Forestry Best Management Practices
to
Protect Delaware's Water Quality

Department of Agriculture
Delaware Forest Service

Acknowledgments

Beginning in July of 1989 with the formation of the Delaware Forestry Association's (DFA) Forestry Roundtable, a Forestry Best Management Practices manual for Delaware was initiated. The DFA Forestry Roundtable drafted the first version of the manual and printed the draft version in July of 1990. Since then, the manual has been periodically revised and updated.

The contributions of those who participated on the DFA Roundtable and those who have participated throughout its review must be commended and recognized for their valuable work. The Delaware Forest Service sincerely thanks all those involved for their efforts.

Due to space limitations, individual contributors cannot be listed; however, a list of state and federal agencies, organizations, and groups who contributed to this manual through direct input, participation in review groups, and other assistance is provided below:

Delaware Forestry Association
Delaware Tree Farmers
Delaware-Maryland Chapter, Society of American Foresters
Delaware Farm Bureau
Delaware Nature Society
Audubon Society, Delaware Chapter
Sierra Club, Delaware Chapter

Delaware Association of Conservation Districts
New Castle County Conservation District
Sussex County Conservation District

Delaware Department of Natural Resources and Environmental Control
- Division of Water Resources
  - Wetlands and Subaqueous Lands Section
- Division of Soil and Water Conservation
  - Non-Point Source Pollution Program
  - Coastal Zone Management Program
  - Drainage Program
  - Sediment and Stormwater Management Program
- Division of Fish and Wildlife

U.S.D.A. Forest Service, Northeastern Area State and Private Forestry

U.S. Environmental Protection Agency, Non-Point Source Pollution Program

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INTRODUCTION

The Water Quality Act of 1987 (Clean Water Act, PL-100-1, Sec.319) considers a Best Management Practice (BMP) any method, measure, or practice used to protect and preserve water quality including, but not limited to, control of water-caused erosion.

In July of 1994, Governor Thomas Carper signed Delaware's Forestry Erosion and Sedimentation (E&S) Law (Delaware Code Title 3, Chapter 10, Subchapter VI). In this law, the Forestry Administrator of the Department of Agriculture, Forest Service (Delaware Forest Service) is charged to *"provide for the protection of the waters of the state from pollution by sediment deposits resulting from silvicultural activities."* Furthermore, *"the State of Delaware recognizes that water quality protection techniques for silvicultural practices are an integral component of properly managed forests."* One key component in meeting the responsibilities set forth in Delaware's Forestry E&S law is the adoption of water quality protection techniques appropriate to Delaware's forests. Through the cooperative efforts of numerous agencies, groups, and organizations, the adoption of Delaware's Forestry BMP manual meets this goal.

In concert with this goal, the Forestry BMP manual establishes practice specifications designed to meet the goals of Delaware's Water Quality Standards and the Clean Water Act:

1. To minimize surface runoff originating from any type of forestry-related soil disturbance
2. To maintain the integrity of all stream beds and banks
3. To prevent deposition of logging debris in stream beds
4. To establish Streamside Management Zones (SMZs) along perennial water courses to filter sediment from overland flow and maintain stream temperature
5. To provide for rapid revegetation of all exposed mineral soil areas through natural processes supplemented by artificial revegetation where necessary
6. To prevent chemicals, pesticides, fertilizers, or petroleum products from entering or degrading (directly or indirectly) streams, groundwater, and surface water

Purpose of the Forestry Best Management Practices (BMP) Manual

This manual is intended to assist foresters, landowners, contractors, and operators to apply water quality protection techniques, methods, and measures (known as BMPs), while conducting forest management activities in Delaware. It is important to note that this is not a regulatory manual, but a guidance manual. The practices contained within this manual are appropriate to Delaware's forests. However, the practices needed to protect water quality within each forested site will be specific to that site.

Landowners and operators must file an Erosion and Sediment Control harvest permit with the Delaware Forest Service before starting any harvest of 1 or more acres. This permit must include a site map.

A FORESTRY BEST MANAGEMENT PRACTICES (BMP) MANUAL

For any forestry operation, a single BMP or combination of BMPs may adequately prevent erosion and sedimentation. These BMPs are designed to be applicable in all physiographic areas of Delaware.

In this manual, technical specifications for each BMP are discussed in detail. These specifications describe individual methods, measures, or practices that can be used separately or in combination to prevent or reduce adverse water quality impacts from forestry activities.

The key to successful implementation of BMPs is the use of advance planning. Advance planning can identify possible water quality problems and insure that proper and adequate measures take place before a forestry activity begins. Though covered in Pre-Harvest Planning, the principles of thorough site review, resource identification, and advanced planning apply to the implementation of all silvicultural activities.

FORESTRY ACTIVITIES - WATER QUALITY RELATIONSHIPS

Facts About Forest Soil Erosion

Raindrops dissipate energy as they hit the ground. Forest litter, organic matter, and roots absorb this energy and prevent soil particles from moving into streams. An unbroken, litter-covered forest floor and root mat serves to absorb rainfall energy that could erode the land and pollute streams. The forest floor with an intact root system, covered by litter and forest debris, is the best protection against erosion and resulting sedimentation. Removal of the forest canopy does not increase erosion; however, disturbance of the forest litter layer exposes mineral soil and compaction reduces infiltration, which results in erosion potential.

Logging roads, skid trails, and the removal of residual forest material during site preparation disturb forest litter, organic matter, and roots. These activities expose mineral soil, thereby increasing erosion potential. Under these conditions, rainfall energy is not readily absorbed by the bare mineral soil. Research indicates that rain falling on scattered small patches of bare soil will not deliver sediment to streams, unless these patches form unbroken pathways over long downhill distances. Correct silvicultural practices prevent formation of these unbroken pathways.

Within the total forested watershed, up to 25 percent of the mineral soil may be exposed without serious erosion. Frequent patches of litter and slash will trap the soil and the water carrying it, thus keeping rainfall from becoming surface runoff.

On logged forest land, the highest erosion rates are most likely to occur on poorly located and maintained haul roads and skid trails. The expense of establishing a well-designed road system pays off by providing an adequately drained road with moderate grades. Hauling time and the costs of equipment wear and repair are reduced. A well-planned, permanent road system enhances land value by providing easy access for recreation, fire suppression, and forestry and wildlife management activities. By increasing accessibility, the system will lower costs of future management activities.

The first step in reducing erosion rates is to inform the landowner and logger of measures that will reduce erosion and sedimentation from forestry activity. A well-planned, permanent access system is a sound method of reducing erosion in areas that require frequent and/or management access.

WATER QUALITY

There are five major potential water pollutants that may be generated by silvicultural activities: sediment, nutrients, organics, temperature, and chemicals.

Sediment

Sedimentation of water courses is one of the most important considerations in implementation of silvicultural activities. In the process of managing the forest, silvicultural operations have the potential to increase sedimentation rates. However, when these operations are conducted in a proper manner, rates of erosion and possible resulting sediment are minimized.

Movement of water across sloping land is usually below the surface. However, if the forest floor is compacted and the root mat destroyed, movement will be in the form of channelized surface flow. In this situation, a strip of vegetation left along a stream is relatively ineffective in filtering sediment. The key is to prevent channelized surface water movement and thereby maintain high infiltration rates on the forest floor. BMPs are designed to achieve these important functions.

The inherent erosion potential of a site depends primarily on soil type and slope. Sediment delivery to waterways is influenced by these factors as well as the amount of soil exposed, the length of exposure, the proximity to streams, and precipitation. The BMPs indicated here outline general considerations and suggest proper action, thus providing the forest manager, landowner, and logger, flexibility for alternative solutions and allowing site-specific recommendations.

Nutrients

Nutrients—primarily phosphorus and nitrogen fertilizers—are sometimes applied to the forest to stimulate tree growth. Both elements occur naturally in forest soils. These naturally occurring nutrients are transported via runoff and groundwater. Nutrients absorbed onto sediment particles (phosphorus), dissolved in the water column (nitrogen), or present as particles (nitrogen and phosphorus) can have a profound effect on water quality. Research has not found a significant increase in nutrient levels in water draining from forests which have been artificially fertilized, except when fertilizer was allowed to fall directly upon bodies of water. Proper application will alleviate this problem.

Fertilization of forest land in Delaware is presently insignificant.

Organics

Oxygen deficiencies can result from the deposition of organic matter in water. This is primarily a problem in slow-moving streams or ponds. Most forest streams are adequately aerated if no debris is deposited. Organic debris deposition and resulting oxygen depletion problems can be alleviated by using appropriate BMPs near streams.

Temperature

The temperature of forest streams is affected by removal of shading vegetation. This impact is dependent on the physical characteristics of the waterway (surface area, volume of flow, channel gradient, and bed material) and the type of aquatic life present. Small streams are most easily affected by exposure and are usually shaded by low vegetation. Water temperatures can increase rapidly following heavy thinning or removal of the overstory. Use of Streamside Management Zones (SMZs) will aid in minimizing increases in water temperature. Where SMZs are not used as permissible under appropriate rules and regulations (Delaware Seed Tree Law), reforestation during the following growing season will ensure establishment of low vegetation initially and full tree canopy over the long term. Thus, short- and long-term shading of vegetation will minimize temperature increases.

Chemicals

Chemicals in streams can be eliminated through proper planning at the time of application and identification of water courses. Research indicates that little impact occurs except where chemicals are applied directly to the water surface. Strict adherence to label directions for application of chemicals and disposal of containers should be followed.

WILDLIFE HABITAT

This manual gives specific guidelines to protect water quality and is not intended to provide specific guidance for wildlife habitat management. However, properly managed forests (e.g. where Forestry BMPs are implemented) provide benefits to wildlife through maintenance of long-term forest habitat types. Landowners desiring to maximize wildlife benefits should seek information and assistance from a professional wildlife biologist of the Department of Natural Resources and Environmental Control (DNREC), Division of Fish and Wildlife.

The concepts and options which follow are not intended to satisfy all needs for all wildlife species, but rather are designed to reduce adverse impacts and provide additional benefits to wildlife habitat.

Harvesting

A forest harvest's impact on wildlife habitat is not necessarily commensurate with the size of the harvested area; equally important is the harvest's size and shape and the quality of adjacent forested lands. The size of the area harvested should be determined on a case-by-case basis to meet the greatest number of landowner goals. Where possible, sufficient areas consisting of undisturbed forest stands adjacent to the harvested area should remain (providing for cover, shelter, and travel corridors).

The shape of the harvest area should correspond to existing land contours and natural barriers. An irregularly shaped harvest area provides increased edge, which is beneficial to many wildlife species. The harvesting plan should be structured to minimize disturbance in sensitive areas such as streams, sloughs, springs, and depressions.

Technical Specifications for Best Management Practices

GUIDELINES

FOR

PRE-HARVEST PLANNING

Definition

Pre-harvest planning is the collection of information about the specific area to harvest. Information gathered in this process can determine the best time and method of harvest. An effective pre-harvest plan will take into consideration all aspects of a harvest and plan for the implementation of BMP's that will minimize the adverse effects of the operation.

Purpose

To provide a plan prior to harvest that identifies an efficient operation and maintains water quality through the use of one or a combination of BMP's.

Condition Where Practice Applies

Locations of future commercial harvesting operations.

Specifications

The objective of pre-harvest planning is for the forester, landowner/manager, and logger to determine, based on conditions found on the site, which BMP's are necessary in order to protect water quality. A written harvest plan and timber sale contract are both desirable and good business practices, and BMP compliance should be a performance requirement of such contracts. A written harvest plan should take into account BMPs as well as other applicable regulations.

1. Identify all resources: soils, perennial and intermittent streams, drainage patterns, slope, topography, wetland hydrology and/or other wetland indicators, identification of sensitive areas and resources (such as unusual plants and animals), archaeological sites and grave yards, and adjoining land uses.

2. Locate property boundaries.

3. Identify BMPs needed to prevent soil and site degradation.

4. Schedule harvest operations to minimize soil compaction and site degradation, e.g., a harvest should occur only during the mid-summer months during dry soil conditions.

