settling basin. It shall be a minimum of 150 feet long. The 10-year, 24-hour peak discharge shall be passed at a velocity of 0.5 feet per second or less (Manning's n = 0.025) and a flow depth of 0.5 feet or less. Provisions shall be provided for removing settled solids from the channel as necessary to maintain proper functioning.

A filter strip may be a relatively uniform grass area or grass waterway. Minimum dimensions shall be based on the peak outflow from the concentrated waste area or settling facility based on a 10-year, 24-hour rainfall.

Grass area (overland) filter strips shall be generally on the contour and sufficiently wide to pass the design flow at a depth of 1.0 inches or less. Flow length shall be sufficient to provide at least 20 minutes (1,200 seconds) of flow-through time for a 0.5" flow depth and 755 seconds for a 1-inch flow depth. Flow-through time equals the filter strip length divided by the average flow velocity. Manning's equation with a "n" value of 0.3 shall be used to determine the average flow velocity. Table WI-3 from Chapter, 12, AWMFM, can be used for minimum filter strip lengths for 0.5-4.0 percent filter strip slopes.

Tables WI-1 and WI-2 in Chapter 12, AWMFM can also be used for filter strip design if applicable.

When lot runoff is allowed to directly enter the filter strip (no settling basin), the filter strip length will be increased to 150 percent of the minimum filter length.

Grass channel (channelized) filter strips shall be designed to convey the design flow at a depth of 0.5 feet or less with a Manning's "n" value of 0.25. The cross section of constructed channels shall be trapezoidal. Figures WI-1 through WI-8 from Chapter 12, AWMFM can be used to determine the flow depth and velocity and volumes of flow for various channel widths and slopes up to 2.5 percent. Flow-through time shall be a minimum of 40 minutes (2,400 seconds) for channel slopes of 2.5 percent or less. The flow-through time shall be increased 900 seconds for each 1 percent increase above 2.5 percent (i.e., 3.0 percent slope = 2,850 seconds, 3.5 percent slope = 3,300 seconds).

Foreign water runoff from adjacent acres shall be diverted from the filter area where possible.

Grass species and shape of channel shall be such that grass stems will remain upright during design flow.

Filter strips for controlled overland flow treatment of liquid wastes.
These criteria apply to filter strips for waste water from milk parlors, milking centers, waste treatment lagoons, food processing plants, and animal waste storage facilities.

Grass area (overland flow) filter strips shall be installed on natural or constructed slopes of 2 to 6 percent. They shall have minimum flow lengths of 100 feet on 2 percent slopes and proportionately up to 300 feet on 6 percent slopes. Weekly waste water application rates should not exceed 6 in. and should be only 1 or 2 inches for highly concentrated wastes. Daily application times should not exceed 6 hours, and should be decreased to 2 hours for more concentrated wastes such as that from animal waste storage facilities. Filter strips should be rested at least 2 days each week.

Filter strips on forest land.

These criteria apply to filter strips for runoff as part of a forestry operation to reduce delivery of sediment into waterways.

As a guide, the length of flow through undisturbed forest floor should be at least 25 feet for slopes of less than one percent and proportionately up to at least 65 feet for 30 percent slopes and at least 150 feet for 70 percent slopes. Longer flow lengths should be used as contributing drainage areas increase.

Establishing Vegetation.

Seedbed preparation and grass mixtures shall be as stated in "Critical Area Planting" (342) in the Wisconsin Technical Guide. Equipment shall not be operated on the filter strip when the soil is wet. Compacting the soil will tend to reduce the infiltration rate and tracks or depressions will tend to channelize water flow.

Operation and Maintenance.

Development of rills and small channels within filter areas must be minimized. Needed repairs must be made immediately to reestablish sheet flow. A shallow furrow on the contour across the filter can be used to reestablish sheet flow. Vegetation must be maintained in a vigorous condition. If livestock have access to the filter area, it must be fenced to control grazing.

The lot shall be cleaned or scraped frequently to reduce the amount of sediment leaving the lot area. The manure shall be stacked or stored at a location so that runoff from the storage area does not enter the filter area unless provided for in the design.

The settling basin shall be cleaned as soon as possible after any storm event that causes a significant amount of sediment deposition. Storing accumulated sediment deposits and cleaning the basin during a runoff event can cause large concentrations of pollutants to enter the upstream portion of the filter strip. These large concentrations can damage the vegetation and possibly increase the downstream pollution potential.

The filter system should not be operated daily due to possible anaerobic conditions developing in the soil. Two or more filters may be needed in some cases.

Vegetation when cut must be removed from the filter strip. When the vegetation is left on the filter area, the effluent leaving the filter will frequently have a higher pollution potential.

Plans and Specifications

Plans and specifications for filter strips shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Design Documentation Requirements

Location map, upstream drainage area, lot area, storage volumes and capacities (manure and/or solids, and water), discharge from lot or settling basin, filter strip length, width and slope, seeding requirements.

Construction (As Built) and/or Certification Documentation Requirements

Weir or orifice measurements, profile and cross section of completed construction, slope, length, statement regarding adequacy of vegetation.

FILTER STRIP SPECIFICATIONS

Engineering Specifications

All trees, stumps, brush, rocks, and similar materials that can interfere with installing the filter strip shall be removed. The materials shall be disposed of in a manner that is consistent with standards for maintaining and improving the quality of the environment and with proper functioning of the filter strip.

The filter strip shall be shaped to the grade and dimensions shown on the plan or as staked in the field.

Fills of more than six inches shall be built up by spreading the soil in layers. Grading operations shall not be performed under soil moisture conditions that will result in excessive damage to soil structure.

After cuts and fills have been completed, the surface shall be smoothed to remove minor irregularities. All grading work shall be finished in accordance with the design and to tolerances specified.

If necessary, topsoil shall be stockpiled and spread to the required grade and thickness. Excess spoil shall be disposed of in areas where it does not interfere with the required flow characteristics of the filter strip.

Vegetative Specifications Guide

Specify methods of seedbed preparation; adapted plants; planting dates and rates of seeding or sprigging; need for mulching, use of a stablizing crop, or mechanical means of stabilizing; and fertilizer, soil amendment, and weed control requirements for maintenance.

SOIL CONSERVATION SERVICE

GRASSED WATERWAY (ACRE)

Definition

A natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff.

Scope

This standard applies to natural or constructed channels that are to be established to vegetation and used for water disposal. Grassed waterways with stone centers are also included.

Purpose

To convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding and to improve water quality.

Conditions where practice applies

All sites where added capacity, vegetative protection, or both are required to control erosion resulting from concentrated runoff and where such control can be achieved by using this practice alone or combined with other conservation practices. This practice is not applicable where its construction would destroy important woody wildlife cover and the present watercourse is not seriously eroding.

Planning considerations

The most critical time in successfully installing grassed waterways is when vegetation is being established. Special treatment or protection may be required to reduce the sedimentation hazard and aid vegetation establishment. Design features that might be considered are:

1. Installation of mulch or various types of netting.
2. Sod strips placed at selected intervals perpendicular to the centerline of the waterway.
3. Diversion of flow until vegetation is established.

4. Sediment basins placed at the downstream end of the waterway. These basins must significantly increase the waterway cross section to provide sediment trapping efficiency.

Supplemental irrigation may also be warranted. The vegetation should be well established before large flows are permitted in the channel.

Drainage areas must be adequately treated to control sediment deposition in the grassed waterway. Large depositions of sediment will reduce the design capacity. Sediment also may carry substances that are detrimental to waterway vegetation or downstream water quality.

Grassed waterways that serve as terrace outlets shall be established prior to the terrace construction.

Design criteria

Capacity

The minimum channel capacity shall be that required to convey the peak discharge expected from the 10-year frequency, 24-hour duration storm for all channel slopes 1 percent or greater. When the channel slope is less than 1 percent, out-of-bank flow may be permitted if such flow will not cause excessive erosion and will remove the water before the crops are damaged.

For channel slopes less than 1 percent, the minimum channel capacity shall be that required to convey the peak discharge from the 2-year frequency, 24-hour duration storm. When the channel depth exceeds the design depth for these waterways and the flow is confined in the channel (i.e. straightened sections, narrowed floodplains), the velocity from the 10-year frequency, 24-hour duration storm peak discharge shall be less than the allowable velocity in these confined sections.

Peak discharge for all storms will be determined by the method outlined in chapter 2 of the SCS Engineering Field Handbook (EFH) or SCS Technical Release 55.

Capacity of waterways shall be based on vegetative retardance A, B, or C. The retardance used shall be in accordance with exhibit 7-2, page 7-18 of the EFH. The retardance used shall consider the types of grasses to be seeded and the type of management anticipated. The charts in the EFH or the SCS publication "Design Charts Vegetated Channel Trapezoidal Cross Section" may be used to proportion the waterway. When these charts are not adequate, procedures given in chapter 7 of the EFH can be used.

Velocity

Design velocities shall be in accordance with table WI-1.

Table WI-1

Slope range (%)	Permissible velocity 1/ Erosion resistant soils (ft/sec) 2/	Permissible velocity 1/ Easily eroded soils (ft/sec) 3/
0-5	7	5
5-10	6	4
over 10	5	3

1/ Use velocities exceeding 5 ft/sec only where good cover and proper maintenance can be obtained.

2/ Cohesive (clayey) fine-grain soils and coarse-grain soils with cohesive fines with a plasticity index of 10 to 40 (CL, CH, SC, and GC).

3/ Soils that do not meet the requirements for erosion-resistant soils.

Maximum velocities shall be determined by using a vegetative retardance of D or E. Velocities can be obtained by using the procedures, Manning's "n" values, and recommendations in the EFH or as listed in the SCS publication "Design Charts Vegetated Channel Trapezoidal Cross Section".

Width

The bottom width of trapezoidal waterways shall not exceed 60 feet unless multiple or divided waterways or other means are provided to control meandering of low flows.

Side slope

Side slopes shall not be steeper than a ratio of 2 horizontal to 1 vertical. They should be designed to accommodate the land user's equipment. Grassed waterways where equipment crossing is desired should have a minimum top width to depth ratio of 24 to 1.

Depth

The minimum depth of a waterway that receives water from terraces, diversions, or other tributary channels shall be that required to keep the design water surface elevation at, or below, the design water surface elevation in the terrace, diversion, or other tributary channel at their junction when both are flowing at design depth.

All grassed waterways shall have a minimum depth of 0.6 feet.

<u>Drainage</u>
Subsurface Drains (SCS standard 606), Underground Outlets (SCS standard 620), stone center waterways, or other suitable measures shall be provided for in the design for sites having prolonged flows, a high water table, or seepage problems. Water-tolerant vegetation such as reed canarygrass may be an alternative on some wet sites. For adequate cover and proper drainage, the flowline of the tile or conduit should be at least 1.5 feet below the bottom of the grassed waterway. Tile or conduit will normally be offset from the bottom along one or both sides of the grassed waterway.

<u>Stone center waterways</u>
Stone center waterways may be used where prolonged flows and wetness will occur. These drains shall be installed on the centerline of the waterway. The capacity of the stone center section shall be approximately 2 times the anticipated prolonged flow.

The required stone size and gradation will be in accordance with SCS Standard 468, Lined Waterway or Outlet. The design velocity for the stone shall be the same velocity used for the waterway.

When the stone center will be placed on erosive soils, a suitable sand-gravel filter or bedding layer or a geotextile must be placed beneath the rock. The filter or bedding layer shall have a minimum thickness of 6 inches where the flow depth will be the greatest. The layer thickness may be reduced near the edges of the stone section.

Soil mechanics design procedures for filter or bedding layers should be considered where high maintenance costs, large base flows, or required drainage of the base soil material are expected.

<u>Outlets</u>
All grassed waterways shall have a stable outlet with adequate capacity to prevent ponding or flooding damages. The outlet can be another vegetated channel, an earth ditch, a grade stabilization structure, or other suitable outlets. Easements may be needed when waterways outlet into road ditches.

<u>Channel crossings</u>
Channel crossings and culverts are to be installed according to criteria contained in Wisconsin Standard 560, Access Road.

<u>Establishment of vegetation</u>
Grassed waterways shall be vegetated according to the SCS practice standard Critical Area Planting (342).

When infertile subsoils will be exposed by construction operations, the topsoil from the construction area should be stripped and stockpiled for respreading on the infertile areas when construction is completed.

Maintenance
A maintenance program shall be established to maintain waterway capacity, vegetative cover, and the outlet. Vegetation damaged by livestock, machinery, herbicides, or erosion must be repaired promptly. To protect nesting wildlife, mowing vegetation in grassed waterways may be delayed until July 15.

Plans and specifications

Plans and specifications for grassed waterways shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Design documentation requirements

Location map, waterway number or reach, drainage area, watershed land slope, runoff curve number, design flow, retardences, design velocities, channel slope, bottom width (trapezoidal), top width (parabolic), side slopes, flow depth, and seeding requirements.

Construction (as-built) and/or certification documentation requirements

Waterway number or reach, length, width to vegetate, vegetation (seeding-acres, sodding-square yards), channel slope and cross section for each waterway reach, and any drainage appurtenances.

SOIL CONSERVATION SERVICE

DIVERSION (FT)

Definition

A channel constructed across the slope with a supporting ridge on the lower side.

Scope

This standard applies to the installation of all diversions except floodwater diversions (400) and diversion dams (348).

Purpose

To divert excess water from one area for use or safe disposal in other areas.

Conditions where practice applies

This practice applies to sites where:

1. Runoff damages cropland, pastureland, farmsteads, feedlots, or conservation practices such as terraces or stripcropping.
2. Surface flow and shallow subsurface flow caused by seepage are damaging sloping upland.
3. Runoff is in excess and available for use on nearby sites.
4. A diversion is required as part of a pollution abatement system.
5. A diversion is required to control erosion and runoff on urban or developing areas and construction or mining sites.

Planning considerations for water quantity and quality

Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

2. The type of outlet, time of water detention, geology, and topography of the site.

Quality

1. Effects on erosion and the movement of sediments, pathogens, and soluble and sediment attached substances carried by runoff.

2. Effects of nutrients and pesticides on surface and ground water quality.

3. Filtering effects of vegetation on movement of sediment and dissolved and sediment attached substances.

4. Short-term and construction-related effects on the quality of downstream water.

5. Effects on the movement of dissolved substances below the root zone and toward the ground water.

6. Potential for uncovering or redistributing toxic materials and low productive soils that might cause undesirable effects on the water on plants.

Design criteria

Capacity

Diversions used as temporary measures, with a life span of less than 2 yr, shall carry as a minimum the 2-yr frequency, 24-h duration storm.

Diversions that protect agricultural land and those that are part of a pollution abatement system must have the capacity to carry the peak runoff from a 10-yr frequency, 24-h duration storm as a minimum.

Diversions designed to protect areas such as urban areas, buildings, and roads, shall have enough capacity to carry the peak runoff expected from a storm frequency consistent with the hazard involved but not less than a 25-yr frequency, 24-h duration storm with a freeboard of not less than 0.3 ft.

Diversions that are designed for a 10-yr frequency or less shall have a minimum of 0.1 ft of freeboard. A freeboard of up to 0.3 is suggested for diversions that are anticipated to accumulate significant volumes of sediment, or to reduce maintenance costs.

Peak rates of discharge will be determined by using chapter 2 in the Engineering Field Manual or by using methods described in SCS Technical Release No. 55.

Vegetated diversions will be designed for flow depth and capacity by using a degree of retardance consistent with the management anticipated with regard to mowing and other farming practices. Retardance shall be in accordance with exhibit 7-2, page 7-18, of the Engineering Field Manual. The degree of retardance will usually be A, B, or C, for agricultural diversions. For diversions that are a part of a farmstead or urban area which will be mowed frequently, the maximum degree of retardance of D may be considered.

Design charts in chapter 9 of the Engineering Field Manual or other approved methods or charts may be used for design. If acceptable charts are not available, Manning's "n" value can be found by using exhibit 7-1, page 7-17 in the Engineering Field Manual.

Cross section
The channel may be parabolic, V-shaped, or trapezoidal. The diversion shall be designed to have stable side slopes. The ridge height shall include an adequate settlement factor. The ridge shall have a minimum top width of 4 ft at the design elevation. The minimum cross section shall meet the specified dimensions. The top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement. The minimum settlement factor shall be 10 pct of the fill height. See figure 1 for dimensions.

Location
The location of the diversion shall be determined by outlet conditions, topography, land use, cultural operations, and soil type. A diversion in a cultivated field must be aligned to permit use of modern farming equipment.

Grade and velocity
Channel grades may be uniform or variable. Channel velocity shall not exceed that considered nonerosive for the soil and planned vegetation or lining.

Maximum allowable velocities for vegetated diversions shall be based on retardance D or E and shall not exceed those shown in table 1. A Manning's "n" value of 0.03 or less shall be used for determining maximum allowable velocities in bare channels.

Table 1 - Permissible velocities for diversions

Soil texture	Permissible velocity - ft/s				
	Bare channel	Channel vegetation			
		Retardance	Poor	Fair	Good
Sand, silt, sandy loam, and silty loam 1/ SW,SP,ML,SM, SM-SC,CL-ML	1.5	D or E	1.5	2.0	3.0
Silty clay loam and sandy clay loam 1/ SC,CL (PI< 10)	2.0	D or E	2.0	3.0	4.0
Clay 1/ MH,CH,CL (PI>10)	2.5	D or E	2.5	4.0	5.0

1/ Unified Soil Classification System designations. PI is the plasticity index.

Protection against sedimentation

Diversions should not be used below high-sediment-producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with or before the diversions. If movement of sediment into the channel is a significant problem, a vegetated filter strip shall be used where soil or climate does not preclude its use. Then, the design shall include extra capacity for sediment and be supported by supplemental structures, cultural or tillage practices, or special maintenance measures.

Channel crossings

Design criteria for livestock and/or equipment crossings shall be in accordance with the standard for access road (560).

Outlets

Each diversion must have a safe and stable outlet with adequate capacity. The outlet may be a grassed waterway, a vegetated or paved area, a grade stabilization structure, an underground outlet, a stable watercourse, or a combination of these practices. The outlet must convey runoff to a point where outflow will not cause damage. Vegetative outlets shall be installed and established before diversion construction to insure establishment of vegetative cover in the outlet channel. Underground outlets consist of an inlet and underground conduit. The release rate when combined with storage is to be such that the design storm will not overtop the diversion ridge. On large watersheds, runoff flows are usually too large to outlet entirely through underground outlets.

The design elevation of the water surface in the diversion shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Vegetation

Disturbed areas that are not to be cultivated shall be established to grass as soon as practicable after construction. If the soils or climatic conditions preclude the use of vegetation for erosion protection, nonvegetative linings such as gravel, rock rip-rap, or cellular block may be used. Seedbed preparation, seeding, fertilizing, and mulching shall comply with critical area planting (342) and mulching (484) standards. The vegetation shall be maintained and trees and shrubs controlled by hand, machine, or chemicals.

Operation and maintenance

A maintenance program shall be established to maintain diversion capacity, storage, ridge height, and the outlets. Maintenance needs are to be discussed with the landowner or operator who is responsible for maintaining the practices installed with SCS assistance. Diversion ridges can be hazardous for farming operations or mowing. Any hazards must be brought to the attention of the responsible person.

Plans and specifications

Plans and specifications for installing diversions shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Design documentation requirements

Location map, runoff and design data, length profile of channel and ridge, outlet conditions, bottom and top widths, side slopes, depth, grade, pertinent elevations, pipe material, diameter, and length (if applicable), and vegetation requirements.

Construction (as-built) and/or certification documentation requirements

Length, channel grade, cross section(s) of critical points or locations, pertinent elevations and conditions of vegetation.

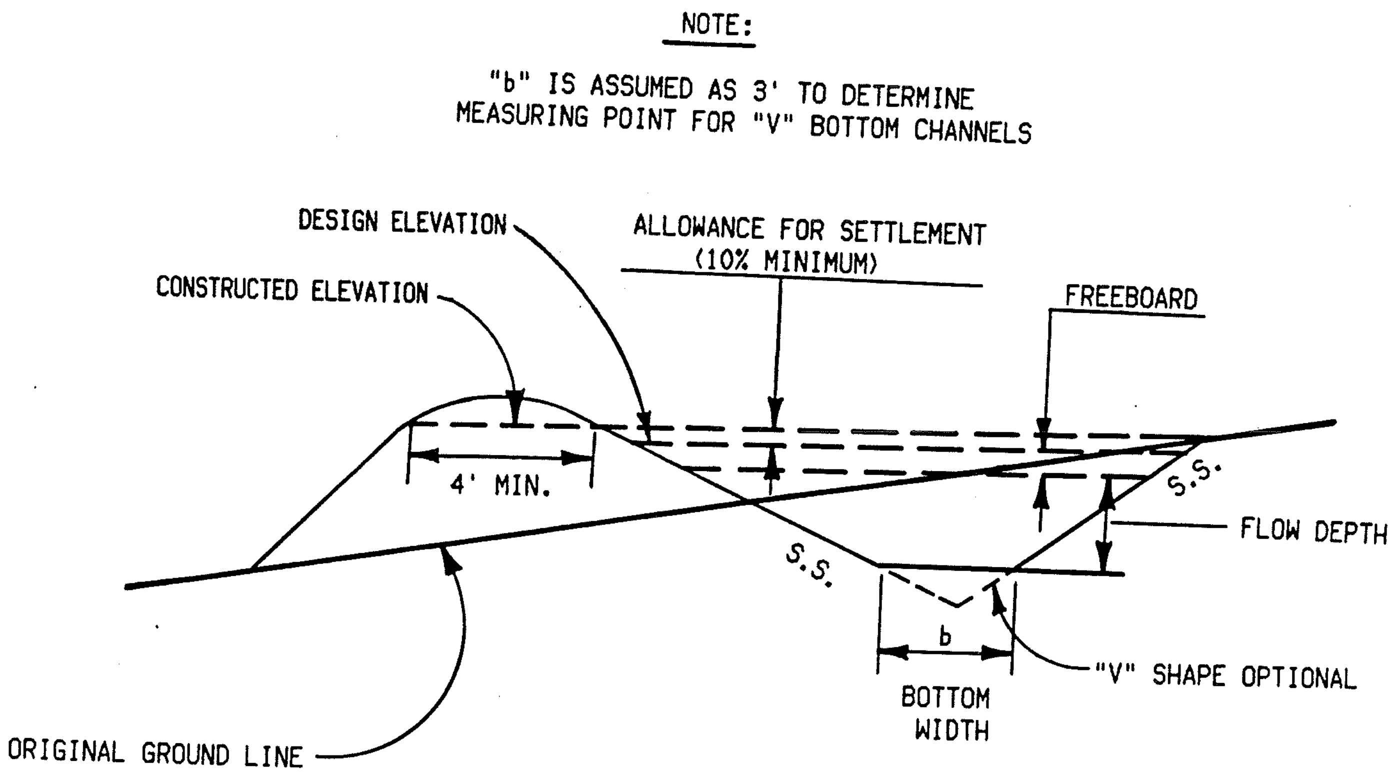

FIGURE 1

DIVERSION SPECIFICATIONS

All ditches or gullies not filled, and undesirable trees and other obstructions not removed before construction begins shall be part of the diversion construction. The diversion shall be constructed to planned alignment, grade, and cross section.

The channel shall drain properly so no standing or ponded water results.

The embankment portion or ridge shall be compacted by the construction equipment travel over the entire surface layer or as specified on the drawings. Diversion ridges constructed across gullies or depressions shall be compacted sufficiently to keep settlement within tolerable limits. The borrow material shall contain sufficient moisture to compact properly.

If underground conduits are located under diversion ridges, mechanical compaction or water packing shall be required. Installation and backfill of conduit trenches shall be made in advance to allow adequate settlement. The materials used for the inlet and conduit shall be as shown on the plans and shall meet the requirements for subsurface drains (606). The surface of the finished diversion shall be reasonably smooth and present an acceptable appearance.

Topsoil shall be stockpiled and spread over excavations and other areas to facilitate revegetation. If vegetation is needed, seedbed preparation, seeding, fertilizing, and mulching shall comply with requirements on the drawings.

SOIL CONSERVATION SERVICE

CRITICAL AREA PLANTING
(ACRE)

Definition

Planting vegetation, such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas (does not include tree planting mainly for wood products).

Purpose

To stabilize the soil, reduce damage from sediment and runoff to downstream areas, and improve wildlife habitat and visual resources.

Conditions Where Practice Applies

On highly erodible or critically eroding areas. These areas usually cannot be stabilized by ordinary conservation treatment and management and if left untreated can cause severe erosion or sediment damage. Examples of applicable areas are dams, dikes, mine spoil, levees, cuts, fills, surface-mined areas, and denuded or gullied areas where vegetation is difficult to establish by usual planting methods.

Specifications Guide

1. Protection. Protect all critical area plantings from fire, animals, and traffic (vehicle or foot) during the establishment period.

2. Supporting practices. Where needed and practical, use diversions to carry runoff water away from the area until cover is established. Terraces may be necessary on long slopes. Water and sediment control basins are also useful.

3. Sloping. Where possible, slopes shall be 2:1 or flatter. Eliminate all dropoffs. The toe of a slope along streambanks shall be stable before attempting seedings on the slopes.

4. Seedbed. Prepare a thoroughly tilled but firm seedbed wherever conditions will permit.

5. Liming. When seeding grasses alone, apply liming materials when pH tests below 5.5. Acceptable pH range for most grasses is 5.5 to 7.5. When alfalfa is seeded, apply liming materials when pH tests below 6.5. The optimum pH for alfalfa is 6.8. When birdsfoot trefoil is seeded, apply liming materials when pH tests below 6.0. The acceptable pH range for birdsfoot trefoil is 6.0 to 7.5. Apply suitable liming materials. Adolomitic or calcitic liming material will supply sufficient Ca to maintain crop growth. Dolomitic lime sources have the added benefit of increasing available Mg.

6. Fertilizing. Fertilize according to soil test or at the rate of 400-600 pounds of 20-10-10 1/ or equivalent per acre. Work into the upper 3 inches of soil where conditions will permit. (435 pounds per acre equals 1 pound per 100 square feet, or 10 pounds per 1,000 square feet.)

7. Select seeding mixture. Select seeding mixtures from the table on pages 8 and 9. Several alternative seeding mixtures are nearly always feasible. Rates are based on pounds of Pure Live Seed (PLS). Increase seeding rates by 50 percent if seed is broadcast or a properly tilled seedbed cannot be prepared.

8. Inoculation. Inoculate all legume seed in accordance with manufacturer's recommendations. When seeding with a hydroseeder, use five times the recommended rate of inoculant. Do not mix inoculent with liquid fertilizer.

9. Seeding methods. When possible, seed grasses and legumes 1/4-inch deep on clayey soils and 1/2-inch to 1-inch deep on sandy and organic soils. Seed may be drilled or broadcast with common types of equipment, or by hand. Seed may be sown with a cultipacker or with a hydroseeder. Distribute seed uniformly. Mixtures with low seeding rates require special care in sowing. When possible seed immediately following seedbed preparation. Seed streambanks and open ditches immediately following construction whenever possible. When hydroseeded or broadcast, cultipack areas not mulched after seeding, if conditions will permit.

1/ For warm season grasses, do not apply nitrogen during the establishment year. Apply 50 pounds of nitrogen per acre the first year after establishment.

10. Seeding dates: 2/ 3/

a. For grasses and legumes. For spring seedings, seed as early as possible and no later than June 1. For later summer seedings, seed between July 15 and August 15 in the central part of the state that includes MLRA's 3/ 90, 91, 94A, 95A, and 96. Make later summer seedings between August 1 and September 1 in the southern part of the state that includes MLRA's 95B, 105 and 110. Late summer and fall seedings are hazardous and not recommended for the northern part of the state that includes MLRA's 92 and 93.

Legumes may also be seeded as a frost seeding, dormant seeding or seeded the following spring over the mulch.

b. For grasses alone. Cool season grasses will be seeded in spring through late summer. Warm season grasses will be seeded in the spring but prior to July 1. Make no grass seedings in the fall later than September 1 in MLRA's 90, 92, 93 and 94A or later than September 15 in MLRA's 91, 95A, 95B, 96, 105, and 110.

c. Dormant seedings. Critical area plantings prepared for seeding from Sept. 1-15 to Nov. 1 may be mulched prior to seeding. Seeding will be done after November 1. These seeding dates are risky. A split application of seed may also be made, using half in November and the balance early in spring.

d. Frost seedings. Frost seeding is sowing seed on the soil surface that has been made friable by freezing and thawing. The soil surface is usually "honeycombed" with small cracks. These seedings are made in late February and March on seedbeds which were prepared in the fall and were limed, fertilized, and mulched according to needs, and where a fall seeding of an annual crop may have been established for temporary protection. No further seedbed preparation is required. Frost seeding rates shall be increased by 50 percent. Frost seedings shall not be made on areas covered with ice or snow, or on areas that have not been previously mulched or seeded to an annual stabilizing crop. Do not frost seed into winter wheat or rye.

2/ Under Wisconsin conditions, best results are obtained when warm-season grasses are seeded in spring. May is the optimum time.

3/ MLRA - Major Land Resource Area

11. Companion Crop. A companion crop may be used with and without mulching. Areas not mulched shall require a companion crop to be planted with the permanent seeding to control erosion. Oats, barley, or spring wheat at the rate of not more than one and one-half (1-1/2) bushels per acre shall be seeded in the spring or fall. Winter wheat or rye may be seeded in the fall at the rate of one and one-half (1-1/2) to two (2) bushels per acre. Do not seed later than September 1 in MLRA's 90, 92, 93, and 94A or later than September 15 in MLRA's 91, 95A, 95B, 96, 105 and 110. The companion crop shall be mowed before heading. Mow 8 to 10 inches high to avoid harm to the permanent seeding.

12. Temporary Stabilizing or Mulch Crop. Areas needing protection during periods when permanent seedings are not made shall be seeded to annual species for temporary protection. The residue from this crop may be either incorporated into the soil during seedbed preparation at the next permanent seeding period or left on the soil surface and the planting made as a frost seeding. Corn, sudangrass, and oats are normally sown between May 15 and July 15. Rye and winter wheat are normally sown between July 15 and September 15. Do not seed after October 15.

Stabilizing Crop

Species	Rate/Acre	Fertilizer
Oats	3 bushels	Apply N, P & K as for permanent seeding.
Corn	3 bushels	
Sudan rass	35 pounds	
Rye 1	2 bushels	
Winter wheat 1/	2 bushels	

1/ Rye and winter wheat should be destroyed by seedbed preparation at next permanent seeding period.

13. Mulching. See Mulching (484).

Areas disturbed during construction or denuded slopes five (5) feet or more in vertical height shall be mulched and the mulch anchored after seeding. This will include slopes 4:1 or steeper. Slopes flatter than 4:1 shall be mulched if slope length is longer than twenty (20) feet.

Construction that exposes heavy textured subsoil, sand, gravel, or rocky material shall be mulched after seeding. Steep areas that are topsoiled shall be mulched.

Mulching is optional on slopes less than five (5) feet in vertical height or less than 20 feet long.

After the optimum seeding period has passed, mulch shall be applied for temporary protection on all disturbed areas not seeded. At the next permanent seeding period, the mulch may be incorporated into the soil during the seedbed preparation, or if the required lime or fertilizer has been applied and worked into the soil before mulching, the mulch may be left over winter for soil protection and the seed applied in the mulch as a frost seeding. If a frost seeding is not made, a new seedbed shall be prepared just prior to seeding.

Mulch shall consist of grass hay, grain straw, shredded cornstalks, strawy manure, wood chips, or other materials listed in the Mulching (484) standard and specification and shall be free of noxious weeds as listed in applicable state laws.

Mulch* shall be applied at the following rates:

Straw or hay - 1 1/2 tons/acre (Anchor with suitable equipment)
Chopped or shredded cornstalks - 4 tons/acre
Strawy manure - 6-8 tons/acre
Wood chips - 6-9 tons/acre

*For other materials, see Mulching (484).

14. Sodding. Use sod where it is desired to quickly provide permanent cover for protection against erosion. Sod may be laid any time of year that it can be satisfactorily cut and moisture can be provided until it becomes established. Specifications for sodding include:

   a. The area to be sodded shall be free of stones, roots, and other debris. Where possible, divert surface water from sodded areas until established.

   b. Site preparation. Subsoils shall be graded and smoothed and covered with topsoil if the subsoil is not suitable for germination and establishment of recommended seedings. Seedbed preparation and liming shall follow specifications 4 and 5. Apply 500 pounds of 20-10-10 fertilizer, or equivalent, per acre (1.5 lbs./100 sq. ft.) in lieu of a soil test. With commercially produced sod, mix fertilizer thoroughly with top 3 inches of soil. For pasture grown sod, mix half of the fertilizer thoroughly with the top 3 inches of soil and topdress the other half after laying the pasture-grown sod.

c. Sod requirements. Grass shall consist of dense growth of acceptable grasses, free of broadleaved weeds. All debris shall be removed from sod prior to cutting. If sod is too dry to roll, it will be watered a few hours before cutting. Grass shall be mowed to 1 to 2 inches. Sod thickness shall be: Kentucky bluegrass and creeping red fescue - 3/4 to 1-1/4 inches; smooth bromegrass and reed canarygrass - 1-1/2 to 2 inches. Sides shall be cut straight and ends square.

d. Sod placement. Sod shall be laid as soon as possible after cutting, normally within 2 days. Surfaces which are not moist must be sprinkled prior to laying sod. The sod will be laid, starting at the bottom or base of slopes, working upward. The sod shall be laid at right angles to drainage flow. Sod pieces shall not be stretched.

Joints - on the locations where ends join - shall be staggered like in laying bricks. On outside edges of sodded areas, extend one strip of sod a minimum distance of 30 inches beyond the others at intervals of 8 feet or less.

The upper edge of the sod strips shall be turned down slightly at the top of slopes to help conduct runoff onto the sod area. Apply a thin layer of topsoil to all open joints and around all open exposed edges. On steep slopes and in areas where water concentrates, the sod is to be covered with a wire mesh (chicken wire) or pegged down with small wooden pegs to assist in holding sod in place. These holddowns shall remain in place until the sod is established and firmly rooted.

Tamp firmly, or roll, to insure good root contact with the underlying soil. A good soil-sod interface is necessary for best results.

e. Watering. All sodded areas shall be watered immediately after tamping or rolling. The water must be applied at a slow rate which does not allow runoff. Sufficient water shall be applied to insure moisture penetration to a depth of at least 6 inches. Watering shall be continued as needed to prevent the sod from drying out for one month or until the sod is thoroughly knitted together.

15. Reed canarygrass sprigging. Sprigging with reed canarygrass gives fast establishment in wet waterways and small gullies, or on streambanks and shorelines. Reed canarygrass can easily be propagated by sprigs or small sod chunks or green hay. This is best accomplished in early spring, but can be done throughout the growing season. Methods of vegetative propagation include:

a. Broadcast sprigging:

(1) Spread roots and rhizomes (sod chunks) over entire area.

(2) Disk or work by hand the entire area to partially cover sod chunks.

(3) Some packing is desirable.

b. Spot sprigging:

(1) Dig "fist"-sized sod chunks.

(2) Transplant with a spade or planting bar or simply press into wet soil at the water's edge. (1" x 4" board works well).

(3) Suggested spacing is 1x1 foot.

16. Crownvetch. Crownvetch (Coronilla varia), a long-lived rhizomatous legume, can be started from seed or crowns. On small areas, crowns are considered as economical for establishment. A 3x3-foot spacing results in a satisfactory ground cover. Early spring is considered the best time to transplant crownvetch vegetatively. However, it may be transplanted throughout the growing season. Water in dry periods during establishment.

17. American beachgrass. Sand blows and dunes may be vegetated with American beachgrass. Set culms at 18-inch spacing and 6 inches deep. Trees may become established after beachgrass stabilizes the soil, on blowouts and secondary dunes. On frontal dunes maintain beachgrass by fertilization.

18. Tawny daylily and ribbongrass. Tawny daylily (Hemerocallis fulva) and other daylilies and ribbongrass (Phalaris arundinacea picta) are very versatile ground cover plants which may be recommended throughout Wisconsin. Each is widely adapted under well drained to somewhat poorly drained conditions and can be used in either sun or shade on both good and poor soils. Both are propagated vegetatively, normally in the spring of the year. Spacing of 1x1 foot is suggested. Clump plantings of daylily at much wider spacing adds to the natural beauty of an area. Daylilies shall not be used in waterways or other areas where water concentrates.

19. Topsoiling. Most critical areas can be revegetated successfully without adding topsoil. On exposed rocky, sandy, gravelly, shaley material or extremely fine textured subsoils where vegetation cannot be established successfully, at least 4 inches of friable soil material or topsoil shall be added to the soil surface before commencing the seedbed preparation. Mix the added soil material into the surface of the planting site with a chisel plow, disk or other implement.

20. Woody plants. Woody shrubs, trees, or vines will be used only after initial stabilization, using grasses and/or legumes. Plant in accordance with the purpose of the planting. Refer to: Tree Planting (612), Wildlife Upland Habitat Management (645), and Recreation Area Improvement (562).

Conservation Plan and Design Documentation Requirements

Location on the conservation plan map and the seed mixture, rate of seeding and the fertility requirements documented in the conservation plan. In lieu of a conservation plan, provide a location map and document the seed mixture, rate of seeding, the fertility requirements, and the number of acres planned.

Certification Documentation Requirments

Documented in the conservation plan in the applied column. In lieu of a conservation plan, document the number of acres established on the SCS-CONS-6.

Seeding Mixtures 2/ 3/		lbs. of PLS	Site Suitability 1/ Excessively Drained	Well Drained	Poorly Drained
1.	Birdsfoot Trefoil	6	2	1	2
	Crownvetch 4/	5			
	Kentucky Bluegrass	2			
	Smooth Bromegrass	5			
	Tall Fescue	5			
2.	Crownvetch 4/	5			
	Smooth Bromegrass	15	2	1	
	Tall Fescue	10			
3.	Birdsfoot Trefoil	6			
	Smooth Bromegrass	15		2	1
	Tall Fescue	10			
4.	Smooth Bromegrass	20			
	Tall Fescue	10		1	2
	Kentucky Bluegrass	(1) 5/			
5.	Smooth Bromegrass or	30		1	2
	Tall Fescue				
	Perennial Ryegrass 6/	(3) 5/			
6.	Reed Canarygrass	20		2	1
	Perennial Ryegrass 6/	(2) 5/			
7.	Crownvetch 4/	5	2	1	
	Kentucky Bluegrass	4			
	Creeping Red Fescue 7/	2			
8.	Birdsfoot Trefoil	6		1	2
	Kentucky Bluegrass	4			
	Creeping Red Fescue 7/	2			
9.	Kentucky Bluegrass	16		1	2
	Creeping Red Fescue	8			
10.	Kentucky Bluegrass	8			
	Creeping Red Fescue 7/	16	1	2	
11.	Crownvetch 4/	5			
	Birdsfoot Trefoil	6	2	1	2
	Kentucky Bluegrass	2			
	Creeping Red Fescue 7/	4			

Seeding Mixtures 2/ 3/		lbs. of PLS	Site Suitability 1/ Excessively Drained	Well Drained	Poorly Drained
12.	Smooth Bromegrass Timothy Red Clover or Alsike clover or Birdsfoot Trefoil	20 8 3 3 6		1	2
13.	Switchgrass 9/	6 8/	2	1	2
14.	Alfalfa Smooth Bromegrass or or Tall Fescue	6 20	2	1	
15.	Alfalfa Red Clover Smooth Bromegrass Tall Fescue	5 3 15 10		2	1
16.	Big Bluestem 10/ Little Bluestem Switchgrass Indiangrass Sideoats grama	5 (2) 5/ 3 2 (2) 5/	2	1	2
17.	Smooth Bromegrass Reed Canarygrass Annual Ryegrass	24 4 2	2	2	1

1/ 1 - Preferred, 2 - will tolerate.
2/ Mixtures for best wildlife nesting cover in order of preference are: 13, 16, 14, 5.
3/ Adapted varieties can be found in Section II-K of the Wisconsin Technical Guide. UW-Ext. Publications A1525 "Forage Crop Varieties and Seeding Mixtures" and A1525-1 "Perennial Legume Forage Crop Variety Update."
4/ Recommended varieties for Wisconsin include Emerald, and Penngift.
5/ ( ) - may be added to the mixture.
6/ Annual vegrass may be substituted for perennial ruegrass.
7/ Redtop may be substituted for creeping red fescue.
8/ For establishment in a grassed waterways or outlet, see Wisconsin Technical Note - Agronomy-WI-26, dated December 3, 1981.
9/ Recommended varieties for Wisconsin include Blackwell, Cave-in-Rock, Nebraska 28 and Wisconsin native harvest.