5. Identify approximate locations of main haul road and skid trails.

6. Identify potential log landing(s) and sawmill location(s).

7. Identify stream or drainage crossings locations.

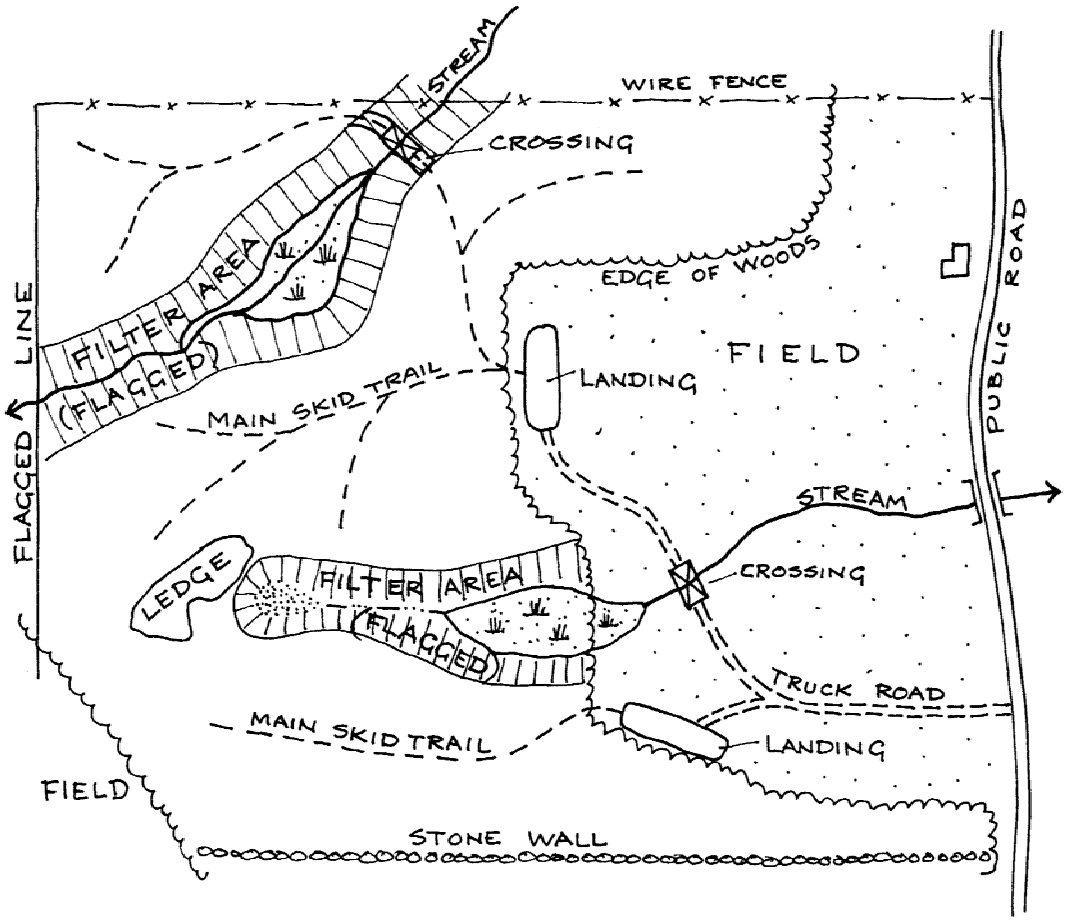
8. Identify Streamside Management Zones (SMZs).

A walk through the harvest area with a topographic map, aerial photograph, soil type map, or other site map will provide the landowner and operator with greater insight to existing ground conditions. A site review will aid in determining potential log landing and road locations, as well as locations of streams, wet areas, sensitive areas, and species of concern. The Delaware Forest Service can provide assistance with on-the-ground site reviews, determination of BMPs needed, current rules and regulations, and contract provisions.

In some situations, the best practice to control sedimentation may not be covered by the standard practices in this manual. One example is existing roads adjacent to streams. Under such circumstances, a pre-harvest plan should be discussed with Delaware Forest Service personnel, and an alternative practice can be developed prior to harvest.

The format of a harvest plan may be a simple listing of BMPs to be used and a site map showing locations of roads, skid trails, landing(s), Streamside Management Zones (SMZs), stream crossings, soils, and other areas of special concern. A harvest plan can also be one component of a larger forest management plan. The Delaware Forest Service also provides assistance with development of plans and site maps.

Sample Pre-Harvest Plan Site Map



This photo courtesy of the Maine Forest Service

GUIDELINES

FOR

TRUCK HAUL ROADS

Definition

A road system–temporary or permanent–installed for transportation of products from the harvest site by truck. Usually this is a single-lane road, installed by a bulldozer or other mechanical equipment, which contains turnouts and possibly a series of cuts and fills.

Purpose

To efficiently and effectively transport products from the site while protecting the land and water quality. The roads are often used to develop the forest for increased recreational use; provide access for wildland fire suppression; and/or other silvicultural activities. Properly located and constructed roads will also provide increased safety, higher vehicle speeds, and longer operating periods, while reducing operating and maintenance costs.

Conditions Where Practice Applies

Where the harvest area and volume per acre makes it necessary and economically feasible for an operator to install a road system. Also, where recreational, wildland fire access, and long-term management needs are sufficient to warrant the expense when product profit margins do not.

Specifications

1. Roads should follow contour as much as possible with grades of less than 10 percent. Steeper gradients, (i.e., those exceeding 15 percent), are permissible for distances usually not exceeding 200 feet. Fewer erosion problems will be encountered by breaking or changing road grade frequently rather than with long, straight, continuous gradients. On soils with severe erosion hazard, grades should be 8 percent or less, but grades exceeding 12 percent for no more than 150 feet may be acceptable as long as measures are taken to prevent erosion. Covering the road surface with two- to three-inch gravel can maintain stability. Where gravel is not needed for stability, seeding should be considered, as per *Revegetation of Bare Soil Areas* and/or *Temporary Cover Planting Specifications*. Water diversion by cross drainage interception of surface water on the road is often needed to prevent excess water from reaching steeper road grades. (See *Cross Road Drainage,* pg. 21; *Rolling Dip,* pg. 33 and *Broad-based Dip,* pg. 30 specifications.)

2. Perennial streams and intermittent streams with well-defined stream channels should be crossed as close to a right angle to the stream as possible. Structures should be sized so as not to impede fish passage or stream flow. Use *Stream Crossings* specifications, pg. 15.

3. Install water turnouts prior to a stream crossing to direct road and runoff water into undisturbed areas of the Streamside Management Zone (SMZ). Road gradients approaching water crossings are changed to disperse surface water at least 25 feet from the stream. Roads should be located (with the exception of stream crossings) a minimum

distance of 50 feet or more from any stream channel. For more specific information, see *Water Turnout*, pg. 25 and *Streamside Management Zone* (SMZ). pg. 11 specifications.

4. Outslope the entire width of the road where road gradient and soil type will permit. Usually inslope the road toward the bank as a safety precaution on sharp turns, road gradients of 15 percent, or on clay and/or slippery soils. Use cross drainage on insloped or crowned roads to limit travel distance of runoff water.

5. Where roads are insloped or crowned and the road grade exceeds 2 percent for more than 200 feet, install a broad-based or rolling dip within the first 25 feet of the road slope. (See *Rolling Dip*, pg. 33 and *Broad-based Dip*, pg. 30 specifications.)

6. Avoid road placement on saturated soils. For sites with generally level topography, place roads on dry soils and on uplands. For sites with rolling topography, place roads on side slopes, avoiding level ridge tops.

7. Where truck haul roads intersect main highways, use gravel, wooden mats, or other means when necessary to keep mud off the highway entrance.

8. Provide a minimum width of 10 feet for a single truck road. Increase width as necessary at curves and turnouts.

9. Vertical road bank cuts should normally not exceed five feet in height. Road bank cuts more than five feet high should normally be sloped to at least a 2:1 ratio and seeded to prevent erosion. (See *Revegetation of Bare Soil Areas* specifications, pg. 38.) Roads requiring high-cut banks should be used only when no alternative is feasible.

10. Ensure good road drainage with properly constructed and spaced turnouts, broad-based dips, rolling dips, culverts, and bridges.

11. For cross drains, install rip-rap, brush or straw bales at the outlets of culverts, or dips to absorb and spread runoff as needed.

12. Cut trees along the road where sunlight is necessary to ensure drying of the road. For roads crossing Streamside Management Zones (SMZ), tree removal should be planned to ensure maintenance of cover and/or basal area requirement.

13. Use brush barriers, straw bales or check dams as needed along the road-fill areas or other sensitive areas.

14. Minimize debris and slash entering watercourses during road construction, stream crossing, and other related construction activities.

Road Maintenance and Management Specifications

1. When possible, restrict traffic on roads during unfavorable conditions such as saturated soils. Haul only during dry weather on wet soils, erodible soils, or road gradients exceeding 10 percent. Use of wooden mats and/or gravel may allow operations during wet soil conditions.

2. Keep roads free of obstructions, ruts, and logging debris to allow free flow of water from the road surface.

3. Control the flow of water on the road surface by keeping drainage systems open at all times during and following management operations.

4. Inspect the road at regular intervals to detect, correct, and maintain its safe and sound condition. This includes the removal of any debris or fallen snags from the road surface and watercourses.

5. When all silvicultural activities are completed, re-shape the roadbed. Ensure that drainage systems are open and seed all areas of bare soil greater than or equal to 5 percent slope. Also seed areas subject to erosion along the access roads, main skid trails, and log landings. (See *Revegetation of Bare Soil Areas* specifications, pg. 38.)

6. Inspect stream crossings, culverts, and other road structures at regular intervals to detect, correct, and maintain their operation and protection of watercourses.

7. When the timber sale contract is released by the operator, or the area is returned to the landowner, access and road maintenance become the responsibility of the landowner.

GUIDELINES

FOR

LOG DECKS, LANDINGS, AND PORTABLE SAWMILL LOCATIONS

Definition

An area where logs are collected. This includes landings at the end of skid and haul roads as well as concentration yards near sawmills.

Purpose

To have a centralized location where harvested timber products are collected for sorting, sawing, and/or loading onto trucks.

Condition Where Practice Applies

A harvest area large enough to necessitate concentrating materials for loading.

Specifications

This practice generally results in disturbance of the soil surface. Care should be taken to properly locate decks, landings, and portable sawmills to minimize the potential for erosion and/or sedimentation.

The following points should be considered in the location and use of landings and concentration yards:

1. Locate suitable sites for decks, landings, and portable sawmills in advance of road construction.

2. Locate portable sawmills and decks at least 50 feet from the Streamside Management Zones (SMZ). Plan locations to ensure stream channel and surface drainage patterns are protected from logging debris and slash. (See *Streamside Management Zone* specifications, pg. 11.)

3. Decks and yards should have a slight (2 to 5 percent) slope to allow for drainage and should be on well-drained soils.

4. Provide for adequate drainage on approach roads and trails so that surface water does not drain onto deck area and cause muddy conditions.

5. Consider a diversion ditch around the uphill side of decks to intercept the flow of water and direct it away from the deck.

6. On-site equipment service and repairs (particularly for oil and hydraulic systems) should avoid site contamination by draining waste materials into containers. Properly dispose of all containers, garbage, and trash off site and in accordance with appropriate solid waste disposal practices.

7. Locate residue piles (sawdust, slabs, etc.) outside of surface water drainage areas so that water within the residue will not drain into adjacent streams or bodies of water.

8. Following the completion of operations, stabilize decks, landings, and portable sawmill locations to prevent erosion and sedimentation as soon as possible to meet successful seeding requirements. (See *Revegetation of Bare Soil Areas* specifications, pg. 38.) Seeding is not necessary if site preparation, reforestation, or other silvicultural activities are to be performed in a timely manner and provide for stabilization of bare soils.

GUIDELINES

for

SKID TRAILS

Definition

An unsurfaced, single-lane trail, or road usually narrower and sometimes steeper than a truck haul road.

Purpose

To skid logs, trees, or other round wood products from the stump to a common landing or concentration area.

Conditions Where Practice Applies

Where harvesting requires centralizing the products for sawing and/or loading on trucks or trailers, and where topography and size of operation make skidding the primary and most economical means of collecting trees, logs, or other round wood products.

Specifications

Plan major skid trails to minimize damage to the residual stand, reduce erosion and sedimentation, insure diversion of runoff, and provide the most economical method for skidding products.

1. After locating log landings and truck haul roads, plan skid trail approaches with grades under 15 percent to reduce runoff movement.

2. Locate skid trails to parallel the slope contour, whenever possible. Gradients should not exceed 15 percent, except as required to avoid boundary lines, sensitive areas, or other areas not accessible using skid roads of lesser grades. When skidding is dispersed and mineral soil is not exposed, steeper grades are permissible. If steeper grades are necessary, practices must be used to prevent concentrated water flow which causes gullying. See *Water Turnouts,* pg. 25, *Rolling Dip,* pg. 33, and *Broad-based Dip,* pg. 30 specifications.

3. Skid trails should be located outside of Streamside Management Zones (SMZs) whenever possible. (See *SMZ* Specifications, pg. 11.)