10/ Recommended varieties for Wisconsin include:

Big Bluestem - Champ, PM-SD-27, NDG-4, Rountree and Wisconsin native harvest

Little Bluestem - Blaze, Camper and Wisconsin native harvest

Indiangrass - Holt, Nebraska 54, Oto, PM-ND-444, Rumsey and Wisconsin native harvest

Sideoats grama - Butte, Killdeer, Pierre, Trailway and Wisconsin native harvest

Special seeding equipment or seeding by hand will be necessary.

This supplement temporarily amends seeding mixtures 12, 14, and 15 of the Critical Area Planting standard and specification. This supplement may be used until an adequate supply of smooth bromegrass is available. At that time it will be cancelled and the original mixtures will be re-instated.

Changes:

You may substitute tall fescue for smuoth bromegrass in mixtures number 12, 14, & 15.

APPENDIX FOUR

COMPANIES IN WISCONSIN WHICH MAY TAKE WOOD WASTE

WOOD WASTE

Counties Served	Company Name	Phone	Processing Required	Minimum Amount Accepted	Remarks
ALL COUNTIES					
	ECOLOGY RECYCLING	(414)567-1771	NO PROCESSING		
	FOSTER LIQUIDATORS	(715)597-2425	NO PROCESSING		
	GOEMAN WOOD PRODUCTS, INC.	(414)673-6090	NO PROCESSING	TRUCKLOADS	
	GOEMAN WOOD PRODUCTS, INC.	(414)673-6090	OTHER	TRUCKLOADS	IN CONTAINERS
	NORTH AMERICA MICRO CORPORATION	(414)863-6911	NO PROCESSING		
	RADZINSKI, BOB	(414)834-2559	NO PROCESSING		
	RECYCLERS TRANSPORT	(414)535-4176	NO PROCESSING		
	SAINT MARIE RECYCLING	(414)294-3262	NO PROCESSING		
	V.I.M. CORPORATION	(708)858-5180	IN GAYLORD BOX	12,000 LBS.	
BARRON					
	PALLET RECYCLING	(621)488-0474	NO PROCESSING		TRAILER LOADS FOR PICK UP
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
BAYFIELD					
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
BROWN					
	GERALD E. BRAUN CONSTRUCTION CO.	(414)869-2251	SHREDDED		NO PAY.
	MASTALIR SERVICES, INC.	(414)388-4038	NO PROCESSING		NO PAINTED WOOD.
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED
BUFFALO					
	MODERN CLEANUP SERVICE	(608)781-6666	SHREDDED		
BURNETT					
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
CALUMET					
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED
COLUMBIA					
	NORSKE WOODWORKS	(608)767-3994	NO PROCESSING		WOOD CHIPS
CRAWFORD					
	FAHERTY, INC.	(608)348-9586	NO PROCESSING	$50 PER TON	
DANE					
	NORSKE WOODWORKS	(608)767-3994	NO PROCESSING		WOOD CHIPS
DODGE					
	NORSKE WOODWORKS	(608)767-3994	NO PROCESSING		WOOD CHIPS

WOOD WASTE

Counties Served	Company Name	Phone	Processing Required	Minimum Amount Accepted	Remarks
DOOR					
	MASTALIR SERVICES, INC.	(414)388-4038	NO PROCESSING		NO PAINTED WOOD.
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED
DOUGLAS					
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
DUNN					
	PALLET RECYCLING	(621)488-0474	NO PROCESSING		TRAILER LOADS FOR PICK UP
GRANT					
	FAHERTY, INC.	(608)348-9586	NO PROCESSING	$50 PER TON	
GREEN					
	NORSKE WOODWORKS	(608)767-3994	NO PROCESSING		WOOD CHIPS
IOWA					
	FAHERTY, INC.	(608)348-9586	NO PROCESSING	$50 PER TON	
	NORSKE WOODWORKS	(608)767-3994	NO PROCESSING		WOOD CHIPS
JACKSON					
	MODERN CLEANUP SERVICE	(608)781-6666	SHREDDED		
JEFFERSON					
	NORSKE WOODWORKS	(608)767-3994	NO PROCESSING		WOOD CHIPS
	TURNER PALLET SERVICES	(414)425-4760	LOOSE		CALL FOR SITES
	TURNER PALLET SERVICES	(414)425-4760	SHREDDED		CALL FOR SITES
KEWAUNEE					
	MASTALIR SERVICES, INC.	(414)388-4038	NO PROCESSING		NO PAINTED WOOD.
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED
LA CROSSE					
	MODERN CLEANUP SERVICE	(608)781-6666	SHREDDED		
LAFAYETTE					
	FAHERTY, INC.	(608)348-9586	NO PROCESSING	$50 PER TON	
MANITOWOC					
	MASTALIR SERVICES, INC.	(414)388-4038	NO PROCESSING		NO PAINTED WOOD.
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED

WOOD WASTE

Counties Served	Company Name	Phone	Processing Required	Minimum Amount Accepted	Remarks
MILWAUKEE					
	TURNER PALLET SERVICES	(414)425-4760	LOOSE		CALL FOR SITES
	TURNER PALLET SERVICES	(414)425-4760	SHREDDED		CALL FOR SITES.
MONROE					
	MODERN CLEANUP SERVICE	(608)781-6666	SHREDDED		
OUTAGAMIE					
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED
PEPIN					
	PALLET RECYCLING	(621)488-0474	NO PROCESSING		TRAILER LOADS FOR PICK UP
PIERCE					
	PALLET RECYCLING	(621)488-0474	NO PROCESSING		TRAILER LOADS FOR PICK UP
POLK					
	PALLET RECYCLING	(621)488-0474	NO PROCESSING		TRAILER LOADS FOR PICK UP
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
RACINE					
	REC SYSTEMS OF WISCONSIN, INC.	(414)642-3363	SHREDDED	TRAILERLOADS	CALL
	TURNER PALLET SERVICES	(414)425-4760	LOOSE		CALL FOR SITES
	TURNER PALLET SERVICES	(414)425-4760	SHREDDED		CALL FOR SITES.
RICHLAND					
	FAHERTY, INC.	(608)348-9586	NO PROCESSING	$50 PER TON	
ROCK					
	NORSKE WOODWORKS	(608)767-3994	NO PROCESSING		WOOD CHIPS
RUSK					
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
SAUK					
	D & D DISPOSAL CO.	(608)356-3911	LOOSE		
SAWYER					
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
SHAWANO					
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED
SHEBOYGAN					
	MASTALIR SERVICES, INC.	(414)388-4038	NO PROCESSING		NO PAINTED WOOD.

WOOD WASTE

Counties Served	Company Name	Phone	Processing Required	Minimum Amount Accepted	Remarks
ST. CROIX					
	PALLET RECYCLING	(621)488-0474	NO PROCESSING		TRAILER LOADS FOR PICK UP
TREMPEALEAU					
	MODERN CLEANUP SERVICE	(608)781-6666	SHREDDED		
VERNON					
	MODERN CLEANUP SERVICE	(608)781-6666	SHREDDED		
WALWORTH					
	REC SYSTEMS OF WISCONSIN, INC.	(414)642-3363	SHREDDED	TRAILERLOADS	CALL
	TURNER PALLET SERVICES	(414)425-4760	LOOSE		CALL FOR SITES
	TURNER PALLET SERVICES	(414)425-4760	SHREDDED		CALL FOR SITES.
WASHBURN					
	RICE LAKE LUMBER & PALLET CO.	(218)727-3213	NO PROCESSING		
WASHINGTON					
	TURNER PALLET SERVICES	(414)425-4760	LOOSE		CALL FOR SITES
	TURNER PALLET SERVICES	(414)425-4760	SHREDDED		CALL FOR SITES.
WAUKESHA					
	REC SYSTEMS OF WISCONSIN, INC.	(414)642-3363	SHREDDED	TRAILERLOADS	CALL
	TURNER PALLET SERVICES	(414)425-4760	LOOSE		CALL FOR SITES
	TURNER PALLET SERVICES	(414)425-4760	SHREDDED		CALL FOR SITES.
WAUPACA					
	FILTER MATERIAL, INC.	(715)258-5525	BALED	10,000 LBS.	UNIFORM CONTENT, CLEAN, BAGGED
WINNEBAGO					
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	NO PROCESSING		
	WHOLESALE PALLET DISTRIBUTORS	(414)496-0100	OTHER		PRICE REQUIRED

These range from [illegible] to 40 tons per hour. [illegible]

PARTIAL LISTING OF WISCONSIN PLANTS FIRING WOOD WASTE

Action Floor Systems	P. O. Box 469	Mercer, WI 54547
Algoma Hardwood, Inc.	1001 Perry St.	Algoma, WI 54201
Allen Dock Mfg.	533 Spring Ave.	Florence, WI 54121
AMPI	1511 East Fourth St.	Marshfield, WI 54449
AMXCO	P. O. Box 391 P. O. Box 504	Rice Lake, WI 54868 Marinette, WI 54143
Appleton Paper, Inc.	P. O. Box 129	Combined Locks, WI 54113
Ashley Furniture Corp.	423 Cleveland St.	Arcadia, WI 54612
August Lotz Co., Inc.	146 N. Center St.	Boyd, WI 54726
Badger Paper Mills	P. O. Box 149	Peshtigo, WI 54157
Barron Sr. High School		Barron, WI 54812
Bayside Timber	11th Ave. E.	Ashland, WI 54806
Bay View Industries	7821 S. 10th St.	Oak Creek, WI 53154
Beloit Box Board Co.	801 Second St.	Beloit, WI 53511
Benchmark Corp.	2341 W. Hagen Rd.	Chippewa Falls, WI 54729
Best Western Hudson House Inn	1616 Crestview Dr.	Hudson, WI 54016
Biewer Wisconsin Sawmill	400 Red Pine Ct.	Prentice, WI 54556
Big River Dry Kiln Corp.	550 Fremont St.	Trempealeau, WI 54661
Birchwood Lumber & Veneer	P. O. Box 54	Birchwood, WI 54817
Birchwood Mfg. Co.	38 E. Messenger St.	Rice Lake, WI 54868
Birds Eye Veneer Co.	P. O. Box 12	Butternut, WI 54514
Black Bear Forest Products	P. O. Box 96	Glidden, WI 54527
Brown County Cabinets, Inc.	998 Glory Rd.	Green Bay, WI 54303
Brunkow Hardwood Corp.		Nelson, WI 54756
Buckstaff Co.	1127 S. Main	Oshkosh, WI 54901
Capitol Interiors	493 S. Ellis Ave.	Peshtigo, WI 54157
Chippewa Industries, Inc.		Drummond, WI 54832
Chitke Farms	Rt. 1 - Box 71	Arcadia, WI 54612
Christiansen Bldg. Center	36051 Mapleton St.	Oconomowoc, WI 53066
Clopay Millwork Div.	625 Elizabeth St.	Shawano, WI 54166
Conrad Furniture	P. O. Box 1411	Wausau, WI 54401
Consolidated Papers, Inc.	P. O. Box 50 2627 Whiting Rd. Cty. Trk. U	Wisconsin Rapids, WI 54494 Stevens Point (Whiting), WI 54481 Wis. Rapids (Biron), WI 54494
Cornell Corp.	STH 27 S	Cornell, WI 54732
Coulee Region Enterprises, Inc.	Box 306	Bangor, WI 54614
Cross Pointe Paper	Box 340	Park Falls, WI 54552

PARTIAL LISTING OF WISCONSIN PLANTS FIRING WOOD WASTE (Continued)

Dejno's, Inc.	920 Bridge St.	Antigo, WI 54409
Dresser Tie & Lumber, Inc.	Route 8	Hayward, WI 54843
Duckert Pallet Corp.	310 Portland Rd.	Waterloo, WI 53594
Ebner Box, Inc.	P. O. Box 344	Cameron, WI 54822
Edelweiss Cheese Co.	M447 Cty. Trk. C	Marshfield, WI 54449
Eggers Industries	164 N. Lake St.	Neenah, WI 54956
Eggers Plywood Co.	1819 E. River St. 1702 13th St.	Two Rivers, WI 54241 Two Rivers, WI 54241
Fort McCoy	ATTN: AFZR-DEH-E P. O. Box 5000	Sparta, WI 54656-5000
Gateway Lodge	Po Box 147	Land O' Lakes, WI 54540
Gerry Wood Products Co.	P. O. Box 217	Suring, WI 54174
Glenville Millwork & Supply		Baraboo, WI 53913
Glidden School District	370 S. Grant St.	Glidden, WI 54527
Goodman Forest Ind. Ltd.	Mill St.	Goodman, WI 54125
Green Bay Packaging	P. O. Box 1107	Green Bay, WI 54305
Hamilton Industries	1316 18th St.	Two Rivers, WI 54241
Hayward Middle/Elem. School	P. O. Box 860	Hayward, WI 54843
Hayward Senior High School	P. O. Box 860	Hayward, WI 54843
Hayward Wood Products	P. O. Box 638	Hayward, WI 54843
Heritage Hardwoods, Inc.	P. O. Box 488	Shawano, WI 54166
Hood Equipment	P. O. Box 307	Iron River, WI 54847
Hotz Mfg.	P. O. Box 110	Shawano, WI 54166
IKE International	500 E. Maple St.	Stanley, WI 54768
Joerns Healthcare, Inc.	5555 Joerns Drive	Stevens Point, WI 54481
Johnson Timber Corp.	PO Box 810	Hayward, WI 54843
Kersten Lumber	USH 45	Birnamwood, WI 54414
Keshena High School		Keshena, WI 54135
~~Khoury Bros.~~ Aspen Lbr - Drummond Div	Box 99	Drummond, WI 54832
Knetter Cheese, Inc.	700 South 8th St.	Cameron, WI 54822
Kretz Lumber Company	CTH H	Antigo, WI 54409
Lakeland Union High School		Minocqua, WI 54548
L-P	606 Wilderness Drive P. O. Box 553 P. O. Box 190	Mellen, WI 54546 Hayward, WI 54843 Tomahawk, WI 54487

PARTIAL LISTING OF WISCONSIN PLANTS FIRING WOOD WASTE (Continued)

Lake Holcomb Public School	Spooner & Jenkins St.	Holcomb, WI 54745
LAMICO, Inc.	P. O. Box 223	Oshkosh, WI 54902
Larson Pallet Co.	P. O. Box 528	Ogema, WI 54459
Lincoln Wood Products	701 N. State St.	Merrill, WI 54452
Lionite Hardboard Div. GP	P. O. Box 138	Phillips, WI 54555
Little Rapids Corp.	P. O. Box 776	Rhinelander, WI 54501
Lullabye Furniture Co.	1017 3rd St.	Stevens Point, WI 54481
Magnum Timber Corp.	P. O. Box 166	Hixton, WI 54635
Mapleton Wood Products, Inc.	508 Grant St.	Thorp, WI 54771
Marinette School District	1010 Main St.	Marinette, WI 54143
Marion Plywood	P. O. Box 238	Marion, WI 54950
Mayline Co.	619 Commerce	Sheboygan, WI 53081
Mellen School	420 S. Main St.	Mellen, WI 54546
Memorial Medical Center	1615 Maple Lane	Ashland, WI 54806
Meng's Sawmill	Rt. 1 - Box 8	Rockland, WI 54653
Menominee Indian School Dist.	P. O. Box 399	Keshena, WI 54135
Menominee Tribal Enterprises		Neopit, WI 54150
Menzer Lbr. & Supply	105 Main St.	Marathon, WI 54448
Mid State Contracting	2001 CTH U	Wausau, WI 54401
Middle River Health Facility		Hawthorne, WI 54842
Midwest Containers	P. O. Box 648	Sheboygan, WI 53081
Midwest Dist., Div. of Menards	Route 2 - Box 121	Eau Claire, WI 54701
Milfab	433 E. South St.	Stoughton, WI 53589
Morgan Products Ltd.	P. O. Box 2446	Oshkosh, WI 54903
Mosinee Paper		Mosinee, WI 54455
Nagel Lumber Co.		Land O' Lakes, WI 54540
Necedah Pallet Co., Inc.		Necedah, WI 54646
Nekoosa Papers, Inc.	100 Wisconsin River Drive	Port Edwards, WI 54469
Nelson Hardwood Lumber		Richland Center, WI 53581
Nemshoff Chairs	2218 W. Water St.	Sheboygan, WI 53081
Neopit Elementary School		Neopit, WI 54150
Niagara of Wisconsin Paper	P. O. Box 5	Niagara, WI 54151
Nicolet Hardwood Corp.	P. O. Box 305	Laona, WI 54540
Norco Windows, Inc.	P. O. Box 309	Hawkins, WI 54530
Northern States Power	South Bainbridge St. 122 N. 14th Ave. West	La Crosse, WI 54601 Ashland, WI 54806

PARTIAL LISTING OF WISCONSIN PLANTS FIRING WOOD WASTE (Continued)

Northwest Hardwoods	Linden St. 718 2nd Ave. SW	Dorchester, WI 54425 Onalaska, WI 54650
Oscar Mayer	910 Mayer Ave.	Madison, WI 53704
Owen Forest Prod. Co.	P. O. Box 506	Marathon, WI 54448
Owen Wood Products	331 N. Oak St.	Owen, WI 54460
P. J. Murphy For. Prod. Corp.	1001 Dougherty Rd.	Ladysmith, WI 54848
Packaging Corp. of America	N9090 Hwy. E.	Tomahawk, WI 54487
Park Falls School	400 9th St. N 477 1st Ave. N	Park Falls, WI 54552 Park Falls, WI 54552
Pluswood	P. O. Box 2248	Oshkosh, WI 54903
Polar Mfg.	P. O. Box 4	Polar, WI 54418
Pride Mfg.		Florence, WI 54121
Proctor & Gamble Paper Prod.	501 Eastman	Green Bay, WI 54305
Pukall Lumber		Woodruff, WI 54568
R-Way Furniture Co.	740 S. Commerce St.	Sheboygan, WI 53081
Red Arrow Prod.	P. O. Box 1537	Manitowoc, WI 54221-1537
Reedsburg Hwd.	1580 Laukant St.	Reedsburg, WI 54959
Repap Paper Corp.	N. Main St.	Kimberly, WI 54136
Rib Lake School		Rib Lake, WI 54470
Rice Lake School	700 Augusta St.	Rice Lake, WI 54868
Richardson Brothers Co.		Sheboygan Falls, WI 53085
Robbins, Inc.	P. O. Box 37	White Lake, WI 54491
Rodman Industries	P. O. Box 76	Marinette, WI 54143
Rollohome Corp.	115 E. Upham	Marshfield, WI 54449
S & S Wood Products	318 Green St.	Independence, WI 54747
St. Croix Valley Hardwoods, Inc.	230 Duncan St.	Luck, WI 54853
SNE Corp.	116 Wood St.	Stevens Point, WI 54481
Schmidt Lumber Co.	820 E. Mauer	Shawano, WI 54166
Schmitt Timber Corp.	N8539 CTH B	Spring Valley, WI 54767
Schroeder's Flowers	1530 S. Webster Ave.	Green Bay, WI 54301
Schweiger Mfg.	116 W. Washington	Jefferson, WI 53549
Scott Paper Co.	106 E. Central	Oconto Falls, WI 54154
Semling Menke Co.	S. Nast St.	Merrill, WI 54452
Sentinel Structures, Inc.	477 S. Peck Ave.	Peshtigo, WI 54157
Silver Creek Lumber	P. O. Box 240	High Bridge, WI 54846
Simmons Juvenile Products	613 E. Beacon	New London, WI 54961
Smeckert Mfg.	518 Bird St.	Abbotsford, WI 54405

PARTIAL LISTING OF WISCONSIN PLANTS FIRING WOOD WASTE (Continued)

Stanwood	711 N. Broadway	Stanley, WI 54768
Stetson Hardwood, Inc.	P. O. Box 159	Stetsonville, WI 54480
Superior Fiber Products	P. O. Box 365	Superior, WI 54880
T. J. Hale Co.	W139N9499 STH 145	Menomonee Falls, WI 53051
Tannery Lane Co.	P. O. Box 26	Rib Lake, WI 54470
Thilmany Pulp & Paper Co.	Stribley Rd.	Kaukauna, WI 54130
Tiffany Tie & Lumber Co.	P. O. Box 518	Whitehall, WI 54773
Tigerton Lumber	Cedar St.	Tigerton, WI 54486
Tower Pallet Co.	P. O. Box 428	De Pere, WI 54115
U. S. Paper Mills Corp.	P. O. Box 3309	De Pere, WI 54115
Vulcan Corp.	P. O. Box 68	Antigo, WI 54409
WCCO Lbr. & Dry Kiln, Inc.	Rt. 1 - Box 160	Rockland, WI 54653
Walnut Hollow Farm	Rt. 2	Dodgeville, WI 53533
Walter Bros. Lumber Mfg.		Radisson, WI 54867
Weathershield Mfg. Inc.	P. O. Box 309	Medford, WI 54451
Weber Mfg. Co.	P. O. Box 71	Shawano, WI 54166
Webster Lumber Co.	P. O. Box 305	Bangor, WI 54614
Webster School	P. O. Box 9	Webster, WI 54893
Wetterau Wood Products	1600 Deleglise St.	Antigo, WI 54409
Weyerhaeuser	P. O. Box 130 P. O. Box 200	Marshfield, WI 54449 Rothschild, WI 54474
Winter High School	CTH W	Winter, WI 54895
Wisconsin Dairies	Rt. 1	Alma Center, WI 54611
Wisconsin Trailer Co.	2427 STH 17	Phelps, WI 54554
Wisconsin Veneer & Plywood		Mattoon, WI 54450
Wolf River Dry Kilns	P. O. Box 224	New London, WI 54961
Wood Chip Corp. of America	1000 S. State St.	Merrill, WI 54452
Woodruff Lumber	132 E. Cameron Ave.	Vesper, WI 54489
Zelazoski Wood Products	103 Edison	Antigo, WI 54409

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PRIMARY WOOD USING INDUSTRIES ALPHABETICAL INDEX

FIRM	TYPE	COUNTY
ABRAMS LUMBER CO	SAWMILL	OCONTO
ADAMS BROTHERS	SAWMILL	RUSK
ALBER & ALBER	SAWMILL	LINCOLN
ORVILLE ALBRIGHT	SAWMILL	GREEN
ALGOMA LUMBER CO	SAWMILL	KEWAUNEE
AMERICAN EXCELSIOR CO	EXCELSIOR	MARINETTE
AMERICAN EXCELSIOR CO	EXCELSIOR	BARRON
ANDERSON BROS SAWMILL	SAWMILL	MARINETTE
DONALD B ANDERSON	SAWMILL	BAYFIELD
HERMAN J ANDERSON LUMBER CO	SAWMILL	LANGLADE
JERRY ANDERSON	SAWMILL	ST. CROIX
JOHN M ANDERSON	SAWMILL	DOOR
ANDERSON SAWMILL & MFG INC	SAWMILL	MARATHON
ANDERSON WOOD FUELS	WHOLE TREE	MARATHON
ANP DIMENSIONAL HWD	SAWMILL	PRICE
APPLETON PAPERS INC	PULPMILL	OUTAGAMIE
ARSENEAU'S SAWMILL	SAWMILL	LINCOLN
AUGUST LOTZ CO INC	SAWMILL	CHIPPEWA
B & J SAWMILL	SAWMILL	GRANT
BADGER COUNTRY LOG HOMES	SAWMILL	MANITOWOC
BADGER PAPER MILLS INC	PULPMILL	MARINETTE
BAGLEY SAWMILL	SAWMILL	GRANT
BAKER SAWMILL	SAWMILL	POLK
WERNER BALLWEG & SONS	SAWMILL	DANE
ADDISON BALSLEY	SAWMILL	RICHLAND
BARKLEY SAWMILL	SAWMILL	LINCOLN
LAWRENCE J BATZ SAWMILL	SAWMILL	DANE
LAMBERT J BAUER	SAWMILL	PEPIN
BAYLAND VENEER	VENEER	BROWN
BAYLAND VENEER	SAWMILL	BROWN
BAYSIDE TIMBER CORP	CHIP PLANT	ASHLAND
BEAVER CREEK WOOD PRODUCTS	SAWMILL	BARRON
BEAVER CREEK FOREST PRODUCT	SAWMILL	PRICE
GARY BEAVER	SAWMILL	MARQUETTE
BECHERER'S SAWMILL	SAWMILL	WASHBURN
BEE FOREST PRODUCTS	SAWMILL	PEPIN
DUANE BEEKSMA	SAWMILL	BAYFIELD
EUGENE BEHNKE	SAWMILL	SHAWANO
BEIERLE SAWMILL & LOGGING	SAWMILL	WALWORTH
RALPH BENSEN	SAWMILL	CLARK
BENSON SAWMILL	SAWMILL	LINCOLN
BER-MACS MILL	SAWMILL	DOUGLAS
BIEWER WISCONSIN SAWMILL	SAWMILL	PRICE
BIEWER WISCONSIN SAWMILL	TREATING	PRICE
BERNARD BINFORD	SAWMILL	ASHLAND
BIRCHWOOD LUMBER & VENEER	SAWMILL	WASHBURN
BIRCHWOOD LUMBER & VENEER	VENEER	WASHBURN
BIRCHWOOD MANUFACTURING CO	VENEER	BARRON
BIRDS EYE VENEER INC	VENEER	ASHLAND
BLK RIV COUNTRY LOG HOMES	SAWMILL	JACKSON
BLAHNIK LUMBER	SAWMILL	DOOR
RAY BLOCK	SAWMILL	SHAWANO
BOB'S SAWMILL	SAWMILL	LAFAYETTE
BOBTON INC	SAWMILL	MARINETTE
GLEN BOETTCHER	SAWMILL	MARATHON
RONALD BOETTCHER	SAWMILL	MARINETTE
BOLDIG & SONS CO INC	SAWMILL	SHAWANO
MELVIN BONKRUDE	SAWMILL	BARRON
HARVEY I BORNTREGER	SAWMILL	TAYLOR
JOE M BORNTREGER	SAWMILL	MONROE
SAM M BORNTREGER	SAWMILL	MONROE
REX BOWEN SAWMILL	SAWMILL	WAUPACA
BRANDNER TIMBER CORP	WHOLE TREE	TAYLOR
BRAUN FOREST PROD	SAWMILL	CLARK
ROYCE BRECHLER	SAWMILL	PORTAGE
WAYNE BREHMER	SAWMILL	FOREST
BREIDUNG'S LOGGERS	SAWMILL	BUFFALO
NEIL BREMER	SAWMILL	BUFFALO
ROMNEY L BROWN	SAWMILL	RUSK
BRUNETTE BOX FACTORY	VENEER	BARRON
BRUNETTE BOX FACTORY	SHAVINGS	BARRON
BRUNETTE IND WOOD PRODUCTS	SAWMILL	BARRON
BRUNETTE IND WOOD PRODUCTS	VENEER	BARRON
BRUNKOW HARDWOOD CORP	SAWMILL	BUFFALO
JOHN BUCHMAN LUMBER CO	SAWMILL	WASHBURN
BUFFALO LUMBER & TIE CO INC	SAWMILL	BUFFALO
BURNETTE LBR CO	SAWMILL	BARRON
FRED BUSSE & SONS INC	SAWMILL	WINNEBAGO
C & W SAWMILL	SAWMILL	GRANT
CARR SAWMILL	SAWMILL	LINCOLN
CASWELL WOOD SPECIALTIES	SAWMILL	FOREST
CASWELL WOOD SPECIALTIES	TREATING	FOREST
CEDAR & FOREST PRODUCTS	SAWMILL	ONEIDA
CENTRAL WIS HWD INC	SAWMILL	JUNEAU
CENTRAL WIS LBR INC	SAWMILL	MARATHON
VIRGIL CHANDLER	SAWMILL	GRANT
CHIP & BLOCK SAWMILL	SAWMILL	CLARK
CHIPPEWA VALLEY LOGGING CO	SAWMILL	PEPIN
CHRISTENSEN MILLS INC	SAWMILL	BROWN
CHUNAT & MOHR	SAWMILL	CRAWFORD
DARRELL & STANLEY CLEMENS	SAWMILL	DANE
COATS LUMBER & SAWMILL	SAWMILL	COLUMBIA
COLOMA WOODLAND ENTERPRISES	SAWMILL	WAUSHARA
RAY CONNICK	SAWMILL	WINNEBAGO
CONN-WALD LBR INC	SAWMILL	FOREST
CONRAD LUMBER	SAWMILL	OUTAGAMIE
CONRATH BROTHERS	SAWMILL	WAUPACA
CONSOLIDATED PAPERS INC	PULPMILL	WOOD
COOK LUMBER COMPANY	SAWMILL	FOREST
COPP'S CABINS & SAWMILL	SAWMILL	VILAS
EUGENE COTTRELL	SAWMILL	FOREST
COUDERAY WOOD PRODS	SAWMILL	SAWYER
COUNTRY SIDE SAWMILL	SAWMILL	COLUMBIA
COUNTRYSIDE SALES & SERVICE	SAWMILL	WINNEBAGO
COUNTY LINE WOOD PRODUCTS	SAWMILL	VILAS
CRANBERRY CREEK SAWMILL	SAWMILL	DANE
MICHAEL CROFT	SAWMILL	MARINETTE
CUMMINGS LUMBER CO INC	SAWMILL	POLK
DAIRYLAND FOR PRODS	SAWMILL	CLARK
JOSEPH DARGA	SAWMILL	MARINETTE
DAVIS SAWMILL	SAWMILL	LINCOLN
GEORGE DEBAKER	SAWMILL	KEWAUNEE
DEEP VALLEY SAWMILL	SAWMILL	SHAWANO
DEERBROOK PALLETS	SAWMILL	LANGLADE
DEER CREEK LOG & LBR	SAWMILL	PRICE
JOSEPH DEKEYSER	SAWMILL	OCONTO
ALBERT DE LAET	SAWMILL	MARINETTE
DELMAR LUMBER COMPANY	SAWMILL	CHIPPEWA
DEPPELER WOOD SHOP	SAWMILL	GREEN
EDWARD E DEVENPORT	SAWMILL	CRAWFORD
DIDIER SAWMILLS	SAWMILL	WASHBURN
JIM DIDITZ	SAWMILL	ONEIDA
WIC DIMMIG	SAWMILL	VILAS
RICHARD DOBRINSKA	SAWMILL	LANGLADE
ERWIN DOEHLER	SAWMILL	KEWAUNEE
DRESSER LUMBER & TIE CO	SAWMILL	POLK
DRESSER LUMBER & TIE CO	SAWMILL	SAWYER
DRUMMOND WOOD PRODUCTS	SAWMILL	BAYFIELD

PRIMARY WOOD USING INDUSTRIES ALPHABETICAL INDEX

FIRM	TYPE	COUNTY
DUFECK MANUFACTURING CO	VENEER	BROWN
DUMKE FOREST PRODUCTS	SAWMILL	MARINETTE
LELAND DUXBURY	SAWMILL	JACKSON
DVORAK'S LUMBER CO	SAWMILL	MARATHON
EBERHART LOG & LBR	SAWMILL	JUNEAU
EBNER BOX INC	SAWMILL	BARRON
EBNER BOX INC	VENEER	BARRON
EDMUNDS FOREST PRODUCTS	SAWMILL	DODGE
ED'S UPPITTY CREEK SAWMILL	SAWMILL	WOOD
TOM EINEICHNER	SAWMILL	ASHLAND
ELI'S LUMBER CO	SAWMILL	PIERCE
JEFF EMERSON	SAWMILL	SAUK
EMPIRE SAWMILL	SAWMILL	FOND DU LAC
ENDEAVOR PALLET CO	SAWMILL	MARQUETTE
ENTERPRISE FOR PROD	SAWMILL	ONEIDA
ERNEST ERKKILA	SAWMILL	DOUGLAS
ESDAILE BOX & LUMBER CO	SAWMILL	PIERCE
F J SAWMILL	SAWMILL	POLK
F J VAN ERT & SON	SAWMILL	DOUGLAS
F & C HARDWOODS INC	SAWMILL	CLARK
WALTER FABER	SAWMILL	ST. CROIX
FELSER FOREST PRODUCTS	SAWMILL	SAWYER
FELTZ MFG CO INC	SAWMILL	PORTAGE
PETER FIEDOROWICZ	SAWMILL	MARINETTE
FISCHER BROTHERS	SAWMILL	JEFFERSON
D A FISHER	SAWMILL	ONEIDA
FJELSTAD SAWMILL INC	SAWMILL	VERNON
JOHN & TED FLAMANG	SAWMILL	DOUGLAS
CROSS POINTE PAPER CORP	PULPMILL	PRICE
EUGENE FLEES	SAWMILL	PORTAGE
FLY CREEK SAWMILL	SAWMILL	TREMPEALEAU
FOREST GREEN LBR PRODS	SAWMILL	RUSK
FOREST SAW MILL INC	SAWMILL	FOREST
FOX-HASSE MFG CORP	VENEER	DANE
CARL R FRAMKE	SAWMILL	MARATHON
DANIEL FRANE	SAWMILL	ONEIDA
FRAZIER & SONS LOG & LBR	SAWMILL	GRANT
FROST LUMBER CO	SAWMILL	PORTAGE
GARY B FULLER SAWMILL	SAWMILL	CRAWFORD
JON GEHRMAN	SAWMILL	SHAWANO
GEORGIA PACIFIC CORP	PULPMILL	WOOD
LIONITE HDBD DIV G-P	HDBOARD	PRICE
LENERD GERKE	SAWMILL	LA CROSSE
HERMAN & HUGO GILLES	SAWMILL	BAYFIELD
GILMAN FOREST PROD	PELLETS	TAYLOR
GILMAN SHAVINGS	SHAVINGS	TAYLOR
GLENVILLE MILLWORK	SAWMILL	SAUK
GLOBE BLDING MATERIALS INC	PULPMILL	CHIPPEWA
ROBERT GOLI	SAWMILL	WAUPACA
GOODMAN FOREST IND LTD	SAWMILL	MARINETTE
GOODMAN FOREST IND LTD	VENEER	MARINETTE
ARCADE SAWMILL	SAWMILL	WINNEBAGO
GRAETZ MANUFACTURING CO	SAWMILL	MARINETTE
RICHARD GRAUPNER	SAWMILL	MANITOWOC
GREAT NORTHERN TIMBER SER	SAWMILL	LINCOLN
G A GREENWOOD FOR PRODS INC	SAWMILL	SAUK
BERT GRELL LUMBER CO	SAWMILL	RICHLAND
JAMES GREZENSKI FOR PRODS	SAWMILL	PORTAGE
GRIMM'S SAWMILL	SAWMILL	WASHBURN
GROVE CHARCOAL CO	CHARCOAL	SHEBOYGAN
J J GRUNEWALD	SAWMILL	SHAWANO
MELVIN GULLICKSON	SAWMILL	EAU CLAIRE
RUSSELL GUNNLAUGSSON	SAWMILL	DOOR
STEVE GUSTAFSON	SAWMILL	BAYFIELD
WILLIAM GUSTAFSON	SAWMILL	BAYFIELD
E HAGENAH LUMBER CO	SAWMILL	VERNON
HAGEN HILL	SAWMILL	GREEN LAKE
HAHN BROS LUMBER CO	SAWMILL	PRICE
DALE HALONIE	SAWMILL	BURNETT
RALPH HAMEL FOREST PRODUCTS	SAWMILL	WOOD
RALPH HAMEL FOREST PRODUCTS	SAWMILL	CRAWFORD
DAVE HANKINS	SAWMILL	DOUGLAS
HANNEMAN SAWMILL	SAWMILL	MARINETTE
DANIEL S HANSEN MAT	SAWMILL	OCONTO
HANSON & LEJA	SAWMILL	JEFFERSON
LEO D HANSON	SAWMILL	MARINETTE
HANSON & SON LUMBER	SAWMILL	BARRON
ROBERT HANSON	SAWMILL	IOWA
HANSON SAWMILL	SAWMILL	LINCOLN
WALDEMAR HANSON	SAWMILL	ASHLAND
HARBOR LUMBER INC	SAWMILL	DOOR
HARDWOOD HILLS SAWMILL	SAWMILL	GREEN
HARNISCH LBR CO INC	SAWMILL	DUNN
HART TIE & LBR CO INC	SAWMILL	JACKSON
HART TIE & LBR CO INC	SAWMILL	SAUK
MILAN HARTWIG	SAWMILL	MARQUETTE
HARVATH SAWMILL	SAWMILL	MARINETTE
HATLEY VENEER INC	VENEER	MARATHON
HAYCREEK SAWMILL	SAWMILL	BURNETT
HAYWARD WOOD PRODUCTS	SAWMILL	SAWYER
HEARTWOOD MILLING	SAWMILL	PORTAGE
CLARENCE HEIKKILA	SAWMILL	BAYFIELD
HEIKKINEN SAWMILL	SAWMILL	PRICE
LEO HENDRICHS	SAWMILL	MARINETTE
HENDRICKS PORTA-SAW	SAWMILL	SAWYER
HESS LOGGING & LUMBER	SAWMILL	WASHBURN
HOCHSTETLER SAWMILL	SAWMILL	TREMPEALEAU
HOCKERS SAWMILL	SAWMILL	BROWN
ROBERT HOLMES	SAWMILL	ASHLAND
SIGURD HOLMQUIST	SAWMILL	MARINETTE
GENE HOLTE LOGGING	SAWMILL	DUNN
JOHN HORBINSKI	SAWMILL	MARINETTE
HWY 29 SAWING & PLANING	SAWMILL	KEWAUNEE
IKE INTERNATIONAL CORP	VENEER	CHIPPEWA
TERRY INNEREBNER	SAWMILL	SHAWANO
ISAACSON SAWMILL	SAWMILL	EAU CLAIRE
ISAKSSON LUMBER CO	SAWMILL	BAYFIELD
GORDON JAMISON SAWMILL	SAWMILL	LANGLADE
LEO JANKE	SAWMILL	WAUPACA
MARCEL JAZEWSKI	SAWMILL	TREMPEALEAU
JENSEN TIE & LUMBER INC	SAWMILL	TREMPEALEAU
JERABEK CHAIN SAW SHOP	SAWMILL	KEWAUNEE
JIM'S SAWMILL	SAWMILL	RUSK
JMB PALLET & SPOTTING SER	SAWMILL	PORTAGE
ARNOLD R JOHNSON	SAWMILL	TREMPEALEAU
JOHNSON CREEK LBR	SAWMILL	FLORENCE
JAMES O JOHNSON	SAWMILL	DANE
JOHNSON SAWMILL/EXCAVTNG	SAWMILL	VERNON
JOHNSON TIMBER CORP	CHIP PLANT	SAWYER
JOHN JOHNSTON	SAWMILL	WAUPACA
J & K TREE FARM	SAWMILL	WOOD
K & M TIE & LBR	SAWMILL	DANE
K & S SAWMILL	SAWMILL	OCONTO
ADOLPH KARSHBAUM	SAWMILL	BAYFIELD
CHARLES KAZDA JR	SAWMILL	VILAS
CARL KEENE	SAWMILL	MONROE
KEIM'S SAWMILL	SAWMILL	MONROE
KELLER FOREST PRODS	SAWMILL	WAUPACA