4. Where skid trails cross perennial streams, intermittent streams with well-defined stream channels, or drainage ditches, a temporary bridge or culvert should be installed at minimum. Avoid skidding logs directly through stream channels. Acceptable crossing practices are described in *Stream Crossing* specifications, pg. 15.

5. Approaches to water crossings should be as near to a right angle to the stream as possible. Layers of poles or slabwood (corduroy) along the approach can be used to provide temporary bank protection.

6. Where skidding upslope is unavoidable, climb at approximately a 45-degree angle to the fall line or in a zig-zag pattern, thus breaking the grade and avoiding long steep grades.

7. Skidding should be avoided when the soils are saturated to prevent excessive soil compaction and channelized erosion. When skidding cannot be avoided, or saturated soils are scattered throughout the site, minimize soil disruption by using wooden mat timbers. Remove mat timbers when skidding is completed.

8. Ruts should be minimized throughout the skidding operation. Ruts should not exceed six inches in depth, on average, over a distance of 50 feet. Unavoidable rutting of greater than 18 inches in depth, on average, over a distance of 50 feet should be repaired through back-blading or other methods. Use of mat timbers can reduce rutting. Mat timbers should be removed when the operation is complete.

9. Upon completion of skidding, install water bars in areas subject to erosion as soon as possible. The recommended spacings between water bars are listed in Table 1 below.

Table 1 - Recommended Water Bar Spacing

Slope	Interval	Slope	Interval
0 - 2%	250 feet	11 - 15%	60 feet
3 - 5%	135 feet	16 - 20%	45 feet
6 - 10%	80 feet	21 - 30%	35 feet

Install open-ended waterbars at a 30- to-45 degree angle downslope to prevent water accumulation behind them. A permanent vegetative cover should be established upon exposed roads, trails, and landings having either slopes greater than or equal to five percent of erodible soils. Scattered logging slash or other mulch material which covers the trail may supplement waterbars and vegetative seedings.

GUIDELINES

FOR

STREAMSIDE MANAGEMENT ZONE (SMZ)

Definition

An area on both sides of stream channels, drainage ditches, and bodies of open water where extra precaution is needed in carrying out forestry practices in order to protect bank edges and water quality. Note: SMZs for wetland areas and riparian forests are listed in the *Forested Wetlands and Riparian Forests* section, pg. 53.

Purpose

The purpose of the SMZ is to provide an undisturbed zone to trap and filter out suspended sediment before these particulates reach the stream, and to reduce stream water temperature and other chemical (dissolved oxygen) impacts.

Conditions Where Practice Applies

SMZs should be maintained along perennial streams, intermittent streams with well-defined stream channels, drainage ditches, open water bodies, and where surface runoff will carry sediment loads into streams, except as permitted by current rules and regulations (Delaware Seed Tree Law).

Specifications

1. The minimum width for an SMZ is 50 feet. *Table 2* below lists the minimum width for SMZs based on slope. SMZ width is measured in linear feet horizontally from the perimeter of the water body. For tidal waters, the high water line should be used as the perimeter.

   Where highly erodible soils exist, the SMZ width should be expanded to include the top of the slope, up to a maximum distance of 100 feet. See *Table 7*, pg. 39 for soil erodibility categories.

Table 2 - Minimum Streamside Management Zone Width

Slope Percent	0-10%	11-20%	21-45%
Horizontal distance	50 feet	75 feet	100 feet

2. Limit the use of heavy equipment in SMZs by using dispersed skidding, cable and winch systems, and well-planned skid trail locations. The original litter layer should not be disturbed, to avoid exposing mineral soil. When necessary to prevent erosion and sediment

movement, stabilize bare soils using the appropriate specification(s) for *Revegetation of Bare Soil Areas*, pg. 38. Revegetation specification should be used with the exception of the use of fertilizers, due to the pollution potential.

3. Retain at least 60 square feet of basal area per acre of trees well distributed throughout the area, or retain 60 percent of the overstory. These trees should be equally divided among diameter classes. The landowner may desire to leave up to 80 percent of the crown cover to provide shading for streams.

4. Locate sawmills, log landings, and decks outside the SMZ.

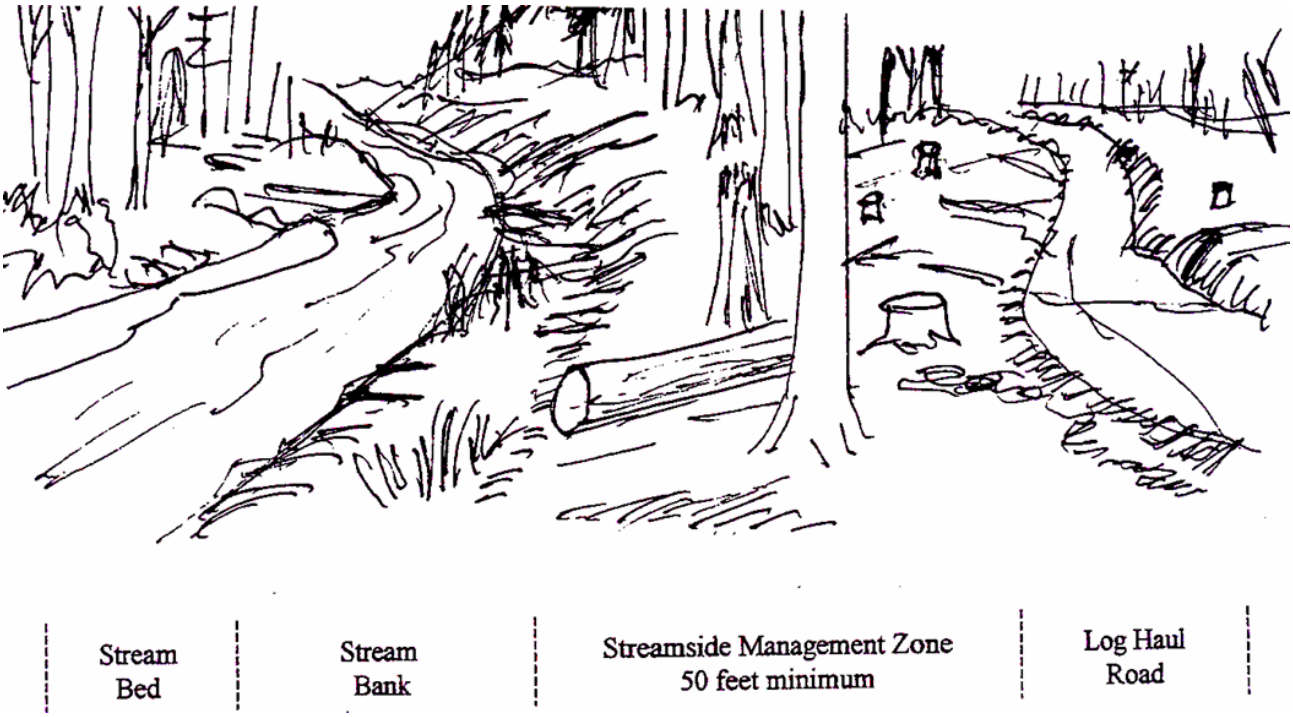
5. Remove all harvested tree laps, slash, tops, and other debris from streams, sloughs, drainage ditches, and open water.

6. Avoid construction of roads within the SMZ. When road construction cannot be avoided, access roads should cross SMZs and stream channels at or near a right angle. (See *Truck Haul Road*, pg. 4 and *Stream Crossing*, pg. 15, specifications) Install energy absorbers such as brush rip-rap or slabwood at cross-drained culvert outlets and water discharge points when needed. The energy absorbers should be installed to permit water flow while dispersing it.

7. Drainage structures, such as ditches (less than 2 feet deep), cross drain culverts, waterbars, rolling dips, and broad-based dips, should be used on truck and skid roads prior to their entrance into a SMZ to intercept and properly discharge runoff waters.

8. SMZs may be desirable on intermittent streams for large drainage areas where wildlife habitat or water quality is a major concern.

STREAMSIDE MANAGEMENT ZONE



GUIDELINES

FOR

SALVAGE AND SANITATION IN STREAMSIDE MANAGEMENT ZONES (SMZs)

Definition

Salvage and sanitation operations are harvests designed to remove damaged, dead, dying, and insect- and/or disease-infested trees.

Purpose

Utilization of forest products which have been damaged by insects, disease, fire, natural disasters, or other factors, and the reduction or elimination of insect or disease infestations that threaten adjacent forests.

Conditions Where Practice Applies

Areas where insect or disease problems pose a threat to adjacent timberland.

Specifications

1. Evaluate the potential threat to neighboring forest resources, including potential susceptibility, extent of spread, resource damage, and economic costs.

2. Consider alternatives for insect and disease control that may be more economical with less potential for site disturbance.

3. Locate haul roads and skid trails outside the SMZ.

4. Harvest areas adjacent to the SMZ to remove potential brood trees, susceptible species, low-vigor trees, and high-quality stems at or near maturity.

5. Harvest timber in the SMZ using dispersed skidding or cable-retrieval techniques. Avoid disturbance of the forest floor.

6. Equipment should not be operated in or adjacent to the SMZ for salvage and sanitation purposes when soils are saturated.

7. Where more that 50 percent of the overstory is to be removed, evaluate the density of the understory and the potential impact on stream temperature to determine the need for revegetation or reforestation.

8. Small areas of less than one acre may be completely harvested to prevent spread of damaging agents.

GUIDELINES

FOR

STREAM CROSSINGS

Definition

Culverts, bridges, or rock fords that allow equipment to cross perennial streams, intermittent streams with well-defined stream channels, and drainage ditches which flow into other drainage systems.

Purpose

To cross stream channels and drainage ditches without creating erosion or increasing stream sedimentation.

Conditions Where Practice Applies

Where permanent stream crossing structures are needed to provide access for implementation of forest management practices, fire reduction and suppression activities, and other forest-based uses, such as recreation.

Temporary crossings may be desirable for intermittent streams without a defined stream channel. Where temporary stream crossings for specific forest practices are desired, contact the Delaware Forest Service for assistance with site review and crossing design.

Specifications

Minimize stream bank disturbance during installation of stream crossings. Stabilize the stream bank approach with rock or other non-erosive material where banks are unstable.

For Tax Ditch Crossings: Assistance in planning crossings and culvert size requirements for tax ditches is available by contacting the appropriate county Conservation District office and DNREC, Division of Soil and Water Conservation, Drainage Section.

Pipe Culvert:

1. Both ends of the pipe should extend at least one foot beyond the edge of the fill material.
2. Select culvert size based on soil type, slope, and the size of the watershed area. See *Table 3* on pg. 16.
3. The culvert should be placed on a 2- to 4-percent grade to prevent clogging.
4. Earth should be hand-tamped to eliminate air pockets at least halfway up the side of the pipe. Space between pipes in a multiple culvert should be one-half of each pipe's diameter. Earth cover or fill dirt over pipes should also be one-half the culvert diameter depth, but not less than one foot.

5. Erosion protection measures can be installed at culvert outlets to minimize downslope erosion. This protection can include rip-rap, plastic filter cloth, large stone, etc. It may also be needed on the upstream end of culverts on flowing streams.

Table 3 - Culvert Size (in inches) for Stream Crossings by Soil type, Slope and Watershed Area

	Light Soils			Medium Soils			Heavy Soils		
Acres Drained	0-5%	5-15%	15%+	0-5%	5-15%	15%+	0-5%	5-15%	15%+
2	15	15	15	15	15	15	15	18	18
4	15	15	15	15	15	18	21	21	21
6	15	15	15	15	18	21	21	27	27
8	15	15	15	15	18	21	24	27	30
10	15	15	15	18	21	24	27	30	36
20	15	15	15	21	24	30	30	36	42
30	15	15	15	21	27	36	36	42	48
40	15	15	15	24	30	36	42	48	54
50	15	15	18	27	36	42	42	48	
60	15	15	18	27	36	42	42	54	
70	15	18	18	26	36	42	48	54	
80	15	18	21	30	36	48	48		
90	15	18	21	30	36	48	48		
100	15	18	21	30	42	48	48		
150	18	21	24	36	42	54	54		
200	21	21	27	36	48				
250	21	24	27	42	48				
300	21	27	30	42	54				
350	24	27	30	42	54				
400	24	27	36	48					

NOTE: Pipes with diameters less than 18 inches are subject to occasional plugging. All pipes require occasional inspection and removal of debris.

Fords:

1. Rock fords or log fords may be used if no practical alternative exists. Fords may be used when stream banks are stable and stream bottoms hard. Fords should only be used when vehicles crossing the stream will not produce increased sedimentation, i.e. muddy water.

2. Approaches and the stream bottom must be hard enough so no turbid water results.

3. Stabilize stream bank approaches with rock or other non-erosive material, where banks are determined to be unstable prior to or during operations.