PRIMARY WOOD USING INDUSTRIES ALPHABETICAL INDEX

FIRM	TYPE	COUNTY	FIRM	TYPE	COUNTY
KARL H KEMP	SAWMILL	PRICE	ROY MALVITZ	SAWMILL	KEWAUNEE
KENNAN LUMBER CO	SAWMILL	PRICE	ANDY MANGELSEN	SAWMILL	POLK
KERSTEN LBR CO INC	SAWMILL	SHAWANO	MARANATHA SAWMILL	SAWMILL	WAUSHARA
KETTLE MORAINE HARDWOODS	SAWMILL	WASHINGTON	MARION PLYWOOD CORP	VENEER	WAUPACA
KETTNER'S SAWMILL & TIMBER	SAWMILL	ONEIDA	MARPLEX PRODUCTS	SAWMILL	ONEIDA
EDWARD KILLIAN	SAWMILL	TREMPEALEAU	JIM MARSKE	SAWMILL	POLK
GARY KLICKO	SAWMILL	COLUMBIA	MARTH WOOD SHAVINGS	PELLETS	MARATHON
KLISMITH LUMBER CO	SAWMILL	PORTAGE	MAST SAWMILL & LBR	SAWMILL	EAU CLAIRE
CLARENCE KLOES	SAWMILL	ONEIDA	WILLIAM MAST	SAWMILL	TREMPEALEAU
ALFRED KNITT	SAWMILL	WAUPACA	MATHEWS LBR CO	SAWMILL	GRANT
KNOBLE LOGGING	SAWMILL	CRAWFORD	DONALD MATHIE SAWMILL	SAWMILL	MARATHON
ORVILLE KNOENER	SAWMILL	SHEBOYGAN	BILL MATTSON	SAWMILL	IRON
MARVIN KNUTH	SAWMILL	SAWYER	JEROME MAYER CUSTOM LBR SAW	SAWMILL	WASHINGTON
KOLBE BROS LBR CO	SAWMILL	MARATHON	WILLIAM H MEIDER	SAWMILL	CHIPPEWA
DELMAR KOLBE	SAWMILL	MARATHON	TED MEIER & SONS FOR PROD	SAWMILL	MARATHON
HENRY KOLB	SAWMILL	LAFAYETTE	MEISTER LOG & LBR CO	SAWMILL	SAUK
LARRY KOLKOWSKI	SAWMILL	OCONTO	MELLEN SAWMILL & LBR SALES	SAWMILL	ASHLAND
LAUREL KOMAREK	SAWMILL	TAYLOR	RICHARD MENCHL	SAWMILL	MANITOWOC
KOPPERS CO INC	TREATING	DOUGLAS	MENOMINEE TRIBAL ENTERPRISE	SAWMILL	MENOMINEE
KORLESKI ENTERPRISES INC	SAWMILL	GREEN	MIDWEST MFG/DISTRIBUTING	TREATING	EAU CLAIRE
KOXLIEN BROS WOOD PRODUCTS	SAWMILL	TREMPEALEAU	I J MILLAN SAWMILL	SAWMILL	FOREST
HENRY KOZUB	SAWMILL	PRICE	NICOLAS MILLAN	SAWMILL	FOREST
ELMER KRAINING	SAWMILL	SHAWANO	EDWARD MILLER	SAWMILL	MANITOWOC
KRETZ LUMBER CO INC	SAWMILL	LANGLADE	MARVIN MILLER	SAWMILL	WAUSHARA
IRVIN KROENKE & SONS	SAWMILL	SHAWANO	MILLER SAWMILL	SAWMILL	DANE
KENNETH KROLOW	SAWMILL	SHAWANO	MIRR'S TREE SERVICE	SAWMILL	GREEN LAKE
JAMES KRUEGER	SAWMILL	ONEIDA	MISSISSIPPI VALLEY HWDS INC	SAWMILL	LA CROSSE
JOHN KRUEGER	SAWMILL	SHAWANO	MORTON MOHN	SAWMILL	LANGLADE
NORMAN KRUEGER	SAWMILL	SHAWANO	RON MONTOURE	SAWMILL	SHAWANO
WILLIAM L KRUEGER	SAWMILL	WAUPACA	VIRGIL MORROW	SAWMILL	GRANT
HERB KRUEGER LBR CO	SAWMILL	MANITOWOC	MOSINEE PAPER CORP	PULPMILL	MARATHON
JIM KUBALA	SAWMILL	DOUGLAS	PAUL MUELLER	SAWMILL	MANITOWOC
GERALD KUEHN & SONS	SAWMILL	CLARK	MUSCODA HARDWOODS	SAWMILL	GRANT
KUHRT LUMBER CO	SAWMILL	BARRON	DAVE E MYSZKA LBR MILL INC	SAWMILL	MARATHON
RON KUNZ	SAWMILL	EAU CLAIRE	NAGEL LUMBER CO INC	SAWMILL	VILAS
L T L SAWMILL	SAWMILL	EAU CLAIRE	NAGEL LUMBER CO	PELLETS	VILAS
L & N MANUFACTURING INC	SAWMILL	RUSK	WILBUR NARAGON	SAWMILL	MARINETTE
L & W SAWMILL	SAWMILL	WINNEBAGO	NEIBAUER LBR CO	SAWMILL	ASHLAND
LAC COURTE OREILLES DEV	SAWMILL	SAWYER	NELSON HARDWOOD LBR	SAWMILL	CRAWFORD
LAKE HOLCOMBE INDUSTRIES	SAWMILL	CHIPPEWA	NEVERMAN FOR PRODS	SAWMILL	MARINETTE
LAMB HARDWOOD LBR	SAWMILL	VERNON	NEW LISBON WOOD PROD	SAWMILL	JUNEAU
GLENN LANDWEHR	SAWMILL	MARATHON	NIAGARA OF WISC PAPER CORP	PULPMILL	MARINETTE
FRED LANGE III	SAWMILL	WAUSHARA	BEN A NIBLER	SAWMILL	LINCOLN
LARSON PALLET CO INC	SAWMILL	PRICE	NICOLET HARDWOODS CORP	SAWMILL	FOREST
RONALD LARSON	SAWMILL	MONROE	NOKOMIS LUMBER COMPANY	SAWMILL	LINCOLN
ART LEE	SAWMILL	DOUGLAS	NORTH CENTRAL PRODUCTS CO	SAWMILL	PIERCE
LEITZKE BROS SAWMILL	SAWMILL	LANGLADE	NORTH COUNTRY LBR CO INC	SAWMILL	ASHLAND
WILBUR L LESLIE	SAWMILL	MARINETTE	NORTH COUNTRY LBR/WEYAUWEGA	SAWMILL	WAUPACA
KERMIT LIERMANN SAWMILL	SAWMILL	MANITOWOC	NORTH COUNTRY VENEER	VENEER	ASHLAND
LITTLE BEAVER LUMBER CO	SAWMILL	MARINETTE	NORTHERN CROSSARM CO INC	TREATING	CHIPPEWA
LOUISIANA-PACIFIC CORP	PARTICLEBD	SAWYER	NORTHERN PRODUCTS INC	SAWMILL	FLORENCE
LOUISIANA-PACIFIC CORP	VENEER	ASHLAND	NORTHERN TIMBER CO	SAWMILL	FOREST
H A LUBAS FOREST PRODUCTS	SAWMILL	OCONTO	NORTHWEST HARDWOODS-CADOTT	SAWMILL	CHIPPEWA
JOHN LUEBKE SONS	SAWMILL	MANITOWOC	NORTHWOODS NATURAL CHARCOAL	CHARCOAL	SHAWANO
ARMAND LUEDTKE	SAWMILL	MARATHON	MARVIN NOTH & SONS	SAWMILL	WOOD
M & M RUSTIC FENCE INC	POST/POLE	MARINETTE	OAKWOOD PRODUCTS CO	SAWMILL	RACINE
SIDNEY MAAS JR	SAWMILL	SHAWANO	ALBIN OLSON	SAWMILL	DOUGLAS
MAAS WOOD PRODUCTS	SAWMILL	LANGLADE	OLSON LUMBER COMPANY	SAWMILL	DUNN
JEROME MACIEJESKI	SAWMILL	WAUSHARA	CARL J ONETSI	SAWMILL	SHAWANO
MADSON LUMBER CO	SAWMILL	PIERCE	ONGNA WOOD PRODUCTS	SAWMILL	SHEBOYGAN
MAGNUM TIMBER CORP	CHIP PLANT	JACKSON	OREGON KAR BODY	SAWMILL	GREEN
MAINA HWD INC dba TEX'S LBR	SAWMILL	SAWYER	EDWARD J ORT LUMBER	SAWMILL	OUTAGAMIE
MOORE MALTPRESS	SAWMILL	DANE	ORT LUMBER INC	SAWMILL	OUTAGAMIE
HILBERT MALUEG	SAWMILL	SHAWANO	THE OUTDOORSMAN	SAWMILL	ADAMS

PRIMARY WOOD USING INDUSTRIES ALPHABETICAL INDEX

FIRM	TYPE	COUNTY
P & S FOREST PROD	SHAVINGS	TREMPEALEAU
PACKAGING CORP OF AMERICA	PULPMILL	LINCOLN
FRANK PALECEK	SAWMILL	ASHLAND
PARADISE FOR PRODS	SAWMILL	KEWAUNEE
STEVE PARAFINIUK	SAWMILL	GREEN LAKE
PARKER LUMBER CO	SAWMILL	WOOD
PARK FALLS HARDWOODS	SAWMILL	PRICE
PATTERSON BROTHERS	SAWMILL	ONEIDA
ED PATZER	SAWMILL	OCONTO
PEARSON FOREST PRODUCTS	SAWMILL	SAUK
JOE PEJKA	SAWMILL	SAWYER
MARION PENNINGTON	SAWMILL	MARINETTE
PENTA WOOD PRODUCTS INC	TREATING	BURNETT
PENTA WOOD PRODUCTS INC	SAWMILL	BURNETT
PEPER FOREST PRODUCTS	SAWMILL	SAUK
PESHTIGO CEDAR POSTS INC	SAWMILL	MARINETTE
PESHTIGO CEDAR POSTS INC	POST/POLE	MARINETTE
PETERS FOREST & LUMBER	SAWMILL	OCONTO
PETERSON WOOD TREATING	TREATING	DOUGLAS
PETERSON LBR & WOOD PRODS	SAWMILL	BURNETT
PETERSON NORTHERN TIM PRODS	SAWMILL	BURNETT
WALTER PETERSON	SAWMILL	DUNN
PAUL E PFLUGHOEFT	SAWMILL	KEWAUNEE
PHELPS WOOD PRODUCTS	SAWMILL	VILAS
PINE CREEK PALLET CO	SAWMILL	TREMPEALEAU
PINE RIVER LBR CO LTD	SAWMILL	FLORENCE
DON PLESHEK	SAWMILL	SHAWANO
RICHARD J POSDAL	SAWMILL	MARINETTE
PRESTON WOOD PRODS INC	SHAVINGS	RUSK
PRIDE MFG CO	SAWMILL	FLORENCE
PUKALL LUMBER CO INC	SAWMILL	VILAS
QUALITY WOOD TREATING CO	TREATING	CRAWFORD
R J LUMBER MILL	SAWMILL	MONROE
R & R BAND SAWMILL	SAWMILL	SAUK
HOWARD RAIVALA	SAWMILL	DOUGLAS
CARL RASMUSSEN FOR PRODS	SAWMILL	SAWYER
FRED RECKELBERG SAWMILL	SAWMILL	KEWAUNEE
THEODORE REINHARDT	SAWMILL	BUFFALO
REISENWEBER WOODWRKG SHOP	SAWMILL	FOND DU LAC
REPAP WIS INC	PULPMILL	OUTAGAMIE
REUBEN REUL	SAWMILL	BARRON
RIDGELAND LBR CO INC	SAWMILL	DUNN
RITTENHOUSE FOREST PRODUCTS	SAWMILL	JUNEAU
RIVER VALLEY FOR PROD INC	SAWMILL	BUFFALO
LEROY ROBERTSON	c*p688IAWMILL	CHIPPEWA
T ROBERTS LATH & LUMBER CO	SAWMILL	FOREST
ROCKBRIDGE SAWMILL INC	SAWMILL	RICHLAND
ROCK VALLEY LUMBER MILL INC	SAWMILL	ROCK
RODMAN IND	PARTICLEBD	MARINETTE
KENNETH ROESLER	SAWMILL	LA CROSSE
ROGALLA'S SAWMILL	SAWMILL	MARATHON
ROSNER MFG FARM	SAWMILL	MARINETTE
ROUSE WOOD CHIPS INC	WHOLE TREE	SHAWANO
ROWELL'S SAWMILL	SAWMILL	OCONTO
HARLAND RUHLAND	SAWMILL	SAUK
RUSTIC ENTERPRISES	SAWMILL	TAYLOR
S & S WOOD PRODUCTS INC	SHAVINGS	TREMPEALEAU
SAMSEL TREE FARM & SAWMILL	SAWMILL	WAUSHARA
WALTER SANDSTROM	SAWMILL	ASHLAND
RICHARD SCALA	SAWMILL	SAWYER
SCHAUT & SONS INC	SAWMILL	OCONTO
SCHLOSSER LUMBER INC	SAWMILL	PEPIN
SYLVESTER SCHNEIDER	SAWMILL	FOND DU LAC
WINFRED SCHOONOVER	SAWMILL	RICHLAND

FIRM	TYPE	COUNTY
RAY SCHRADER	SAWMILL	PRICE
SCHROER HARDWOOD LBR CO	SAWMILL	VERNON
ALBERT SCHULZ	SAWMILL	SHEBOYGAN
SCHWABE ENTERPRISES	SAWMILL	GRANT
SCHWABENLANDER BROTHERS	SAWMILL	CALUMET
SCHWEFEL ENTERPRISES	SAWMILL	DODGE
FRANKLIN SEITZ	SAWMILL	PRICE
SEMRAU'S SAWMILL	SAWMILL	DODGE
SERUM LUMBER CO	SAWMILL	BUFFALO
LEONARD SEXE	SAWMILL	TREMPEALEAU
SEYMOUR WOODENWARE CO INC	SAWMILL	OUTAGAMIE
SEYMOUR WOODENWARE CO INC	VENEER	OUTAGAMIE
SHADRICK SAWMILL	SAWMILL	TAYLOR
GEORGE SHEDIVY	SAWMILL	SAWYER
ANTHONY SHERFINSKI	SAWMILL	MARATHON
JACK SICKLER	SAWMILL	MARATHON
SILVER CREEK LBR INC	SAWMILL	ASHLAND
SMITH'S PORTABLE SAWMILL	SAWMILL	ROCK
RICHARD SMITH LOGNG & SAWNG	SAWMILL	TAYLOR
MARTY SOSNOVSKE FARM	SAWMILL	LINCOLN
DONALD SPATZ	SAWMILL	MARATHON
HOWARD SPLINGAIRE	SAWMILL	DOOR
SQUEEKY SPRINGS LBR CO	SAWMILL	ONEIDA
STACKMAN'S SAWMILL	SAWMILL	SAUK
STALLMAN BROTHERS	SAWMILL	DUNN
STAN'S INDUSTRIAL WDWRK INC	SAWMILL	JUNEAU
RAYMOND STARR	SAWMILL	MARATHON
BEN STEFFES	SAWMILL	FOND DU LAC
STEIDINGER SAWMILL	SAWMILL	MARATHON
RODNEY STERZING	SAWMILL	MARINETTE
RON STEZENSKI	SAWMILL	SHAWANO
STONE HILL SAWMILLING	SAWMILL	MARQUETTE
STREBE'S SAWMILL	SAWMILL	TAYLOR
STUEHLER WOOD PRODUCTS	SAWMILL	JEFFERSON
SUPERIOR FIBRE PROD/SUB GP	HDBOARD	DOUGLAS
SUPERIOR MICHIGAN HWDS INC	SAWMILL	MARINETTE
WILLIAM SUTTIE	SAWMILL	TREMPEALEAU
SWENNES BROTHERS	SAWMILL	LA CROSSE
T & T LUMBER	SAWMILL	DUNN
TELEDYNE OWEN	SAWMILL	CLARK
THILMANY INTL PAPER	PULPMILL	OUTAGAMIE
FORD THOMPSON	SAWMILL	MANITOWOC
CARL D THORNE	SAWMILL	CLARK
EARL THUMS	SAWMILL	TAYLOR
TIFFANY TIE & LBR CO|OOXINC	SAWMILL	TREMPEALEAU
TIGERTON LUMBER CO	SAWMILL	SHAWANO
TIMM SAWMILL	SAWMILL	WAUSHARA
T K N W	SAWMILL	CLARK
TOMAHAWK CASH & CARRY	SAWMILL	LINCOLN
TOMAHAWK WOOD PRODUCTS	SAWMILL	LINCOLN
TOMORROW RIVER LBR CO	SAWMILL	PORTAGE
THOMPSON LUMBER	SAWMILL	DOUGLAS
TOP NOTCH TREE SERVICE INC	SAWMILL	ONEIDA
BLAINE T TORNOW	SAWMILL	MARATHON
BOB TORP SAWMILL	SAWMILL	MANITOWOC
TOWNSEND COMPANY	SAWMILL	ADAMS
TREE ACRES NURSERY	SAWMILL	PORTAGE
TRENTON HARDWOOD	SAWMILL	DODGE
MICHAEL UDELHOFEN SAWMILL	SAWMILL	GRANT
UNITED WOOD PROD	SAWMILL	RICHLAND
ED URBANEK	SAWMILL	KEWAUNEE
U S STICK CORP	VENEER	ONEIDA
RANDALL VALLEY	WHOLE TREE	BARRON
OSCAR VELDBOOM	SAWMILL	SHEBOYGAN

PRIMARY WOOD USING INDUSTRIES ALPHABETICAL INDEX

FIRM	TYPE	COUNTY	FIRM	TYPE	COUNTY
DAVID VOLOVSEK	SAWMILL	CLARK	WENTWORTH LUMBER CO	SAWMILL	DOUGLAS
VORTANZ LUMBER CO INC	SAWMILL	SAWYER	WEYERHAEUSER CO	PULPMILL	MARATHON
W & W HARDWOODS	SAWMILL	CHIPPEWA	WHALLEY MILLS	SAWMILL	WASHBURN
WADE FARMS INC	SAWMILL	WALWORTH	WHISKEY CREEK LBR CO	SAWMILL	MARINETTE
DARREL WAGES	SAWMILL	ASHLAND	WHITE CITY LBR CO	SAWMILL	VERNON
MIKE WALKOWSKI	SAWMILL	VILAS	JACK WHOLLE	SAWMILL	VERNON
STANLEY WALLESER	SAWMILL	VERNON	THOMAS WIEDEMEIER SAWMILL	SAWMILL	MARINETTE
WALNUT HOLLOW FARM	SAWMILL	IOWA	WILD ROSE SAWMILL INC	SAWMILL	WAUSHARA
WALTERS BROS LBR MFG INC	SAWMILL	CHIPPEWA	WILDWOOD WOODWORKS	SAWMILL	DANE
WALTERS BROS LBR MFG INC	SAWMILL	SAWYER	WISCONSIN VENEER & PLYWOOD	VENEER	SHAWANO
WARDEN TREE SERV & SAWMILL	SAWMILL	BROWN	LEONARD WOJCIECHOWSKI	SAWMILL	MARINETTE
BILL WATERMAN	SAWMILL	GRANT	WOLF SAWMILL INC	SAWMILL	CLARK
WAUSAU PAPER MILLS CO	PULPMILL	MARATHON	WOODBINE SAWMILL	SAWMILL	IOWA
WAYNE INDUSTRIES INC	SAWMILL	BUFFALO	WOODCHIP CORP OF AMERICA	CHIP PLANT	LINCOLN
WAYNE PALLETS INC	SAWMILL	DUNN	WOODCHIP CORP OF AMERICA	CHIP PLANT	WOOD
WEBER MANUFACTURING	VENEER	SHAWANO	WOOD CREEK LUMBER	SAWMILL	BUFFALO
WEBER'S LOGS TO LUMBER	SAWMILL	WOOD	WOODS RUN FOREST PRODUCTS	TREATING	DUNN
WEBSTER LUMBER CO BLAIR DIV	SAWMILL	TREMPEALEAU	FREDERICK YENTER & SONS	SAWMILL	MARATHON
WEBSTER LUMBER CO	SAWMILL	LA CROSSE	YODER SAWMILL	SAWMILL	SAUK
WEBSTER WOOD PRESERVING CO	TREATING	LA CROSSE	YOUNG SAWMILL	SAWMILL	LINCOLN
HARRY WEHLING	SAWMILL	DOOR	ZABEL'S SAWMILL & FOR PROD	SAWMILL	OUTAGAMIE
WEIDNER HARDWOOD LBR	SAWMILL	KEWAUNEE	WILBERT C ZAHRT	SAWMILL	MARATHON
WEIRGOR SPRINGS FOR PRODS	SAWMILL	SAWYER	DANIEL ZAPPA	SAWMILL	BARRON
WEISENBERGER TIE & LBR CO	SAWMILL	MARATHON	FRED ZASTROW	SAWMILL	MARATHON
JIM WEISS	SAWMILL	DUNN	ZDROIK LUMBER	SAWMILL	ONEIDA
EDWARD WENTLAND	SAWMILL	WAUSHARA	RAY ZOBEL & SONS INC	SAWMILL	SAUK

APPENDIX FIVE

DETENTION BASIN DESIGN

This guidance have been prepared by the Wisconsin Department of Natural Resources - Bureau of Water Resources.

Chapter Four: Detention Basins

Introduction

Detention basins are excavated areas or enhanced, natural depressions designed to contain stormwater runoff. These structures detain or impede flows by storing runoff and releasing this stored volume at a reduced rate of flow. This flow reduction reduces the risk of flooding downstream. For this reason these structures have historically been employed to reduce the peak discharges and provide greater protection to areas that are susceptible to flooding.

With the increased public interest in improving water quality, detention basins have gained importance for their ability to remove pollutants from storm water runoff. The objective of this chapter is to assist engineers and designers in planning and designing of water quality detention basins by presenting sizing and construction design criteria to meet water quality goals. While we recommend flood control and/or peak shaving components be incorporated into the basin structure, we feel that the existing guidance from the U.S. Natural Resources Conservation Service, (formerly Soil Conservation Service), the Army Corps of Engineers, and others have guidance to satisfy these design guidance needs, and therefore will not be covered in this document.

As a note of caution: The uncontrolled and unplanned construction of multiple detention basins within a watershed may change the natural flow conditions and has the potential to increase flooding in the downstream reaches. These structures also have the capability to cause flooding upstream due to backwater affects. Construction of stormwater facilities should be part of an overall watershed management plan. The

designer and/or contractor should coordinate construction of detention basins or any other stormwater facility with local municipal, county, and regional planning representatives to minimize the risk of potential flooding both upstream and downstream of the facility.

Recommended Design Objectives for Detention Basins

To obtain the water quality gains recommended by the Wisconsin Department of Natural Resources, urban water quality basins should meet the following criteria;

1. Stormwater best management practices must remove 80 percent total suspended solids from runoff generated from the developed tributary drainage area on an annual basis. This can be accomplished by providing a permanent wet or dead storage pond equal to the volume of the runoff from 1.5 inch rainfall and by providing sufficient pond surface area to remove the 5 micron particle for discharges associated with the 1.5 rain over 4 hours.

2. Stormwater best management practice shall limit the peak discharge from the post-developed site, to the peak discharge of the pre-developed site, for the 2-year 24 hour rainfall event. This requirement is intended to limit streambank erosion downstream of the facility. In cases where the facility's discharge will have no adverse impact on the downstream conveyance system, this requirement can be waived.

By complying with the above criteria, a significant amount of the pollutants contained in stormwater runoff will be removed.

In addition to improving water quality, properly designed wet detention basins may provide other benefits. If additional storage is provided, the peak stormwater discharge from a site may be reduced. Through proper siting and by using irregular shapes an improvement in the aesthetics of the area may be accomplished, giving a natural look to the detention facility. In some cases increased recreational opportunities may be created by integrating the detention basin into the surrounding land use. If located appropriately and maintained, wet detention facilities are an attractive amenity, and in many cases, will actually increase the surrounding land values (Schueler, 1987). **Accomplishing the benefits mentioned above usually requires that basin design be incorporated into the development plans as one of the primary elements of the project.**

Types of Detention Basins

There are several types of detention basins ranging from dry to wet detention. While dry detention will reduce the risk of flooding and streambank erosion by attenuating peak flows, this practice has a very limited ability to remove pollutants. For this reason dry detention is not recommended as a water quality improvement practice. Wet detention and extended wet detention, on the other hand, are capable of removing pollutants from stormwater, and attenuating peak flows. Generally, these structures are one of the more cost effective water quality improvement practices available. The detention structures described in this technical manual will concentrate on wet detention. The design of an extended wet detention basin will incorporate many of the same aspects of the wet detention. The basic differences between the extended wet detention and the wet detention is that extended wet detention requires a smaller discharge, longer detention time, larger storage area requirement, and vegetative species must be more tolerant of varying water levels.

Because no standard definitions of the various stormwater storage facilities have been established, the types of detention basins used in this manual are defined below :

A wet detention basin, is an impoundment containing a permanent pool of water. It also has additional storage capacity above the pool surface to provide temporary storage for runoff peak rate reduction. Water quality treatment is usually accomplished by both physical and biological processes in the permanent pool. Wet detention basins may be used as a single pollutant removal facility or as a pretreatment device for another stormwater device.

An extended detention basin, is a detention facility designed to temporally store storm water runoff for an extended period of time. Extended detention basins rely on detention time to allow for physical settling of pollutants. Extended detention systems typically have a shallow marsh in combination with a dry area, or have a permanent pool in combination with a dry area. Extended wet detention or a wet detention basin in combination with another practice will be some what more effective in removing silts, clays, phosphorous, and some of the other pollutants from storm water.

Detention Basin Benefits

Wet detention basins are generally effective stormwater quality management structures if designed and maintained correctly. These basins can be used on a site by site basis or as a regional stormwater facility. Use as a regional facility introduces economy of scale providing advantages over site by site installations. If assessed for the total drainage area, regional facilities have smaller land area requirements, are less costly to construct than multiple on site basins, and a single basin requires less maintenance than numerous on-site facilities. Multiple facilities also must be designed in a manner that does not increase the chance of flooding downstream, which often adds to the design complexity due to flow routing requirements.

Detention basins can also be used in conjunction with other water quality facilities to enhance pollutant removal capabilities. By reducing discharge flow and removing sediment in upstream basins, water quality practices downstream operate more efficiently. Artificial wetland stormwater management systems and infiltration basins are examples where the normal flashy flows and sediment generated from most urban areas would not allow these management measures to operate effectively on a long term basis. These practices require some type of pretreatment to limit flow rates and to reduce the stormwater sediment loads that would cause premature failure in these stormwater management strructures. Installing a detention basin before these practices can reduce flow rates and sediment loads to levels that prevent premature failure, and allow these practices to operate more effectively, often providing pollutant removal efficiencies at levels higher than both practices could achieve operating separately. The required rate of discharge from a detention basin used in conjunction with a downstream practice, such as an artificial wetland stormwater management system or infiltration device, will depend on the inflow requirements and the volume capacity of the downstream practice.

When comparing wet detention to other water quality practices, wet detention generally requires less land area to install than other practices that are able to achieve comparable levels of pollutant removal. Detention basins, because of their storage capability, are able to handle much larger volumes of flow than other practices such as grassed swales, infiltration practices, and wetlands. In addition, detention basins are less susceptible to failure and require less maintenance than wetlands and infiltration practices.

The major pollutants contained in stormwater include sediment, lead, arsenic, copper, mercury, atrazine, PAH's (polycyclic aromatic hydrocarbons), phosphorous, zinc, bacteria, and dissolved nutrients. (Nationwide Urban Runoff Program, NURP, study - 1983 EPA study) The estimated removal rates for 3 of the stormwater best management practices are given in Table 4.1 below. The data for the data was compiled from several sources: Pitt, 1991; Schueler, 1987; Stahre, 1990 and Maryland, 1991. Please note that removal rates for arsenic, mercury, atrazine, PAH's, and dissolved nutrients are not given in the table below because the data was not available or was inconclusive.

Table 4.1

Percent Reduction by Practice

Pollutant	Wet Basin	Artificial Wetland	Infiltration Basin
Suspended Solids	70 -95	75-98	75-99
Total Phosphorous	40-70	40-80	50-75
Nitrogen	60-90	40-95	45-70
COD	20-55	N/A	N/A
Lead	70-90	50-95	95-99
Iron	43-92	N/A	N/A
Zinc	40-80	65-80	N/A
Oxygen Demand	50-90	N/A	70-90
Copper	60-80	60-80	N/A

Negative Impacts of Detention Basins

While detention basins are effective for removing a number of pollutants, they do have a number of draw backs. Soluble substances such as certain pesticides, zinc, and petroleum products are not removed by detention ponds to any significant extent on a consistent basis. Detention basins also have an additional draw back in that they provide an opportunity for sunlight to increase water temperatures. This increase in water temperatures may have a detrimental affect on aquatic life of the receiving water body. The Wisconsin Department of Natural Resources has documented cases where ponding has increased water temperatures to levels significantly greater than that of the incoming flow. If thermal impacts to the receiving water body are a concern, then some other method of pollutant removal should be considered, or some method used in conjunction with detention should be used. An infiltration basin, placed downstream of a detention basin would reduce water temperatures and help to mitigate the increase in water temperature.

Safety can also be a concern unless precautions are taken to discourage swimming and entry to the pool area. (Incorporating safety features such as safety shelves into the design will decrease the risk of injury and drowning, but will not eliminate these risks.) Provisions must be made to dredge, test, and properly dispose of sediment on a regular basis. (Dredging should usually occur at least every five years and should not be delayed beyond ten years.) The responsibility for maintenance is often difficult to establish, and sustained accountability for this maintenance is often difficult as well. A maintenance schedule and procedure, along with a maintenance cost estimate should be a part of the detention basin design. A maintenance agreement should also be developed before constructing the basin structure to establish the parties responsible for maintenance and repair.

Working Principles of Detention Basin for Water Quality

Detention basins are designed to interrupt and detain the normal flow of stormwater runoff. Unlike flood control facilities, water quality detention ponds are designed to contain the more common or smaller storm. Ideally, in cases where downstream flood risk would be increased and where bank erosion would be intensified, the water quality facility would include outlet structures that also reduce peak discharges.

Sediment Removal

The primary pollutant removal mechanism used in detention basins, is particle settling with biological and chemical activity also occurring. Settling in detention basins generally takes place at two distinct time scales and hydraulic conditions. The first type is called dynamic settling and occurs during flow through the pond. Quiescent settling occurs during the period between rainfall events or interevent periods. The analysis of settling under quiescent conditions is often conducted using the assumptions of a "plug flow" system. In a plug flow system, the water which has been sitting in the pond from the previous rainfall event is displaced by inflow from the current event. Given enough time in a semi-quiescent water body, gravity pulls suspended solids out of water column and they settle on the bottom of the basin.

In cases of large inflow volumes, flow in the pond occurs predominately across the surface, with much slower velocities existing near the bottom of the facility. In this situation, distribution of flow over a large surface area to slow the inflow velocity is a critical factor in suspended solids removal. Particles settling below the outlet will be captured in the pond, those that do not settle below the outlet will be transported downstream. The relationship between the surface area and the particle removal is described in Wet Detention Ponds pages 35 to 38 by Robert Pitt, November 2, 1993, and excerpts are reproduced here. (See Fig. 4.1)

"Upflow velocity. ······· The path of any particle is the vector sum of the water velocity (V) passing through the pond and the particle settling velocity (v). Therefore, if the water velocity is slow, slowly falling particles can be retained. If the water velocity is fast, then only the heaviest (fastest falling) particles are likely to be retained. The critical ratio of water velocity to particle settling velocity must therefore be equal to the sedimentation length (L) to depth to the bottom of the outlet (D): ······· "

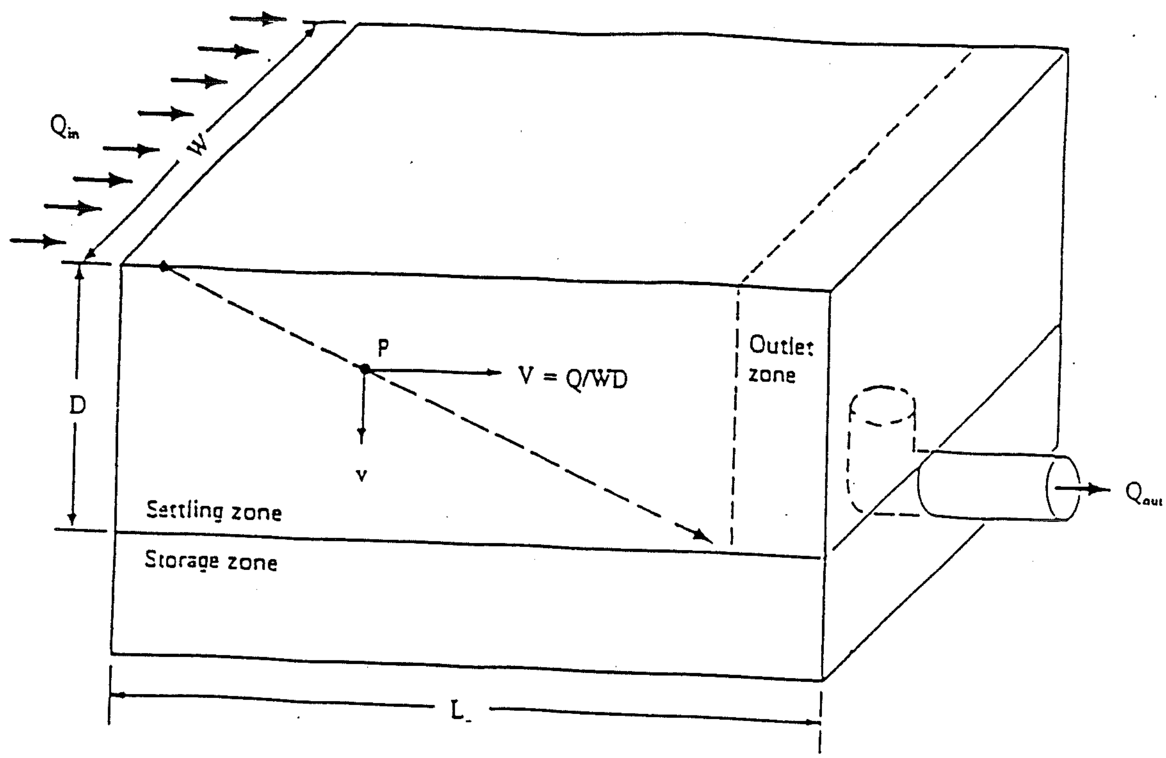


Figure 4.1: Critical velocity
Source: Adapted from Goldman, 1986.

"........ The water velocity is equal to the water volume rate (Q, such as measured by cubic feet per second) divided by the pond cross-sectional area (a, or depth times width: DW):

$$V = Q/a \text{ or } V = Q/DW.$$

The pond outflow rate equals the pond inflow rate under steady state conditions. The critical time period for steady state conditions is the time of travel from the inlet to the outlet. During critical portions of a storm, the inflow rate (Q_{in}) will be greater than the outflow rate (Q_{out}), due to freeboard storage. Therefore, the outflow rate controls the water velocity through the pond. By substituting this definition of water velocity into the critical ratio:

$$Q_{out}/WDv = L/D$$

The water depth to the outlet bottom (D) cancels out, leaving:

$$Q_{out}/Wv = L \text{ or } Q_{out}/v = LW$$

However, pond length (L) times pond width (W) equals pond surface area ($A_{surface}$). Substituting leaves:

$$Q_{out}/v = A_{surface}$$

and the definition of upflow velocity:

$$v = Q_{out}/A_{surface}$$

where: Q_{out} = pond outflow rate (cubic feet per second).
$A_{surface}$ = pond surface area (square feet: pond length times pond width), and
v = upflow velocity, or critical particle settling velocity (feet per second)

Therefore, for an ideal sedimentation pond, particles having settling velocities less than this upflow velocity will be removed. Only increasing the surface area, or decreasing the pond outflow rate, will increase pond settling efficiency. Increasing pond depth does lessen the possibility of bottom scour, decreases the amount of attached aquatic plants, and decreases the chance for winter kill of fish. Deeper ponds may also be needed to provide sacrificial storage for sediment between dredging operations...... "

"..... For continuous flow conditions (such as for water or wastewater treatment), the following relationships can be shown:

t = Volume/ Flow rate, and

Flow rate (Q_{out}) = Volume/t

where t = detention (residence) time.

With v = Q_{out}/A, and substituting:

v = Volume/[(t)(A)], but Volume = (A) (depth)

therefore, v = (A) (depth)/[(t)(A)], leaving

v = depth / t

It is seen that the overflow rate (Q/A) is equivalent to the ratio of depth to detention time. It is therefore not possible to predict pond performance by only specifying detention time. If pond depth was also specified (or kept within a typical and narrow range), then detention time could be used as a performance specification for a continuous or plug flow condition. However, it is not possible to hold all of the water in a detention pond for the specified detention time. Outlet devices typically release water at a high rate of flow when the pond stage is increased (resulting in minimal detention times during peak flow conditions) and lower flow rates at lower stages, after most of the detained water has already been released. The average detention time is therefore difficult to determine and is likely very short for most of the water during a moderate to large storm. It is much easier to design and predict pond performance using the upflow relationships for variable flow stormwater conditions.

The upflow ratio of outflow rate to pond surface area can be kept constant (or less than a critical value) for all pond stages. This results in a much more direct method in designing or evaluating pond performance. Pond performance curves can therefore be easily prepared relating upflow velocity (and therefore critical particle control) for all stages at a pond site. ...."

From the above description, we can see that surface area is the critical factor when designing detention basins for settling efficiency, and depth is primarily important only from the aspect of protecting bottom sediments from surface turbulence.

Pitt also explains the concept of an upflow velocity as a means of simplifying design theory. For the proposes of this manual, the upflow velocity of a 5 micron particle, or a settling velocity of 0.0013 feet/second will be used to accomplish an annual 80 percent removal rate. This particle size was used due to the findings of sampling data taken from runoff in Madison and Milwaukee streets. The findings of this research determined particles equal to and smaller than the 5 micron particle comprised approximately 80 percent of the particle size distribution coming from these Wisconsin streets. While the specific weight of soil particles do vary, therefore affecting the settling velocity, the specific gravity of particles typically found on urban surfaces have a specific gravity of approximately 2.75. This value is generally larger than the specific gravity for native soil particles and was determined by Bob Pitt in his investigations of urban runoff pollutants.

Limiting Peak Flows

As an area is urbanized, the amount of impervious surface area in the drainage area is significantly increased, storm sewers are installed to quickly convey rainfall runoff away from developed sites,and landscaping and surface grading removes natural surface depressions which provided small storage areas for runoff. These combined changes have a number of detrimental effects on receiving streams. These effects are described in greater detail in chapter one, but are listed below for the readers convenience.