4. Any bare soil, erosion, or sedimentation areas created during the use of the ford should be stabilized. See *Revegetation of Bare Soil Areas*, pg. 38.

5. Contact the Delaware Forest Service prior to using ford crossings to insure ford design specifications meet the requirements of current rules and regulations.

Bridges:

1. Construct bridges with minimal disturbance to the stream bank, channel, and an adjacent SMZ.

2. Design bridges to permit unimpeded water flow beneath it resulting from a five-year, 24-hour frequency storm event.

3. Design bridge surfaces to adequately direct stormwater away from the bridge.

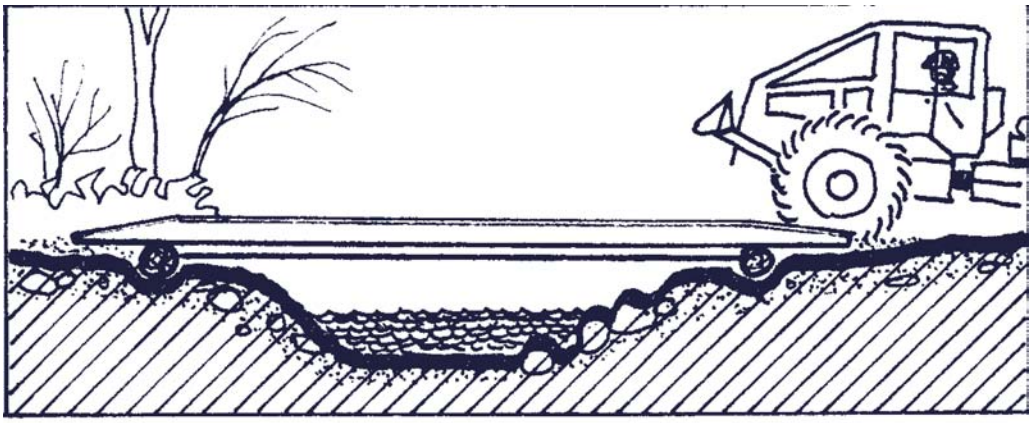
4. Whenever possible, avoid locating bridges on saturated and erodible soils. If construction is required on these soils, design the bridge with sufficient length to discharge traffic onto stable roadbeds on both sides of the water.

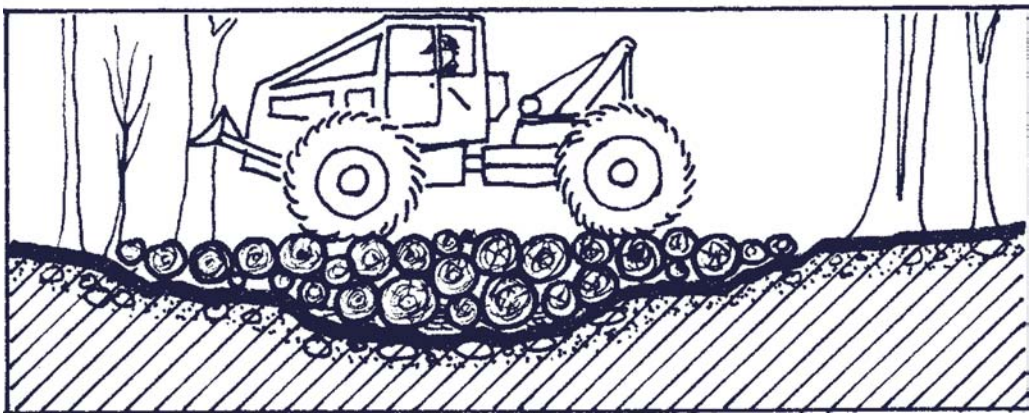
5. Locate bridges at the narrowest stream width whenever possible.

6. Design and install bridges to cross the water body at right angles on as level topography as possible. Where adjacent land slopes to the desired bridge location, design bridge entrance and exit roadways to minimize runoff by installing water turnouts.

7. Design bridge length and width specifications to distribute traffic loads evenly, while preventing erosion of the top of the stream banks.

Sample Temporary Bridge and Culvert Designs





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GUIDELINES

FOR

DRAINAGE MAINTENANCE

Definition

Drainage maintenance is removing soil, debris, and vegetation to provide an efficient and effective flow of surface water within forest land drainage systems. Forestland drainage systems maintenance typically occurs at the final harvest or prior to tree planting. Therefore, maintenance and management of forestland drainage systems for on-going silvicultural operations in Delaware may occur with a frequency of every 30 to 80 years, depending on the forest cover type.

Purpose

To permit maintenance activities of forestland drainage systems and ditches without creating erosion and sedimentation.

Conditions Where Practice Applies

Where an existing forest land drainage system requires maintenance to ensure successful silvicultural operations (while preventing erosion and sedimentation).

If the drainage system is part of an organized tax ditch system, maintenance is more frequent. Ditch right-of-ways must be kept clear of large woody vegetation. For tax ditch maintenance, landowners and operators should consult their tax ditch managers, Department of Natural Resources and Environmental Concerns (DNREC) Division of Soil and Water Conservation, Drainage Section, and/or the appropriate county Conservation District.

More specific to this practice are existing forestland drainage systems which have not been maintained since the start of the last forest rotation. Many of these systems were originally constructed during the 1930's (by the Civilian Conservation Corps), or later, to permit seedling planting, or agricultural cropland use, but were later abandoned for this use and naturally reseeded to forestland or were planted to trees.

Specifications

1. Design maintenance to minimize erosion and sedimentation to the existing and larger downstream drainage systems by matching the equipment to the maintenance task.

2. Avoid use of equipment during saturated soil conditions.

3. Use high-flotation equipment whenever possible on all soil types to reduce compaction and minimize potential for rutting.

4. Soil removal within the ditch or drainage system should be no deeper than the original excavation depth. One method for determining the pre-existing bottom depth is to dig by hand until the previous ditch bottom/hard pan is reached. Soil boring samples throughout the system can achieve the same maximum depth result. Once the maximum depth is determined, the excavation should be planned carefully to prevent erosion by maintaining existing ditch banks whenever possible. Excavated material should be placed so that re-entry into the ditch is prevented and overland flow of surface water is not blocked from entering the ditch. Side-cast material should be stabilized as soon as possible. See *Revegetation of Bare Soils and Temporary Cover Planting* specifications, (pgs. 38 and 42).

5. Minimize ditch bank degradation when removing debris and vegetation.

6. Avoid disruption of the forest floor in adjoining areas and stabilize bare soil areas unless reforestation or other silvicultural activity is to occur in the near future. See *Revegetation of Bare Soils and Temporary Cover Planting* specifications, (pgs. 38 and 42).

GUIDELINES

FOR

CROSS ROAD DRAINAGE
BY PIPE OR OPEN-TOP BOX CULVERT

Definition

Corrugated metal pipe, wooden open-top box culvert, or other suitable material installed within truck haul roads or major skid trails to transmit stormwater runoff and water from roadside ditches.

Purpose

To collect and transmit water safely from side ditches, storm runoff, and/or seeps under haul roads and skid trails without eroding the drainage system or road surface.

Conditions Where Practices Applies

Culverts are appropriate for any operation where cross drainage of stormwater is needed for truck haul roads or major skid trails. In some cases, a culvert is necessary for temporary drainage crossings by skid trails. Permanent installations should be inspected for obstructions prior to the completion of operations.

Specifications

Spacing of culverts can be determined using the following formula:

$$\textit{Culvert Spacing (feet)} = \frac{\textit{Length of roadbed (feet)}}{\textit{Slope \%}} + 100 \textit{ feet}$$

Example: A site has a road which is 400 feet long at 8 percent slope

$$\frac{400}{8} + 100 = 50 + 100 = 150 \text{ feet between culverts}$$

See Table 5, pg. 31 within the *Broad-based Dip* specifications which contains the proper culvert spacing for a 400 foot road at various slopes.

Inspect structures following major rain events. Clean-out maintenance may be needed to remove sediments, gravel, and debris and to allow normal flow of runoff water through the structure.

Pipe Culvert:

1. Both ends of the pipe should extend at least one foot beyond the edge of the fill material.

2. A culvert should be placed on a 2- to 4-percent grade to prevent clogging.

3. Installation should be skewed 15 to 30 degrees downgrade.

4. Erosion protection should be provided for outflows of culverts to minimize erosion downslope or downstream of the outfall; it may also be needed on the upstream end of culverts on flowing streams. This protection can be in the form of rip-rap, plastic filter cloth, or large stone.

Open-Top Box Culvert:

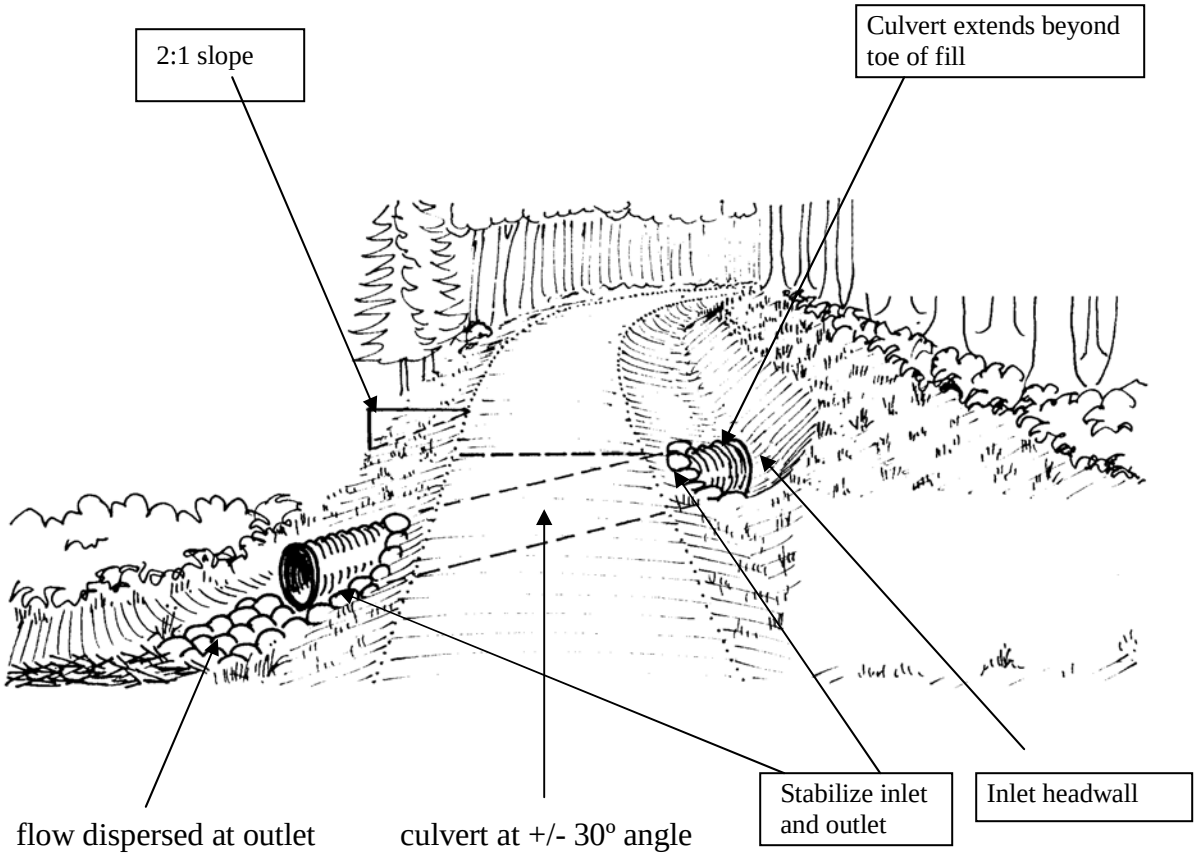
1. Box culverts should be installed flush or just below the road surface, and skewed at an angle of 30 to 45 degrees downgrade.

2. The upper end should be at grade with the side ditch and the lower side, extend into the toe of the upslope bank.

3. Outfall should extend beyond the road surface with adequate rip-rap or other material to dissipate water velocity to assure no erosion of fill material.

Culverts should be firmly anchored and earth compacted at least halfway up the side of the pipe to prevent water from diverting around them. A minimum of half the culvert diameter (but not less than one foot) of fill should be placed above the culvert. Both ends of the culvert should protrude at least one foot beyond the fill. Erosion protection measures should be employed on any earthen fill. See *Revegetation of Bare Soils and Temporary Cover Planting* specifications (pgs. 38 and 42).