- Increased runoff peak discharges
- Increased runoff volumes
- Increased flow velocity during storms
- Decreased time of concentration
- Increased frequency and severity of flooding
- Reduction in base flow between storms
- Increased streambank erosion
- Increased water turbidity due to bank erosion and drainage area erosion
- Stream widens and becomes shallower due to increased peak flows and velocities
- Sediment deposits fill in pools and coat the streambed
- Reductions in the diversity of aquatic species and reductions in abundance
- Increase in toxic chemicals are introduced to water body
- Increase in the frequency of downstream flooding

By restricting peak flows of the post-developed site to the peak flow quantities that existed before development began, damage to downstream areas can be greatly reduced. Detention basins are an excellent practice that can be used to diminish the destructive effects listed above. By designing detention basins to restrict flows and temporarily store the increased flows produced by urbanization, downstream flow conditions can more closely approximate the flow regime that existed before urbanization began in the watershed. This storage of greater runoff volumes produced by urban development reduces the downstream flow quantities and velocities.

Drawing from research that was done by Leopold, 1968; Wolman, 1967; and others, we find that the stream channel is greatly affected by the smaller rainfalls. Research done by these individuals indicates that the course of streams is for the most part determined by the smaller rainfall events. Generally, in Wisconsin, storm events between the 2-year and 1-year return period cause what is called the bankfull flow condition. This flow quantity controls and forms the natural stream channel. Therefore by restricting peak flows from the more common rainfall events, the damaging effects resulting for the increased runoff produced by urbanization can be greatly reduced. While a final determination of the appropriate return period within the range of 1-year to 2-year return period has not been established, research to date indicates that the 2-year 24 hour storm event will cover the wide range of stream flow characteristics and when used with the water quality design guidelines will adequately protect streams from the negative impact of urbanization.

As can be seen from the above description, peak flow limitations are concerned with streams or waterbodies that will be negatively affected by increased flows. Water bodies where the increase in flow produced by urbanization will be negligible to the receiving waterbody do not have to conform to these guidelines. An example of where a basin would have no affect on the receiving waterbody from a quantity perspective, would be a basin that discharges to a large lake. i.e Lake Winnebago, or Lake Michigan.

Detention Basin Design Guidelines

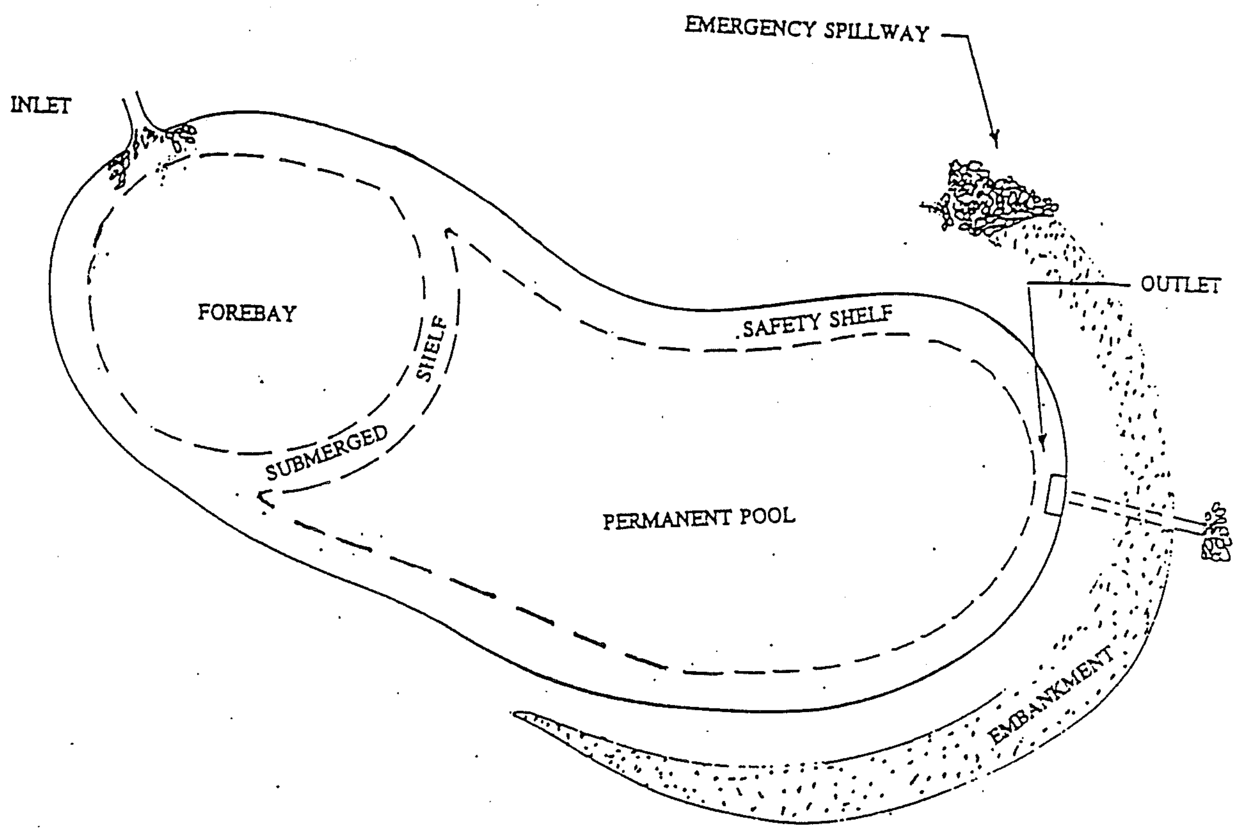
In order to achieve the water quality goals specified earlier in this chapter, a number of design criteria must be observed. The basin consist of a number of design elements which include; permanent pool volume, active storage volume, surface shape, pond depth, slope contours, outlet structure design, inlet structure design, slope stability considerations, safety factors, and others. Each of these items are important design characteristics and they must interact with each other to achieve specified pollutant removals, provide for human safety, and ideally be aesthetically attractive. Guidelines are given in this section to assist engineers and designers in constructing water quality detention basins to meet water quality goals of 80 percent suspended solids removal and maintain the pre-developed 2-year 24 hour peak flow rate. An example of a wet detention basin with its basic features is illustrated in Figure 4.2.

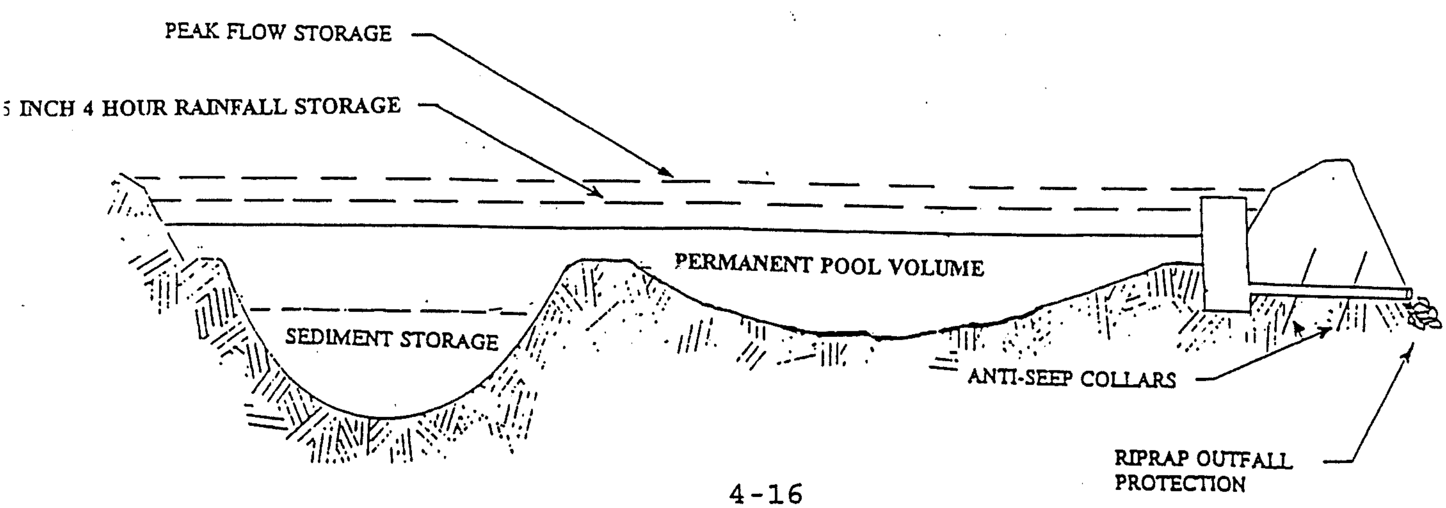
General Planning Guidelines

In planning detention basins there are a number of aspects which must be examined before actual design and construction can begin. Items such as the identification of unique or sensitive natural areas, expected future land use, availability of land to site the practice, the type of permits that will be required, comparison of detention basins to other pollution removal devices, and other considerations must be addressed before design can begin. There are a number of items that need to be considered when initially planning the design of a detention basin. Of particular importance is assessing the flooding potential downstream of the facility and effects that the proposed facility will have on downstream flooding. In order to thoroughly assess the needs that may be required in managing stormwater pollution, a watershed, or sub-watershed study should first be preformed. In many watersheds, and particularly in Priority Watersheds, these studies may have been completed and you should consult local officials, the regional planning agency, and the DNR to obtain these studies or for other watershed information.

Under most circumstances a complete watershed study is cost prohibitive due to the scale of such a project. Most projects tend to be specific to sites less than 400 acres, while many watershed studies cover several square miles. For individual sites, data collection will be more specific to the site and surrounding area and be less regional in nature. However, even

Figure 4.2 Wet Detention Basin





though this is a small site, the contractor still has the obligation to check with the governmental organizations mentioned above to determine how the proposed structure will affect the watershed and if it is consistent with existing watershed plans. In addition the contractor or designer is always responsible to make sure the risk of flooding is minimized by assessing flooding potential both upstream and downstream.

The design of a detention basin is often an iterative and complex process. A brief overview of the design procedure is given below to assist the reader in understanding the order and the overall process that will be covered in the rest of this chapter. Greater detail will be given to describe a number of points given below.

1. Check with local officials, regional planning agencies, and the district office of the Wisconsin Department of Natural Resources to determine zoning restrictions, watershed requirements, and/or surface water requirements that may apply to the development site or watershed.
2. Determine the viability of a detention basin by collecting and analyzing the watershed data and site characteristics mentioned in Chapter 2: Screening Criteria For Individual BMPs.
3. Estimate the wet pond surface area given the future land use of the drainage area using Table 4.2: Recommended Pond Surface Area as a percent of Tributary Area.
4. Calculate the storage volume associated with several elevations or stage levels by using the site survey. Then determine if the area can accommodate:
    a. a permanent pond volume equal to the runoff volume from the drainage area in the fully developed condition for the 1.5 inch rain.

b. an active storage volume, large enough to remove the 5 micron particle from the runoff volume for the drainage area in the fully developed condition for the 1.5 inch 4 hour rain. This is approximately equal to one-half the permanent pond volume.

c. an active storage volume large enough to limit the fully developed area runoff 2-year 24 hour peak flow.

5. Calculate the expected future runoff volume for the 1.5 inch storm and the 2-year 24 hour storm.
6. Create the hydrograph for the 1.5 inch, 4.0 hour rainfall and the 2-year 24 hour storm. These are the inflow hydrographs for the detention basin. (See Chapter 1: Stormwater Discharge Performance Guidelines and Hydrology). Also look at the flood control storms that this facility may control.
7. Determine if the selected sites will accommodate the estimated volumes surface areas; if no, repeat steps 2 through 5; if yes, go to step 8.
8. Design an outlet that will restrict pond discharges from the 1.5 inch 4.0 hour storm to 0.00013 cubic feet per square foot of pond surface area.
9. Route the 1.5 inch rainfall hydrograph through the basin as a check of the water quality active storage and outlet basin design. Are the discharge and storage requirements satisfied? If yes, continue to step 10; if no, redesign outlet or/and modify basin to satisfy storage requirements and repeat steps 7 through 9.
10. Determine the peak runoff, and the runoff volume from the 2-year, 24 hour storm with the drainage area in its pre-developed condition.
11. Develop the runoff hydrograph, and the runoff volume from the 2-year, 24 hour storm with the drainage area in its post-developed condition.
12. Is the peak flow from the hydrograph developed in step 11 less than the peak flow for the outlet designed in steps 7 through 9 above? If yes, design an outlet that limits the

post-developed peak flow to the pre-developed peak flow. For a first estimate of the storage volume needed to limit the post-developed to the pre-developed peak flow use the difference of the post-developed volume minus the pre-developed volume.

13. Route the 2-year 24 hour rain event hydrograph through the basin as a check of the 2-year peak flow storage and outlet design. Are the peak discharge and storage requirements satisfied? If yes, continue to step 14; if no, redesign outlet or/and modify basin to satisfy storage requirements and repeat any steps that may apply from step 7 through 13.
14. Route other peak or flow control storms and check design features.
15. Assess basin flow characteristics as it affects the watershed. This may involve checking with regional and local government staff, or with the Wisconsin Department of Natural Resources.
16. Design details of the basin including safety, maintenance, and operational features.

Basin Sizing Calculations

In developing the design requirements for a properly sized basin, Department of Natural Resources Staff conducted a study to determine the design storm volume to achieve an 80 percent pollutant removal of total suspended solids on an annual basis. The study determined that a pond with a permanent pond sized to contain the runoff from a 1.5 inch rainfall would perform at the required level of pollutant removal. For details of the study please see Appendix C. The design requirements described in this manual use the runoff from the 1.5 inch rainfall for the permanent pond specification and are intended for those developers that may not be acquainted with detention basin computer models. Because the design guidelines given here apply for a wide variety of conditions that may be encountered, the design is necessarily conservative and basins designed using a basin design computer model may be smaller. For situations where there are land area limitations, or land purchases would be costly, the designer may want to employ a computer model. At this time there are a number of computer models that may be used to design detention basins. Please check with local officials to determine which models are acceptable.

The following is a description of the basic elements of the basin structure and the procedure used to size the various components of the detention basin. This sizing procedure deals with methods of determining the size of the various basin storage volumes and the outlet structure design to meet water quality needs. While the function of the inlet structure is described here, information on sizing the inlet structure must be obtained from sources such as the U.S. Natural Resources Conservation Service, formerly Soil Conservation Service, the Army Corps of Engineers, or some other source. The reader is also advised to look to other sources for flood control design elements of the basin structure.

The basic design sequence begins with the inlet structure and the expected inflow from the drainage area. Sizing of the permanent wet pond is covered next. This is followed by the sizing procedure for the water quality active storage volume and the outlet structure. The water quality active storage volume is determined to a large degree by the outlet structure; for this reason the outlet structure and the water quality active storage volumes are determined using a method called flow routing. This process uses the runoff hydrograph for the drainage area as the inflow to the basin.

The design method described here is derived from five main sources as well as a study conducted by the Department of Natural Resources. The sources are: DETPOND: A Model for Evaluating Wet Detention Ponds for Water Quality Benefits by Robert Pitt, and John Voorhees, November 1993; The Sound Storm Water Manual for the Puget Sound Basin by the Washington State Department of Ecology, February 1992; Design Calculations For Wet

Detention Ponds by William W. Walker, Jr., October 1987; Controlling Urban Runoff: A Practice Manual for Planning and Designing Urban BMPs; and Chapter 4 of Applied Hydrology and Sedimentology for Disturbed Areas, Second Edition by Barfield, Warner, and Haan, 1983. The design storm study is described in Appendix C.

Inlet Structure

The detention basin inlet is a structure that takes concentrated flow, and distributes it so that the energy can be more easily dispersed in the permanent wet pond. When properly designed, the inlet transforms the incoming flow from a concentrated flow to a dispersed, surface flow that does not disturb the settled bottom sediments and does not erode areas near the inlet. To prevent erosion near the inlet, areas adjacent to the inlet may need to be protected by armoring the inlet area with vegetation or using some other means.

The inlet structure sizing will be determined by the peak rate of flow generated from the drainage area serviced by the detention basin. The procedure for determining the peak flow for small storms, with a return frequency of 2 years or less, is covered in the hydrology section of Chapter 1. For larger storms publications from the U.S. Natural Resources Conservation Service, formerly Soil Conservation Service, as well as other commonly available publications may be used.

The inlet should be constructed in a manner consistent with methods described for conveyance structures described in the U.S. Natural Resources Conservation Service, formerly Soil Conservation Service standards in USDA-NRCS Wisconsin, Section IV, Technical Guide, Section 468. The minimum design storm for the inlet structure should be a 10 year frequency storm unless the maximum expected flow warrants another storm size be used. Examples of where this exception would apply are, conveyance structures upstream that are sized to carry another design storm, or the installation of a flow splitter that reroutes flows greater than a designated storm size around the structure.

Permanent Pond Surface Area Calculation

In order to settle the 5 micron particle for a 1.5 inch rainfall, the permanent pond must provide an adequate surface area for the expected incoming flows. As a guide to designing the permanent pond surface area, observations noted by Pitt, 1993, may be used to approximate the required surface area. These observations indicate that the surface area recommendations provided in Table 4.2 should be followed when sizing the permanent pool.

In most cases the drainage area consists of mixed land uses, determining the pond surface is then determined by multiplying the land-use by the recommended percent in the table above and summing the components to compute the pool surface area.

As an example, a given 100 acre drainage area has the following land-use characteristics;

residential	52 acres
industrial	13 acres
commercial	25 acres
open space	10 acres

The estimated permanent pond surface area for 80 percent control would be;

(52 acres * 0.008) + (13 acres * 0.020) + (25 acres * 0.017) + (10 acres * 0.006) =

= 1.16 acres of surface area for the permanent pond

This surface area will accommodate most outlets so that the pond discharge requirement of 0.00013 cubic feet per square foot of pond surface area will be met.

Table 4.2

RECOMMENDED POND SURFACE AREA AS A PERCENT OF TRIBUTARY DRAINAGE AREA		
Land Use	Percent of the Drainage Area	
	For 60% Control	For 80% Control
Totally paved areas	1.1	3.0
Freeways	1.0	2.8
Industrial areas	0.8	2.0
Commercial areas	0.6	1.7
Institutional areas	0.6	1.7
Residential areas	0.3	0.8
Open space	0.2	0.6
Construction sites	0.5	1.5

Permanent Pond Volume Calculation

The permanent pond is designed to dissipate the incoming flow energy, allowing suspended solids to settle out due to the reduction in flow velocity. The permanent pond also provides a protective water column over sediments that previously settled out of suspension. In many cases the permanent pond is excavated below the existing surface to insure that the permanent pond water volume will not present a flood risk down stream in cases of impoundment failure.

The permanent pond volumetric calculation described is a simplified method to size the permanent pool for water quality improvement. This method results in a permanent pool volume that may be slightly conservative. A reduced permanent pool volume may likely be obtained by using a water quality detention basin model. The basin must be sized for an 80 percent total suspended solids removal using a NURP average particle size distribution.

The permanent pool consists of three volumes, a sacrificial sediment storage volume, a forebay volume, and a main pool area volume. The total permanent pool volume shall be equal to the total runoff volume generated from a 1.5 inch rainfall falling on the drainage area in its fully developed condition, plus a sacrificial sediment storage volume. The method of calculating the 1.5 inch rainfall runoff volume is described in Chapter 1 of this manual. This calculated total volume must then be confined in an impoundment that agrees with the guidelines described later in this chapter in Basin Design Criteria.

To capture the majority of sediment entering the pond, a sediment forebay area is located adjacent to the inlet. By trapping and holding the majority of sediment in the forebay area, sediment is more easily removed, and the main pond area is preserved, lengthening the useful lifetime of the main pool area. To contain sediments in the forebay requires that a submerged shelf be constructed separating the forebay from the main pool. The surface area of the forebay should be approximately 12 percent of the permanent pond surface area.

Confining these sediments requires that the forebay include a sacrificial storage volume for sediment in addition to a storm water volume. The sediment storage volume must have a minimum wet pond depth of 3 feet above the projected maximum sediment storage volume to prevent resuspention of settled sediments. Past experience indicates that urban detention basins have an annual sediment deposition that is approximately equal to 1 percent of permanent pool volume (Schueler, 1987). This volume multiplied by the desired maintenance design life equals the sacrificial sediment storage volume in the forebay area. The sediment removal frequency should normally be greater than 5 years and should not exceed 10 years. With a pond design life of 10 years would require a sediment storage volume 10 percent of the permanent pool volume. It should be noted that in order to lengthen the life of the main permanent pond area, the pond should initially be constructed 4 feet deep to allow for 1 foot of sacrificial storage.

Summarizing, the permanent pond volume is contained in the permanent pond surface area that was previously calculated, contains the runoff volume from 1.5 inches of rain falling on the drainage area in the developed condition, has a sediment forebay with a surface area equal to 12 percent of the permanent pond surface area, has a sediment forebay capable of storing sediment between cleanout periods equaling 1.0 percent of the 1.5 inch rainfall volume multiplied by the time between cleanouts.

At this point the designer should make the first of many checks to be sure that the site selected will accommodate the pond volumes and flows.

Active Storage Volume

While there may be several layers of active storage in detention basins, we are concerned with the water quality storage volume only. This involves 2 storage volumes, one to limit the flow rate to a discharge of 0.00013 cubic feet per square foot of pond surface area for a 1.5 inch hour rainfall, and the storage volume needed to limit the 2-year 24 hour storm developed peak flow to a pre-developed 2-year 24 hour peak flow. There may be additional volume capacity to limit peak flows from a storm greater than the 2- year 24 hour storm, but as was stated earlier, the designer is advised to refer to other documents for this guidance. As a note of caution, the designer should assess the basin over the entire range of storms for which the structure is designed. The water quality components of the structure will increase the required storage capacity of the structure for flood or peak flow control for larger storms.

The 1.5 inch 4 hour active storage volume is the first storage volume above the permanent pond of the detention basin. In conjunction with the permanent storage pond, this storage volume is responsible for removing suspended solids. As was mentioned earlier the appropriate level of total suspended solids removal is 80 percent. The peak shaving volume for the 2-year 24 hour storm is above this pond stage, and is used to limit streambank erosion downstream of the basin. Both of these volumes are determined by calculating the relationship between the site topography or pond storage volume, and the outlet structure.

The method that is used to calculate the basin storage volume for the 1.5 inch rainfall and the basin storage volume for the 2-year 24 hour peak shaving, is reservoir routing. The two methods are slightly different and the steps for both are listed below

Calculation For The 1.5 Inch 4 Hour Rainfall Active Storage Volume

1. Develop the hydrograph for the 1.5 inch 4 hour storm with the drainage area in its fully developed condition. See the hydrology section of Chapter 1: Stormwater Discharge Performance Guidelines and Hydrology.
2. Using basin site surveys, calculate the storage volumes and surface areas associated with several stage elevations to a height above the expected maximum storage volume.

This information will be needed for the 2 year 24 hour storm and may be needed for larger size storm. To establish accurate storage volumes, break points where the land surface changes slope should be identified and used as a storage stage height. Also record the surface areas at the lower stages. This information is then used to produce a stage-storage table. See Chapter 1 for more detail.

3. Using the permanent pond area, and the storage volumes from step 2 above, choose an outlet structure that will approximate the allowable discharge rate of 0.00013 cubic feet of discharge per second per square foot of pond surface area. Recognize that the surface area of the pond increases as the pond elevation rises. Usually a good first estimate of the needed volume of storage for the 1.5 inch rainfall is 1/2 the volume of the permanent pond volume. Using the designed outlet and the pond storage volumes developed in step 2, develop a pond stage-discharge table or curve. See Chapter 1.
4. Develop the runoff hydrograph for the 1.5 inch 4 hour rainfall. See Chapter 1 of this manual. This hydrograph represents the inflow into the basin for the 1.5 inch 4 hour storm.
5. Route the runoff hydrograph through the pond to check discharge limits and storage. This is done by using the continuity equation. See Chapter 1 of this manual.

Active Storage for Water Quality

A stepped sequence for calculating the water quality volume is described below;

1. Inflow hydrograph - fully developed condition.

   The characteristics of the drainage area in its fully developed condition should be determined and an inflow hydrograph created. The 1.5 inch, 4 hour rainfall hydrograph is described in Chapter 1, pages 1-B-6 through 1-B-17.
2. Stage-storage table. See the example in Chapter 1, page 1-B-36.

3. Choose an outlet structure design.

   In choosing the appropriate initial outlet structure the following requirements and accompanying suggestions can be used as an aid.

   a. The active storage volume must accommodate the runoff from a 1.5 inch rain falling on the drainage area in 4 hours. Generally, it is good to choose an initial active water quality storage volume of approximately one half (1/2) of the permanent pond volume for a first trial.

   b. The ratio of outlet discharge versus pond surface area, Q_{out}/A_s, must not be greater than 0.00013 cubic feet second outflow per square foot of pond surface area for all pond stages in the water quality storage volume layer.

      This ratio is usually at its maximum rate when the pond surface is at the top of the water quality storage volume layer. Checking this ratio for stages below the highest level in water quality volume is generally not necessary. The exception to the above generalization is when the topography of the basin site varies, with steeper side slopes near the permanent pond surface than the slope near the top of the water quality level. If this condition exists, the outlet discharge - pond surface ratio should be evaluated for a number of stage heights.

After accomplishing these two steps, flow routing is utilized. See the discussion in Chapter 1 on flow routing beginning on page 1-B-39 for an explanation of the following steps 4 and 5.

4. Create a pond outflow hydrograph.
5. Create a stage-storage curve.

A pond outflow hydrograph and a pond stage-storage curve are used to determine if water quality goals for the pond will be met, or if a larger storage volume will be required or if an alteration in the outlet structure should be pursued. Please note that this is an iterative process for determining if the outlet and active storage volume will meet the outflow surface area ratio requirement. For example, if a chosen outlet and the consequent pond have an outlet release rate:surface area ratio that is greater than the required 0.00013 cubic feet per second outflow per square foot of pond surface area,

$$Q_{out}/A_s \geq (0.00013 \text{ ft.}^3/\text{sec.})/\text{ft.}^2,$$

then the outlet opening must be reduced or the pond active storage area must be excavated to accommodate greater storage. The resulting design must then be assessed again to determine if the outlet release:surface area ratio requirement is met.

Active Storage for Streambank Protection

In reducing the peak flow for streambank protection, the two year twenty-four hour storm must be maintained at flows similar to the pre-developed flows. Development typically changes stream flows making them more flashy with high peaks and low base flows. This situation creates greater stream bank erosion due to the greater forces produced by flow surges.

To design a structure that will limit peak flows to the pre-developed condition, the stepped procedure described in the active storage for water quality section is repeated except the first two steps are replaced by the following three steps;

1. Calculate the pre-development inflow peak for the 2 year, 24 hour storm using the tabular method in TR-55 (NRCS,1986).

2. Calculate the post-development inflow hydrograph for the 2 year, 24 hour storm using the tabular method in TR-55 (NRCS,1986).

3. Choose an outlet that will limit the peak flow from the detention pond with the drainage area in its developed condition, to the peak flow calculated in the pre-development hydrograph. Ideally the flow from the detention basin should replicate the pre-developed inflow hydrograph as closely as possible, including the base stream flow.

The stepped sequence from this point is identical to the description in Chapter 1 beginning on page 1-B-58.

Basin Design Criteria

The following are general basin design considerations that the designer should examine in order to assure that the basin will provide pollutant removal at the levels mentioned earlier, and that safety and aesthetic issues are addressed.

This section will begin with a description of the basic basin design criteria that should be included in any water quality basin. These are general guidelines for the sound water quality construction practices of the structure. This would include items such as the required depth, the basin width to length ratio, recommended soil slopes, etc. A description of the procedure used to size the various components of the detention basin will then be covered.

Site Investigation

1. Initial field inspection should include identification and location of any springs in the

immediate vicinity of the proposed basin site. The flow from these springs should be considered and rerouted if necessary to prevent destruction of the detention structure. Drainage area peak flow rates should also be considered in determining the flow of water into the detention basin.

2. Soil samples should be taken from the potential detention sites. The following information should be determined from the soil samples:
   - A. In situ soil permeability, to determine if the soil is capable of inhibiting seepage. This information will help determine if a liner will be required to prevent large fluctuations in the surface water.
   - B. If the soil is of a clay or fine silt type, the soil sample will indicate the degree of compaction necessary to inhibit seepage.
   - C. The soil's ability to support loads and maintain its shape.
   - D. If groundwater is within 4 feet of the bottom of the detention basin, a liner should be used to prevent the potential of groundwater pollution. In cases where groundwater is within 4 feet of the liner surface, venting that allows gases on the bottom side of the liner to escape is recommended. This helps to prevent the accumulation of gases which often float the liner out of position forming a "hippo" or large bubble in the pond. Correcting this situation involves a costly operation of draining the pool and retrofitting the pond with necessary venting that could have easily been installed initially. Venting should also be provided in instances where ground water fluctuations may trap air underneath the basin liner.
   - E. If the basin bottom is within 4 feet of a fractured limestone bed, or in other cases where groundwater quality may be jeopardized, a liner must be used.

3. All utility lines shall be located outside the basin site.

4. All sanitary pipes shall be located outside the basin site and shall be located to minimize the chance of pond contamination due to pipe failure.

5. Manholes in the area where the wet surface will overtop the manhole for the 2 year 24 hour event shall be relocated outside the wet surface area.

6. A minimum clearance distance of 5 feet horizontal and 1 foot vertical is required between a storm drain system and other utilities. Check local ordinances to insure that you are in compliance.

Basin Configuration

1. The location of a detention basin should blend in with the surrounding landscape and community as much as possible. While the placement of the facility may be limited due to hydraulic constraints, the design should use areas that are more aesthetically pleasing and will better serve community and recreational needs. If designed properly, basins can utilize the natural terrain to serve as an attractive amenity as well as a drainage facility.

2. The surface shape of the pond shall have a length to width ratio of 3 to 1 or greater. Shapes should conform to the natural contour of the site to the greatest extent practical so that it fits in with the surrounding terrain. Oblong, irregular shapes that avoid dead or stagnant zones are encouraged, because stagnant zones often become overgrown with vegetation and can increase mosquito propagation.

3. The inlet and outlet structure shall be at the opposite ends of the pond to discourage short-circuiting of incoming water. This arrangement encourages a detention time which allows for greater treatment of polluted water. If this arrangement is not possible, baffles or gabions shall be installed to lengthen the flow path.

4. If an earthen embankment is used to detain surface water, all specifications of the United States Department of Agriculture - Soil Conservation Service Field Office Technical Guide section 378 shall be adhered to.

5. Safety precautions to prevent flood damage in cases of embankment or dam failure of the basin structure shall be taken. For more information on this subject see Sections 402 and 403 of the United States Department of Agriculture - Natural Resource Conservation Service, formerly Soil Conservation Service, Field Office Technical Guide.

6. Slope protection will be needed along banks in the zone where the pool water surface elevations fluctuate. Vegetation, or some other type of slope protection may be needed in this zone to prevent soil erosion.

7. The slope contours of a wet detention pond shall observe the following guidelines. (See Figure 4.2) Slopes around detention basins outside of the live storage pool to the wet pond edge may vary from 4 feet horizontally to 1 foot vertically, (4:1), to 10 feet horizontally to 1 foot vertically, (10:1). Slopes steeper than 4:1 can cause safety problems due to slippery footing and hazardous operating conditions during maintenance. Slopes flatter than 10:1 may present drainage problems and provide mosquito habitat.

In the wet pond, the slope near the water's edge should be somewhat steep, 4:1, to reduce mosquito problems and to provide relatively fast pond drawdown after most common storms, (2 year, 24 hour storms). This slope should not exceed 18 vertical inches to reduce the risk of infant drowning. An area around the perimeter of the facility shall have a safety shelf 10 feet wide. This shelved section should be relatively flat, 10 to 1 or flatter, to allow persons who may fall in a chance regain their footing and pull themselves out. The sloped zone toward the center of the pond, beyond the shelf region should be sloped as steeply as soil stability will allow to provide for the maximum volume of wet detention storage.

8. Wet ponds shall have a minimum three foot pool depth in the center section of the pool. This three foot requirement is in addition to any sediment storage that may be required.

9. The surface area requirements shall be observed. For the purposes of this manual, the required detention basin surface area must be sufficient to settle the 5 micron particle from the runoff from a 1.5 inch rainfall with a duration of four hours. General permanent pool surface area design guidelines are given in Table 4.2. The permanent pool surface area must be at least one quarter acre.

10 A forebay area should be located near the inlet. The forebay is designed to capture the coarse sediments and should dissipate flow energy. Forebays should be separated from the main pond by a shelf or bench to help concentrate the captured sediment volume. By concentrating the majority of the sediment deposits, forebays decrease the area that must be cleaned out and reduce maintenance costs.

11 If a variety of vegetation is desirable, varying the water depth can be an effective means of achieving this goal. Shallow depths are generally characteristic of safety shelves that surround the edges of detention ponds. In the areas with depths less than 6 inches, emergent plants may be supported. Submerged plants require water depths between 1 and 2 feet. Open water is obtained with a design depth of four feet or greater. To discourage plant growth, depths should be greater than 4 feet.

Planned vegetation is often an over looked factor in detention basins. Vegetation can be a critical factor in determining the water quality efficiency of the basin. As an example, waterfowl manure can create significant BOD demands on the facility. Where waterfowl may be a problem, vegetation that completely surrounds the pond should be incorporated into the design. This vegetation discourages waterfowl habitation. Vegetation can also have a positive affect on safety, restricting access to unsafe deep water. Vegetation may also be used to enhance the appearance of the detention basin.

For more information on the types of vegetation that may be propagated in wet detention basins, contact the University of Wisconsin - Extension, or examine one of the many articles written on the subject of wildlife plant care. Two examples are <u>Landscape Plants for Wisconsin</u>, (1982) by E.R. Hasselkus, or <u>Landscaping For Wildlife</u> by the Nongame Wildlife Program - Section of Wildlife, Minnesota Department of Natural Resources.

12 To insure that a detention basin is properly sized, existing and planned future land uses must be known. The detention basin designed to take care today's storm water needs may be undersized after ten or twenty years of development in the drainage area. Likewise, a basin with an insufficient inflow of water may have low water levels with foul-smelling

stagnant water. This may happen if a basin is designed only to handle an area's future land use without regard to its existing condition.

13 A utility easement shall be provided to allow maintenance access for sediment removal from the basin forebay area.

14 A dewatering outlet with a shutoff valve shall be installed in the basin to allow the permanent pond and sediment forebay to be drained for maintenance of the structure.

Conveyance Structures

1. Inlets and outlets shall:
   A. Restrict entry by unauthorized persons.
   B. Allow for authorized access for maintenance and general repair.
   C. Use materials and designs that inhibit vandalism.
   D. Provide erosion protection.
   E. Provide a sufficient foundation to reduce settling and frost heave.

2. The minimum pipe size inside dimension shall be 12 inches if it is to be a component of a public storm drainage system. Exceptions to this rule will be made for water quality feeders, inverted elbow pipes and stormwater management low flow openings.

3. All pipes shall be provided with a minimum cover of 1-foot over the pipe.

4. To enhance self-cleaning characteristics, pipe shall not be laid on less than a 1% slope. However, if it is documented that 1 percent is not obtainable, then actual slope may be as low as 0.5 percent. When pipe is laid on an area with a slope greater than 20%, pipe

anchorage should be provided and particular attention should be given to pipe joint areas. (Check local ordinances to determine if the design is in compliance)

5. Anti-seep collars shall be provided for pipe inlets and outlets where pipes pass through berms and may result in berm failure, and shall be installed in accordance with section 378 of the Natural Resources Conservation Service, formerly Soil Conservation Service Technical Guide. "Antiseep collars shall have a watertight connection to the pipe. Maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe. Collar material shall be compatible with pipe materials. The antiseep collar(s) shall increase by 15 percent the seepage path along the pipe."

6. The primary outlet structure of the pond will determine the amount of stormwater storage, and the wet pond storage. The primary outlet should be designed to handle at least the1.5 inch rainfall over a 4 hour duration, and the 2 year 24 hour event with the site in its post-developed condition. The 1.5 inch rain is chosen for water quality improvement. The 2 year 24 hour is chosen to reduce the streambank erosion due to the increase in flow with development.

   To prevent structural damage to the basin facility, an emergency outlet capable of passing the flow equal to the flow capacity of the downstream conveyance system shall be installed. For most communities, the stormsewer system is designed for the ten-year 24 hour event, and most municipalities have provisions to pass the 25 year storm event. Check with local municipal officials to determine the proper design storm for the emergency outlet.

To prevent clogging, trash racks should be installed to filter out material that may be caught in the conveyance system downstream of the outlet. "For pipe outlets smaller than 6 inches in diameter it is suggested that the net trash rack opening be no less than 20 times the opening in of the orifice."

The spacing in the opening of the trash rack should be smaller than the outlet diameter. A general rule of thumb is to provide a trash rack that has a net opening no less than four times the opening of the outlet.

7. Pipe outlets, (both the principle outlet and the dewatering outlet), shall be sufficiently anchored to prevent flotation. For outlets ten feet or less in height, a square concrete base 18 inches thick and twice the width of the pipe width may be used to anchor the outlet. The pipe shall be placed at the center, and embedded 6 inches into the concrete. Other approved methods may be used.

8. An emergency spillway should be provided on all wet detention basins. To reduce the risk of erosion and structural failure, spillways should be placed on undisturbed ground. For placement of spillways on berms, the United States Department of Agriculture - Soil Conservation Service Field Office Technical Guide publication no. 378 should be reviewed.

9. Outlet structures shall provide a skimmer type shield around perforated risers. A devise or configuration that reduces the risk of outlet blockage shall be provided on all outlet structures. (A reverse slope pipe is a configuration that is often used effectively).

10 Easements shall be provided for all structures in need of regular maintenance. This is especially important for manhole facilities.

Maintenance

Inspection should be performed annually and after major storms. The following tasks should be performed at that time.

* Inspection of embankments and repair of any eroded sections.
* Inspection of inlet and outlet structures. Look for erosion, sediment deposits, debris in trash racks, and signs of structural damage. Take corrective action to restore structures to good working order.

In addition to the above tasks, sediment forebays should be dredged within the designed sediment storage cycle, this is usually about every five years but shall not be greater than ten years.

Frequent maintenance should be performed to maintain a pleasing appearance of the facility and to insure proper operation. Grass cutting, hedge and tree trimming, as well as the removal of floating litter and algae should be a scheduled activity throughout the rainy season.

Summary

Storm water runoff typically picks up sediment and other pollutants as it flows across urban surfaces. Detention basins detain stormwater runoff allowing suspended sediment in stormwater to settle out, and to a lesser degree remove pollutants by biological action. This removal of suspended sediments reduces damage to downstream water bodies by causing sedimentation in the pond rather than more environmentally sensitive areas like streams, lakes, and wetlands. Since these sediment particles often attract metals and other pollutants, this sediment removal also reduces pollutant discharge to water bodies as well. Added to the above benefits is the fact that reduced rates of flow also reduce stream bank erosion. This makes detention basins an effective stormwater management measure and one that should be considered when preparing a water quality plan. These facilities, when used as regional stormwater treatment facilities, can be one of the most economical water quality practices available.

Due to basin design complexity, it is suggested that the designer use a computer model when designing wet detention basins. There are presently a number of computer models that can size and design appropriate detention ponds. However, the designer should check with the reviewing agency to determine which models are acceptable for this type of design.

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