Pipe Culvert



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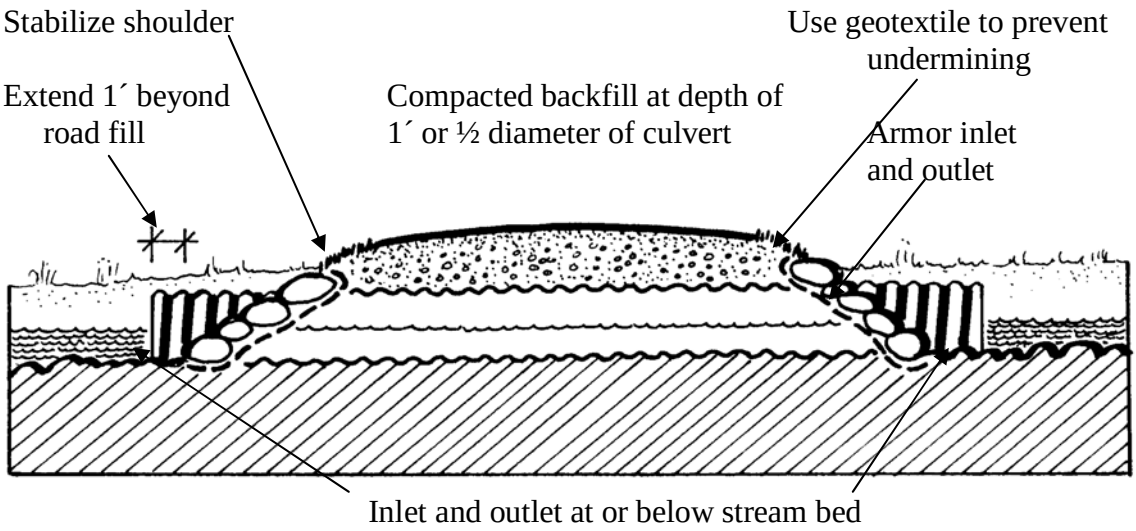
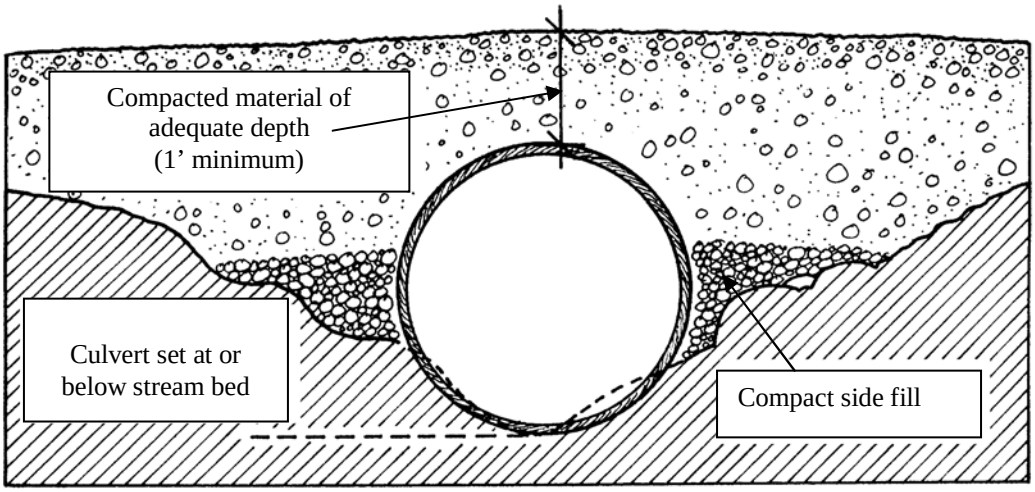




These photos courtesy of the Maine Forest Service

GUIDELINES

FOR

WATER TURNOUTS

Definition

A water turnout, or diversion ditch, to transport water away from roads and/or side ditches.

Purpose

To collect and direct road surface runoff away from one side of the road and into undisturbed areas.

Conditions Where Practice Applies

Any road or trail section where water could accumulate.

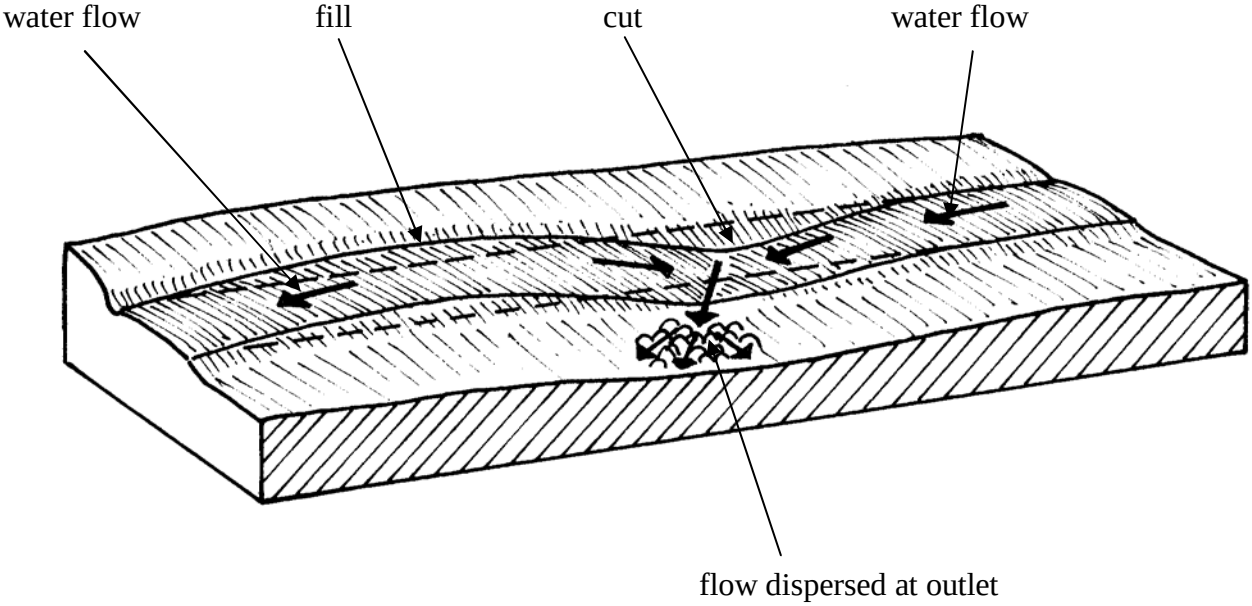
The water should be diverted into undisturbed areas so the volume and velocity is reduced on slopes.

Specifications

A buildup of drainage water in roadside ditches can erode roadbeds, scour the road ditch itself, and transport soil particles downslope. Water turnouts will channel the water away from these roadside ditches and disperse it in areas adjacent to the road.

1. The turnout should intersect the ditch line at an equal depth and be outsloped 1 to 3 percent.
2. On sloping roads, the turnout should be 30 to 45 degrees downslope.
3. Space turnouts to allow the roadbed to dry out and reduce the volume and velocity of side ditch waters.
4. Runoff water should be spread, retained, or filtered at the outlet of the turnout.
5. Turnouts may not feed directly into adjacent drainage or channels.

A Water Turn-out Illustration



This photo courtesy of the Maine Forest Service

GUIDELINES

FOR

WATER BARS

Definition

A trench constructed across a road or trail, reinforced by poles on sandy soils if necessary.

Purpose

To intercept and divert surface runoff from roadside ditches, roads, and trails that will not have vehicular traffic.

This practice will minimize erosion and provide conditions suitable for natural or artificial revegetation. On moderate slopes, water bars will remove water from the road or trail thus allowing adequate natural revegetation within one year.

Conditions Where Practice Applies

This is a practice used on road or trail grades where surface water runoff may cause erosion of the exposed soil. Use only where there will not be any vehicular traffic; if there is a potential for vehicular traffic, use rolling dips.

Specifications

1. Proper Spacing between water bars can be determined from the following table:

Table 4 - Spacing of Water Bars

Percent Grade of Road	Distance Between Water Bars
0% - 4%	250 (feet)
5% - 9%	135
10% - 14%	80
15% - 19%	60
20%+	45

2. Water bars should be at an angle of 30 to 45 degrees downslope to turn surface water off the road or trail. See *Water Bar Top View* and *Cross-section* diagrams on page 28 for detail on specifications.

3. A water bar is comprised of two components: a trench and a berm or bar. The trench should be 1 to 3 feet below the surface of the road or trail and should extend beyond both sides of the water bar. Trench spoil materials should be used to develop the berm or bar height.

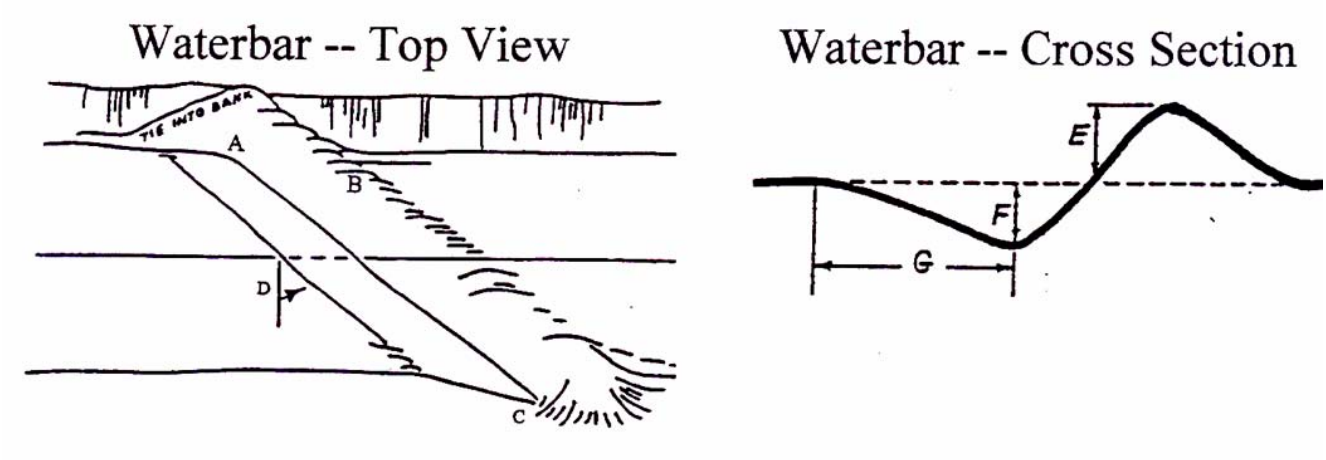
4. The uphill end of the bar should extend beyond the side ditch line of the road and tie into the bank to fully intercept any ditch flows.

5. The outflow end of the bar should be fully opened and extend far enough beyond the edge of the road or trail to safely disperse runoff water onto the undisturbed forest floor. The outlet length should not be excessive. Consider the need for energy absorbers and waterspreaders at or below the outlet-particularly where water is discharged into sensitive areas.

6. On sandy soils, a 5- to 8-inch pole for reinforcement of the water bar should be placed the full length of the trench. This pole should be pegged and filled with soil on the downslope side.

Water bar construction for forest roads with little or no traffic.

Specifications are for average conditions and may be adjusted.



A - Bank tie-in point: cut trench 1 to 3 feet into the roadbed.
B - Berm or bar height: 1 to 2 feet above the roadbed.
C - Drain outlet: cut 1 to 3 feet into the roadbed.
D - Angle trench and bar 30 to 45 degrees downgrade from road centerline.

E - Bar or berm: approx. 2 feet in height.
F - Trench depth: 1 to 3 feet.
G - Trench centerline to roadbed width: 3 to 4 feet.

Functioning Water Bar Illustration

This photo courtesy of the Maine Forest Service

GUIDELINES

FOR

BROAD-BASED DIP

Definition

A dip and reverse slope in a road surface with an outslope in the dip for natural cross drainage.

Purpose

To provide cross drainage on insloped truck roads to prevent buildup of excessive surface runoff and subsequent erosion.

Condition Where Practice Applies

Broad-based dips can be used on truck haul roads and heavily used skid trails having a gradient of 12 percent or less. For gradients of greater than 12 percent, rolling dips are needed. They should not be used for cross drainage spring seeps or intermittent and perennial streams. This practice may be substituted for other surface water cross drain practices such as a pipe or box culvert.

Specifications

1. Installation typically takes place following basic clearing and grading for roadbed construction; however, installation can also occur following road use if evidence of erosion creates the need.

2. A 20-foot long, 3 percent reverse grade is constructed into the existing roadbed by cutting from upgrade of the dip location.

3. Spacing of broad-based dips is determined by the following formula:

$$\textit{Spacing between dips (feet)} = \frac{\textit{Length of roadbed (feet)}}{\textit{Slope \%}} + \textit{100 feet}$$

Example: A site has a road which is 400 feet long at 8 percent slope

$\frac{400 \text{ feet}}{8}$ = 50 feet + 100 feet for a distance of 150 feet apart

Table 5 lists the approximate broad-based dip spacing for a road 400 feet long at varying slopes.

4. The cross drain outslope will be 2 percent to 3 percent maximum.

5. An energy absorber such as rip-rap and, in some cases, a level area allowing water dispersion, should be installed at the outfall of the dip to dissipate water velocity, thus assuring no erosion of cast materials.

6. The dip and reverse grade section may require bedding with three-inch crushed stone in some soils to avoid rutting of the road surface.

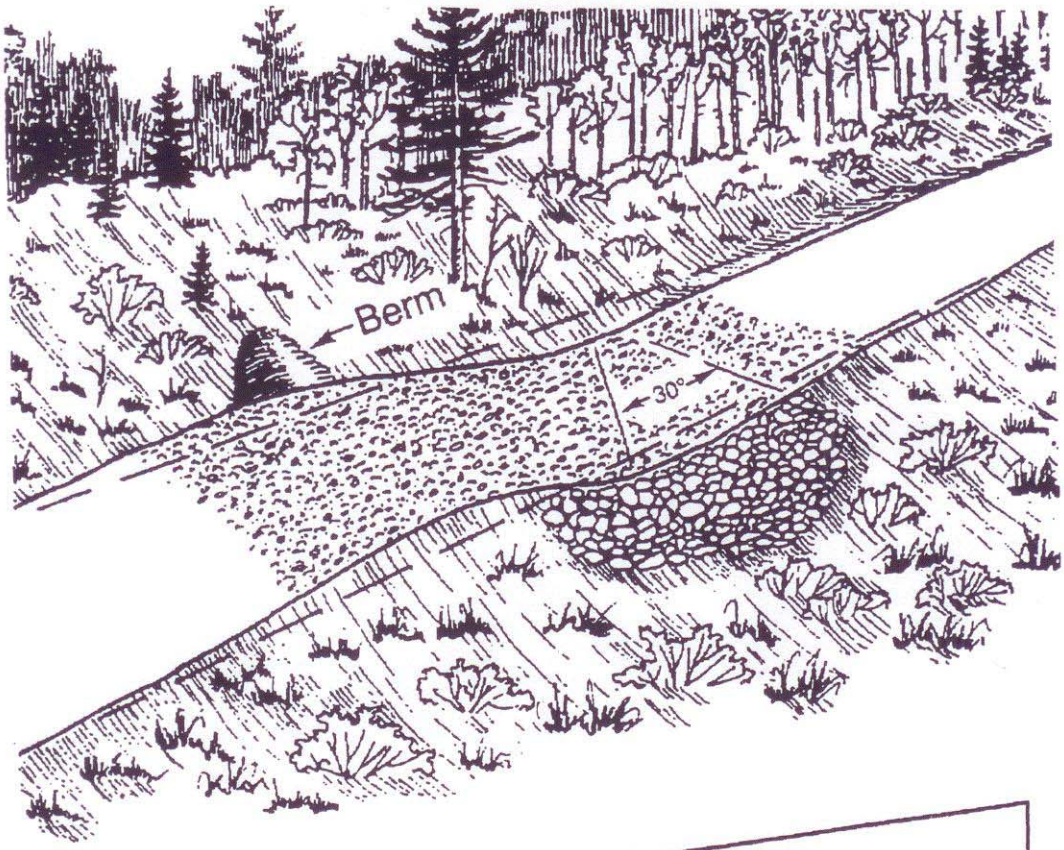
Broad-based dips are very effective in gathering surface water and directing it safely off the road. Dips should be placed across the road in the direction of water flow. This type of structure allows normal truck speeds without adding stress to the vehicle.

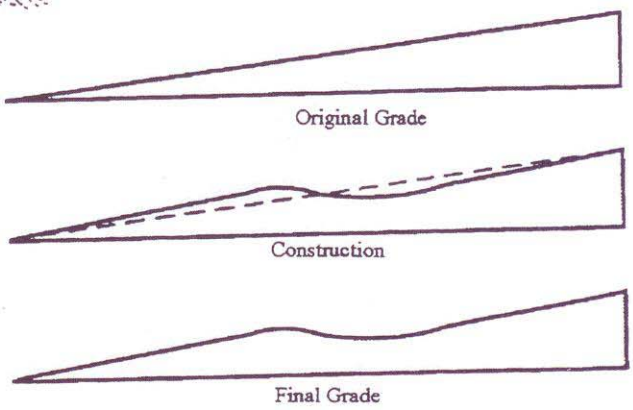
Table 5 – Spacing for Broad-based Dips

Road Grade (Percent)	Spacing Between Dips (Feet)
2%	300
3%	235
4%	200
5%	180
6%	165
7%	155
8%	150
9%	145
10%	140
11-12%	135

An inherent problem in construction of a broad-based dip is recognizing that the roadbed consists of two planes rather than one unbroken plane. One plane is the 15- to 20-foot reverse grade toward the uphill road portion and outlet. The other plane is the grade from the start of a downhill gradient (constructed at the top of the dip or hump) to the outlet of the dip. Neither the dip nor the hump should have a sharp, angular break but be rounded to allow a smooth flow of traffic. Only the dip should be outsloped to provide sufficient break in grade to turn the water. These dips do not damage loaded trucks nor do they slow vehicle speed. Dips require minimal annual maintenance and continue to function years after abandonment.

BROAD-BASED DIP





Broad-based Dip Cross section

GUIDELINES

FOR

ROLLING DIP

Definition

A dip and reverse slope in a road surface with an outslope in the dip for natural cross drainage. Rolling dips are for use on steeper grade roads than broad-based dips.

Purpose

Provides cross drainage on insloped truck roads to prevent excessive surface runoff and subsequent erosion.

Conditions Where Practice Applies

Rolling dips can be used on truck haul roads and heavily used skid trails having a gradient of greater than 12 percent. They should not be used for cross-draining spring seeps or intermittent and perennial streams. This practice may be substituted for other surface water cross practices such as pipe or box culverts.

Specifications

1. Installation can take place following basic clearing and grading for roadbed construction or on skid trails after logging is completed.

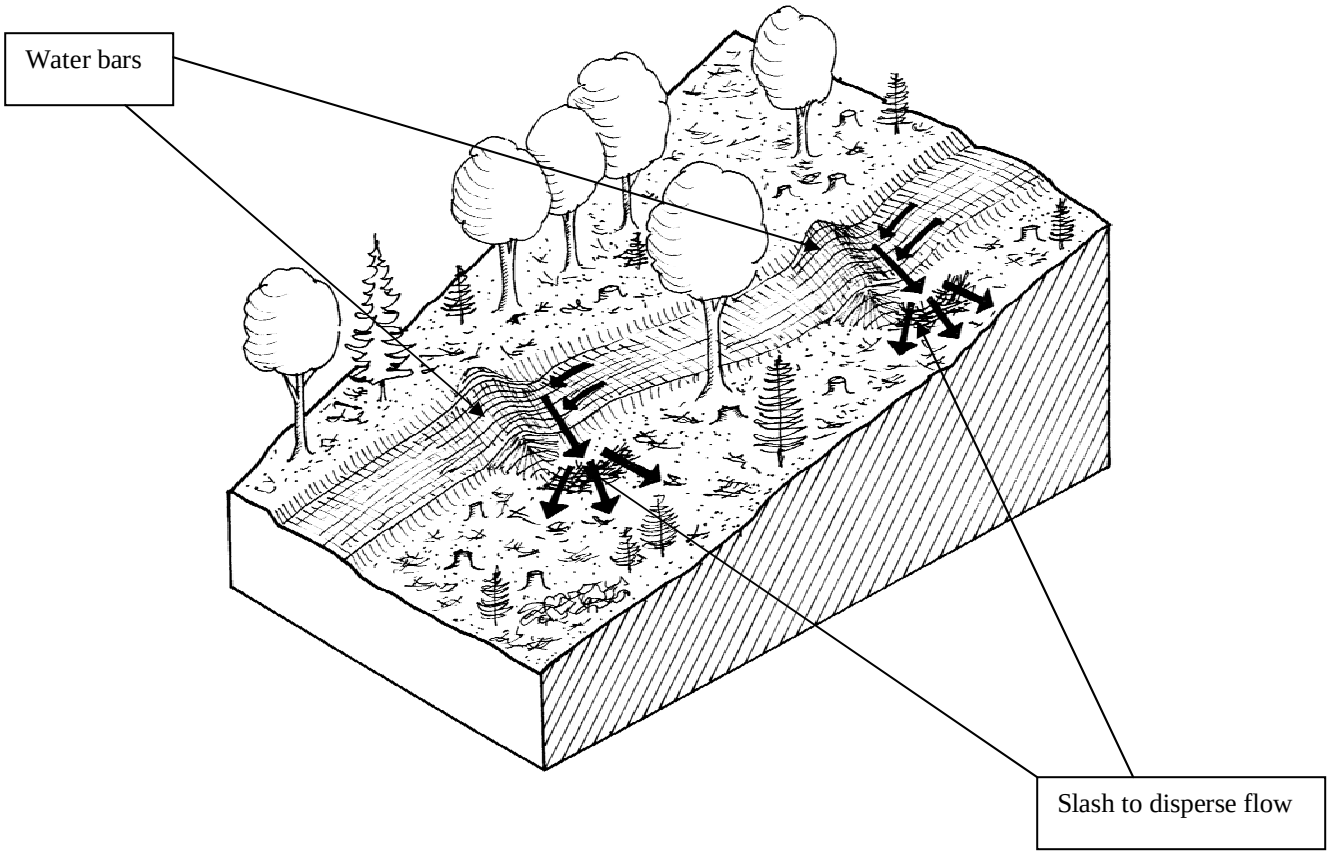
2. A 10- to 15-foot long, 3 to 8 percent reverse grade is constructed into the existing roadbed by cutting from upgrade to the dip location. Use cut material to build up the mound for the reverse grade.

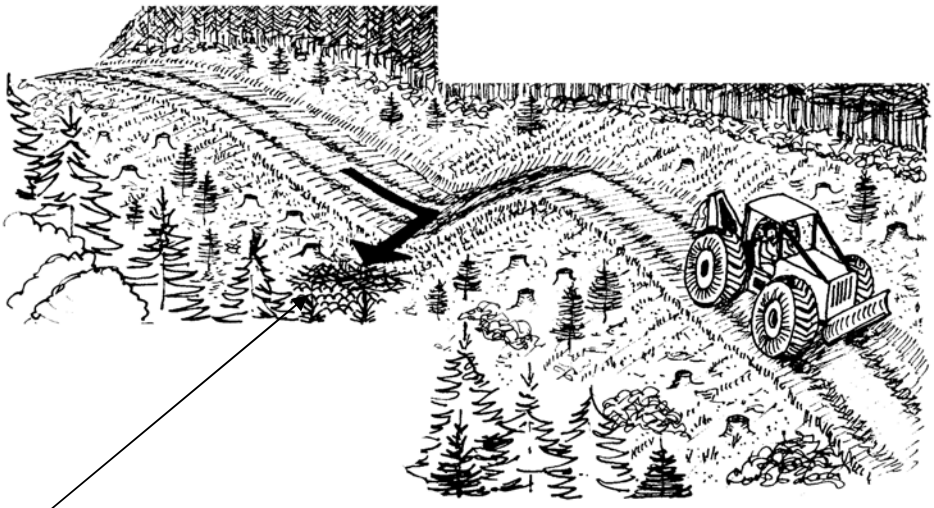
3. Spacing of rolling dips will be determined by the following table:

Table 6 - Rolling Dip Spacing

Grade of Road (Percent)	Distance Between Rolling Dips (feet)
0 - 5%	180
5 - 10%	150
10 - 15%	135
15%+	120

ROLLING DIP





Slash and/or rocks to disperse water

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GUIDELINES

FOR

SITE PREPARATION, REGENERATION, AND IMPROVEMENT

Definition

Site preparation and regeneration refers to methods used to prepare areas for establishing trees and natural regeneration. Improvement refers to methods used to improve tree and forest vigor.

Purpose

Increase the multiple resource benefits received from forest land while maintaining water quality.

Specifications

Site Preparation, Regeneration, and Improvement Planning: Used to integrate site characteristics and water quality protection techniques into project plan, prior to initiation of management activity.

As recommended for harvest operations and all other silvicultural activities, site specific planning should be performed prior to the initiation of the activity. Prior to plan development, examine the site to determine present characteristics including the condition of the site, adjacent property land use(s), soil type(s), identification of any sensitive or unusual resources, drainage patterns, type of harvest conducted, silvics of species to be regenerated, and potential means of regeneration, as well as other factors listed in *Pre-harvest Planning* specifications, pg. 2. Once this analysis is complete, develop a plan which meets forest regeneration and water quality protection goals.

Prescribed Burning: Used to reduce logging residue, unwanted vegetation, and fuel load for wildland fires.

1. Firelines should be constructed on the perimeter of the burn area and along the perimeter of Streamside Management Zones (SMZs). SMZs should be identified and should not be site-prepared. The purpose of locating the fireline along the SMZ is to maintain organic matter for filtration within the SMZ. In some situations, however, a light burn through the SMZ may do less damage than constructing a fireline adjacent to the SMZ.

2. Firelines should have water bars and turnouts as needed to prevent erosion.

3. When firelines cross a drainage, construct them parallel to the stream, or have a turnout that disburses the runoff rather than channels it directly into the stream. (See *Stream Crossings, Water Turnout* (pgs. 15 and 25), and other specifications listed previously.)

4. Firelines should be constructed during optimum conditions for protection of soils from erosion.

5. Conduct prescribed burning when soil moisture or weather conditions are sufficient to prevent removal of all surface duff and root mat. Highly eroded sites, such as old fields or steep shallow soils, should be burned in early morning or following a rain to maintain a portion of the surface duff.

6. Prior to scheduling prescribed burning activities, check with the local Delaware Forest Service (DFS) office concerning current burning regulations. Personnel from the DFS can assist with the prescribed burning planning process. Once prescribed burning has been scheduled, notify the DFS for assistance during operations.

Drum Chopping: Used to knock down residual trees and provide additional fuel for a prescribed burn.

1. Maximum benefits result from drum chopping up and down the slope so the depressions made by the cleats and chopper blades are on the contour, thus reducing the occurrence of channeled surface flow. Schedule this operation to avoid wet or saturated soil conditions.

2. Limited mineral soil is exposed by drum chopping.

Bush and Bog Disking: Used to reduce unwanted vegetation, incorporate organic matter, reduce soil compaction, and improve the site for planting.

1. Disking should be done on the contour whenever possible. Disking should be limited to slopes of less than 10 percent. Disking on slightly steeper slopes is permissible when the slope length is less than 50 feet and the Universal Soil Loss Equation (USLE) soil erodibility factor (K) is less than 0.32. In these cases, check with your local DFS office and/or local Conservation District for assistance.

2. Schedule operations during favorable soil moisture conditions. If soil is too dry, a ball of soil formed in your hand will not hold together. If it is too wet, the ball will not break apart when squeezed between two fingers. When soil moisture is favorable, a ball of soil can be formed but will break apart readily when lightly squeezed between two fingers.

Shearing, Piling, Root Raking, and Bulldozing: Used to remove residual trees and pile logging debris.

1. If an erosion potential exists, preserve site quality and minimize water quality impact by leaving the topsoil and the root mat in place. Leave stumps in place also. Keep the blade and/or rake a minimum of 3 inches above the ground surface.

2. Bulldozing will be limited to slopes of 20 percent or less, with a windrow approximately every 200 feet. Install firebreaks of at least one dozer width within windrows approximately every 200 feet unless they are to be burned under controlled conditions.

3. Windrows placed on the contour will trap sediment and reduce the distance surface water will travel. Provide a 20-foot opening within each 300 feet of windrow and a 20-foot opening to adjoining timberland and/or SMZ.

4. Windrows can cross or occupy small gullies (less than three feet deep) where they will trap sediment. Larger gullies require surface water management to rehabilitate the eroded area.

5. Avoid operations during wet or saturated soil conditions to retain topsoil and root mat, while minimizing potential water quality impacts.

6. Place windrows to prevent logging debris and slash from entering streams, ditches, SMZs, and other drainage patterns during operations.

Bedding: A practice which mounds soil in rows to overcome poor drainage which can occur on flat sites with a high water table. Used to create a tree planting bed where seedling roots will not encounter anaerobic (oxygen-deficient) conditions.

1. Bedding during saturated soil conditions will not be effective and may impact water quality.

2. The height of the beds should not exceed 18 inches.

3. Bedding should be on the contour if slope is discernible. Usually bedding on flat sites is not a problem, and water absorption is improved by the soil cultivation.

Machine Planting: Used to establish tree seedlings; sometimes combined with subsoiling to break up plow layers, hard pans, or compacted soil.

1. Machine planting, subsoiling, and sod scalping should be done on the contour. Hand plant steep slopes.

2. Soil conditions should be suitable for adequate machine operation.

GUIDELINES

FOR

REVEGETATION OF BARE SOIL AREAS

Definition

The establishment of grass and/or legume vegetation on bare soil areas to stabilize the soil and reduce sediment runoff.

Purpose

Minimize the chance of erosion and sediment runoff to water courses.

Conditions When Practice Applies

Applicable to areas where exposed mineral soil, highly erodible soils, severely eroded or gullied areas, and accelerated erosion may contribute to sediment runoff to drainage features.

Specifications

Site and Seedbed Preparation

Upon completion of operations, identify bare soil areas with grades greater than 5 percent, and/or areas of bare soil with erosion potential (landings, sawmill locations, skid trails, or haul roads) and seed them as soon as possible depending on the season.

Perform water control measures, and/or subsoiling (ripping of compacted soils), and/or shaping of the land as needed prior to preparing a suitable seedbed.

Lime and Fertilizer

Apply lime and fertilizer at the completion of specific measures such as ripping or smoothing, but prior to seeding. Establish lime and fertilizer application rates by soil type and soil acidity. Local County Extension Offices test soil samples for a small fee. If soil tests are not used, apply 1.5 tons of lime and 600 pounds of 10-6-4 fertilizer per acre. Note: Government cost share programs often require higher application rates. By using a soil test, appropriate application rates are determined and rates may be reduced. The material should be incorporated into the soil by scarifying the surface by disking or harrowing, using ripper teeth on a bulldozer, or by other suitable machinery capable of preparing a seedbed to a minimal depth of 4 inches.

Seeding

Selected seed mixtures may be broadcast or drilled. Successful seedings are usually in the spring and fall. Broadcast seed can be covered by dragging a chain, brush, disk, or harrow to ensure seed contact with the soil. A mixture of long-term, fine-rooted perennials should be used for effective erosion control. See *Table 8* below for recommended seed mixtures. Numerous seed mixtures have been developed to achieve erosion control and other resource goals, including enhanced wildlife habitat. Consult your local Delaware Forest Service office, Extension Agent, Conservation District office, or Delaware Division of Fish and Wildlife office for assistance. *Table 9* provides the acreage for roads of varying widths and lengths.

Mulching

When seeding is done on highly erodible soils, or under adverse soil or weather conditions, mulch material should be applied immediately after seeding to prevent soil erosion. Seed may also need mulch during adverse weather, soil, or site conditions to increase germination rates. Mulching is especially needed for winter seeding on dry sites. Mulching rates are 1 to 1.5 tons per acre with hay or straw, or 1,500 pounds per acre of wood fiber mulch.

Table 7 - Soil Erodibility Categories

Land Slope (Percent)	Category
0 to 2	Not Highly Erodible
2 to 7	Potentially Highly Erodible
7 +	Highly Erodible

Maintenance

Bush hogging can be utilized to maintain roads which will be used in the future and/or to maintain open areas for wildlife. Seeded areas must be protected from traffic, particularly during wet periods. Freshly seeded roads are particularly vulnerable to damage. Seeded areas should also be protected from grazing and unrestricted vehicle use.

Table 8 - Permanent Seeding Application Rates

Mix no.	Seeding mixtures	Seeding rates		Seeding dates	
		Lbs./Acre	Lbs./1000 Sq. Feet	Coastal Plain	Piedmont
1	Tall Switch Panic Grass	35	0.8	Feb 1 to June 1; Aug 15 to Oct 31.	March 1 - Oct 15.
	Red Fescue	35	0.8		
	Round-head bush-clover	2	0.1		
	Total Mix	72	1.7		
2	Tall Switch Panic Grass	35	0.8	June 1 - Aug 15.	
	Red Fescue	35	0.8		
	Round-head bush-clover	2	0.1		
	Purple Love Grass	2	0.1		
	Total Mix	74	1.8		
3	Tall Switch Panic Grass	70	1.6	Feb 1 - June 1; Aug 15 - Oct 31.	March 1 - Oct 15.
4	Spreading Panic Grass	40	0.9	Feb 1 - Oct 31	March 1 - Oct 15
	Narrowleaf bush-clover	20	0.5		
	Total Mix	60	1.4		

Note:

Use mix no. 1 in areas where some shade is present.

Use mix no. 2 during hot, dry periods of summer.

Use mix no. 3 areas with little or no shade. During hot dry periods of summer, add two pounds of Purple Lovegrass per acre.

Use mix no. 4 in areas where poorly drained soils are encountered.

Table 9 - Determining Road Area (Acres)*

Road Length(feet)	Road Width (feet)					
in Feet	8	10	12	14	18	20
150	0.01	0.01	0.01	0.02	0.02	0.02
200	0.02	0.02	0.03	0.03	0.04	0.05
250	0.05	0.06	0.07	0.08	0.10	0.11
500	0.09	0.12	0.14	0.16	0.21	0.23
1000	0.18	0.23	0.28	0.32	0.41	0.46
2500	0.46	0.57	0.69	0.80	1.03	1.15
5000	0.92	1.15	1.38	1.61	2.07	2.30
5280	0.97	1.21	1.45	1.70	2.18	2.42

* Formula for calculation of Road Area: $\frac{\text{Road width (ft.) X Road length (ft.)}}{\text{43,560 (square ft./acre)}}$

To determine the amount of material needed for a project, multiply the acreage value from *Table 9* by the recommended per acre seeding mixtures found in *Table 8*.

Example:
A 12-foot-wide road surface, 1,500 feet in length has an area of .42 acres.
Seeding mixture #4 meets landowner's desire for wildlife.

Tall Fescue	40 lbs x .42 acre = 16.8 pounds - round up to 17 pounds
Narrowleaf bush-clover	20 lbs x .42 acre = 8.4 pounds - round up to 8.5 pounds
Total Seeding Mixture:	25.5 pounds on .42 acres

GUIDELINES

FOR

TEMPORARY COVER PLANTING

Definition

Quick-growing, temporary vegetation planted when permanent cover cannot be planted due to the season or other reasons.

Purpose

To reduce or eliminate erosion of bare soil until permanent vegetation can be established.

Conditions Where This Practice Applies

Temporary vegetation is desirable to minimize erosion and sedimentation when permanent vegetation cannot be established due to the season of the year. Prepare the site as for permanent seeding. Under favorable conditions, native plants will become established on an area which has temporary cover and permanent seeding will not be necessary.

Specifications

1. Select from *Table 10* (which follows) a quick-growing grass with high seeding vigor that is suited to the area and the time of planting, and will provide a temporary cover which will not interfere with the plants to be sown later for permanent cover.

2. Seedings made in December and January will not provide effective short-term cover.

3. Mulch without seeding should be considered for the late winter when seed germination is low.

Table 10 - Temporary Seeding Application Rates (in pounds)

LATE WINTER - SPRING GRASSES & MIXTURES:

Seed Type(s)	Per 1,000 Sq. Ft.	Per Acre
Grasses may be used alone at the following rates:		
Oats	2	100
Rye	3	110 - 170
Ryegrass	1	30-40
Mixtures of oats and ryegrass may be used at the following rates:		
Oats	1	50
Ryegrass	1/2	20
Mixtures of oats and panic grass may be used at the following rates:		
Oats	1	50
Old Witch Panic Grass	1/2	20

SUMMER GRASSES & MIXTURES:

Seed Type(s)	Per 1,000 Sq. Ft.	Per Acre
Narrow leafed bush clover	1	35-45
Browntop Millet	1	30-40

LATE SUMMER-EARLY WINTER GRASSES & MIXTURES:

Seed Type(s)	Per 1,000 Sq. Ft.	Per Acre
Grasses may be used alone at the following rates:		
Rye	3	110-170
Ryegrass	1	30-40
Oats (Before Oct. 1)	2	100
Barley (Before Oct. 15)	3	100-150
Wheat (After Oct. 1)	3	60
A mixture of rye and ryegrass may be used at the following rate:		
Rye	1-1/2	56
Ryegrass	1/2	20

GUIDELINES

FOR

FOREST CHEMICAL APPLICATION

Definition

The application of pesticides, fertilizers, and other chemical and/or biological agents designed to protect and improve tree growth and survival.

Purpose

To maintain water quality standards during application of pesticides, fertilizers, and other chemical agents.

Condition Where Practice Applies

Sites that are adjacent to or contain open water, streams, drainage ditches, and wetlands.

Specifications

1. Extensive site review, resource identification and location, environmental factors (such as seasonal temperatures and coastal winds), and pre-application planning will be performed to ensure sensitive resource and water quality protection.

2. Perform a thorough analysis of the proposed forest improvement practice agents to ensure that the appropriate chemical and/or biological agents are used to achieve the management goal.

3. Streamside Management Zones (SMZs) are to be maintained and excluded from application of chemical and biological agents. Where SMZs are not identified, establish streamside buffers prior to any forest chemical applications using the same SMZ specifications for size and equipment activity.

4. All other site-specific measures should be taken to keep chemicals and biological agents from reaching streams by direct applications or by surface water runoff. Examples of measures include, but are not limited to: timing the application to ensure adequate foliage for effective application and to minimize direct application to water, restrictions and stoppage of spraying activities when winds exceed 7 miles per hour; and installation of erosion and sedimentation control measures on erodible soils where ground application equipment is to be used.

5. All chemical and biological agents are to be applied in strict accordance with manufacturers' label directions and federal, state, and local laws. Disposal of containers should follow manufacturers' label instructions as well as all federal, state, and local laws.

Pesticides:

Pesticides are chemicals and biological agents used to control vegetation (herbicides), insects (insecticides), or animals (rodenticides). They can be liquid, granular, or powder and can be applied aerially or from the ground. It is important to note that within Delaware, rodenticides are rarely used in silvicultural applications.

Certification Requirements: Pesticides which have been designated "Restricted Use" by the Environmental Protection Agency require application by or under the supervision of applicators certified by the Delaware Department of Agriculture, 2320 South DuPont Highway, Dover, Delaware 19901. Information on the certification process is available from the Department of Agriculture, telephone 302/698-4500.

Precautions: Water quality impact varies widely from one chemical to another and depends primarily on the chemical's mobility, its persistence, and the accuracy of its placement. Water quality can be protected by knowledge of the applied chemical and adherence to the manufacturer's specification and directions. The label contains information regarding applicator safety, species for which the chemical is registered, the pesticide application rate or concentration, appropriate weather conditions for use, environmental impact, and proper container disposal. Material Safety Data Sheets provide toxicological data and are available from the chemical manufacturer.

Forest Fertilization:

Nitrogen, phosphorus, or other elements and agents are applied by ground equipment, helicopter, or fixed-wing airplane for the purpose of enhancing tree growth. Ammonium nitrate is known to be toxic to fish and shellfish. Phosphorus is responsible for the acceleration of the oxygen-depletion process. Therefore, extreme care should be taken in their application to match the forest uptake with the application rate.

1. Do not broadcast fertilizer within an SMZ.

2. Apply fertilizer mixtures at rates appropriate for the targeted tree species and soils.

3. Application of fertilizer and disposal of containers must be made according to the manufacturer's label instructions, as well as federal, state, and local laws.

GUIDELINES

FOR

WILDLAND FIRE CONTROL AND RECLAMATION

Definition

Wildland fire control encompasses manpower, equipment, and techniques required to meet the immediate need to contain and suppress a wildland fire, and to limit the damage to natural and human resources. Reclamation is the stabilization and revegetation of the burned area.

Purpose

To efficiently, safely and effectively control and suppress wildland fires, while protecting water quality; also to take all corrective measures necessary to prevent erosion in the burned area and within firelines.

Condition Where Practice Applies

Areas where fire suppression methods were used to control a wildland fire.

Specifications

1. Use fire suppression equipment in a safe and wise manner. Avoid saturated soils and rutting during fireline building activities. When possible, avoid building firelines down streambanks and into streams.

2. Spraying in a stream pattern with high pressure water over short distances is not effective in wildland fire suppression and can potentially erode bare soils. Use fan or wide-angle spray settings during wildland fire suppression activities.

3. Following suppression and control of the fire, back blade any ruts to prevent gully formation.

4. During reclamation planning, assess reforestation and revegetation needs for bare soils. See *Revegetation of Bare Soils*, pg. 38, *Temporary Cover Plantings*, pg. 42, and *Site Preparation, Regeneration, and Improvement*, pg. 35 specifications. Integrate fireline maintenance and stabilization needs into reclamation plan.

The major purpose of a BMP is to reduce the erosive action and sediment-carrying ability of runoff waters. Additional measures can be considered such as:

Brush barriers - The use of slash materials at the toe slope of a road, culvert outlets, turnouts, waterbars, or dips to reduce and direct surface water flow.

Burlap or jute material - Dams made of sheet material to entrap sediment and release water through fabrics.

Cribs - A square or rectangular structure built of natural materials (logs) and located below an elevated culvert pipe outlet. The crib is filled with stone or brush to absorb and dissipate the force of falling water.

Envirofence - A plastic sheeting material with the capability of retaining most suspended materials and releasing waters through the fabric.

Hay or straw bales - Bales placed end to end forming a small check dam at a drainage or pipe outlet. Bales are secured in place with stakes.

Plastic sheets - Used at culvert outlets to spread (sheet) runoff waters.

Rip-Rap, brush, slabwood - Materials used to absorb or dissipate the forces of concentrated runoff waters.

Sediment traps, basins - Earthen structures which have a limited outlet allowing water to infiltrate or evaporate.

Trash dams - Log dams within small gullies to slow the flow of water and trap sediment.

Wooden mats - The bolting together of lumber–typically 2" x 6" oak planking–to form a mat to support and distribute the weight of vehicles. Often mats are 10' x 16'; however, the equipment, load, and soil type may warrant larger or smaller design sizes.

Best Management Practices For

FORESTED WETLANDS AND RIPARIAN FORESTS

INTRODUCTION

Forested Wetlands

Forested wetlands are found throughout Delaware. Wetlands are considered one of Delaware's vital resources. They provide flood storage, flood-velocity reduction, ground-water recharge, nutrient and sediment control, wildlife habitat, and timber supply.

Wetlands occur in depressions along rivers, lakes, coastal waters subject to periodic flooding, as well as some upland sites. They may be associated with groundwater seeps.

In defining wetlands from an ecological standpoint, the wetland requires three criteria:

(1) hydrology - the degree of flooding or soil saturation,
(2) wetland vegetation (hydrophytes), and
(3) hydric soils.

Wetlands are lands between well-drained upland areas and the waters of lakes, rivers, streams, and bays. The key to recognizing these lands is determining where wetness ends and upland begins. Many wetlands develop in distinct depressions or basins that can be readily observed; others occur in almost imperceptible shallow depressions that cover vast acreage.

These areas are inundated or saturated by surface or ground water at a frequency and duration sufficient to support an abundance of wetland vegetation. Throughout Delaware, a broad spectrum of vegetation occupies wetland sites. Some plant species are classified as hydrophytes (able to grow in oxygen-deficient soil), while others are classified as upland species. Upland vegetative species do occur, however, in wetlands throughout the state. The level of inundation or saturation and its duration (known as wetland hydrology) have a great influence on the types of plants which exist on the site. A key element to the protection of unusual, rare, and endangered species is the identification and location of such resources. The Natural Heritage Section of the Delaware Department of Natural Resources and Environmental Control can provide assistance in the location and identification of these resources (Telephone: 302/653-2880).

Water is a dominant factor determining the nature of soil development and influences the types of plant and animal communities living in the soil and on its surface. Water creates severe physiological problems for all plants and animals except those that are adapted to an aquatic habitat or saturated soil.

Wetland Hydrology

Water regimes are defined by the extent of flooding or soil saturation present during the frost-free growing season.

Permanently flooded - Water covers the land surface throughout the year. Vegetation is composed of water-tolerant plants such as cattails and buttonbush plants. Swamps, marshes, or open and shallow waters are examples of this wetland type.

Intermittently Exposed - Surface water is present throughout the year except in periods of extreme drought. Swamps, marshes, or open and shallow waters are examples of this wetland type.

Semi-permanently Flooded - Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface. Examples of this forest type include swamps with a woody overstory.

Seasonally Flooded - Surface water is present for extended periods (especially early in the growing season), but is absent by the end of the season in most years. When surface water is absent, the water level ranges from surface level to 4 or 5 feet below the surface. Examples of this type are the flood plains or first terraces along streams and rivers which have a woody overstory.

Saturated - The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present. Examples are broad flats with poorly drained soils that may never be flooded. Spring seeps may be included.

Wetland Soil Types

Soil is one of the most important physical components of wetlands. It influences the plant and animal communities through mineral composition, chemistry, organic matter content, moisture, and temperature. When soils are saturated or inundated with water for extended periods, the oxygen within the soil disappates and the soil becomes anaerobic. Soils of this type are classified as hydric soils. The USDA, Natural Resource Conservation Service (previously called Soil Conservation Service), has county soil maps that classify soils. A list of the hydric soils for Delaware is included following the Forested Wetlands Section of this manual on page 62.

Riparian Forests

Riparian forests are streamside forests or forested corridors adjacent to perennial streams. It is important to note that riparian forests are narrow, and other land uses, such as agricultural cropland and residential areas, exist along the outer perimeter. Riparian forests therefore protect and enhance water quality through their filtering capacity. They are also extremely complex ecosystems.

REGENERATION

GENERAL CONCEPTS

Forested wetlands have the capacity to naturally regenerate themselves. Successful regeneration depends on: recognizing the site type and its characteristics; evaluating the stocking and species composition in relation to stand age and site capability; planning regeneration options; and using sound harvesting methods.

Natural regeneration uses the normal cycle of wetland species succession; thus, regeneration cutting options are dependent on the species requirements for successful re-establishment. Landowner objectives determine whether the regeneration cycle will use early or late succession species. Overall, the regeneration cutting system is chosen on the basis of stand, site conditions, and landowner objectives.

Well-stocked, younger stands provide more management and regeneration options than overstocked, older stands. Young stands regenerate with greater vigor and more success than mature or climax stands. Harvesting should be planned to maximize both economic and regeneration potential. Repeated selective harvesting or clearcutting without regard to regeneration usually results in a decline of desired species.

The most effective regeneration cutting system to regenerate desirable, shade-intolerant species is clearcutting or patch-clearcutting. Examples of shade-intolerant species found in Delaware include baldcypress, Atlantic white-cedar, Eastern redcedar, yellow poplar, and loblolly pine.

The most effective regeneration cutting method to re-establish desirable, shade-tolerant species is selective cutting. Examples of shade-tolerant species and species which respond most effectively to a selection cutting method found in Delaware include swamp white oak, swamp chestnut oak, water oak, cherrybark oak, pignut hickory, American holly, and red or green ash.

WETLANDS, THE CLEAN WATER ACT, AND PERMIT CONSIDERATIONS

Normal silvicultural activities such as plowing, seeding, cultivating, and harvesting as part of a established silvicultural operation are exempt from Section 404 permit requirements of the Clean Water Act (Section 404, Permit Requirements, 33 CFR Section 323.4(a)(1)). Road building where Best Management Practices are utilized and the flow, circulation, or reach of the waters or wetlands are not impaired or reduced is also exempt from Section 404 permit requirements. **Discharge of fill materials into waters of the United States from ditching or other activities whose purpose is to convert forested wetlands to other uses is not covered by the silvicultural exemption.** Also, practices where the flow or circulation of the waters may be impaired, or the reach of the waters is reduced, are not covered under the silvicultural exemption of the Clean Water Act. More specific information should be obtained from the U.S. Army Corps of Engineers, Philadelphia District, 100 Penn Square, Philadelphia, PA 19107-3390, (215) 656-6728.

REGENERATION CUT IMPLEMENTATION

I. The harvesting methods used to implement the chosen regeneration cutting system will strongly influence the success of natural regeneration. The following techniques will aid in protecting site quality for all regeneration cutting systems:

1. Harvesting should be performed only on dry or unsaturated soils. Operations performed during saturated soil conditions not only impede equipment operation but cause site degradation through soil compaction, organic layer relocation or soil mixing, and reduced water movement or ponding of the soils.

2. Equipment should have high-flotation tires or wide tracks to minimize soil compaction.

3. Log landings, roads and skid trails should be carefully planned to utilize the driest soils. See specifications for these forest wetlands practices (pgs. 56, 58 and 59).

II. In addition, for selective regeneration cutting systems the following components should be integrated into performance of the harvesting operation:

1. Schedule harvest during the dormant season to take advantage of seed crops and to favor root sprout (coppice) regeneration.

2. Root sprout (coppice) reproduction obtained from growing season harvests will be reduced in quantity and quality compared to coppice from dormant season harvest.

3. Harvest trees at a stump height of less than 10 inches when practical to encourage vigorous sprout (coppice) regeneration.

III. In addition to the previously cited components, the following items should be integrated for clearcutting and patch clearcutting regeneration cutting systems:

1. Schedule harvest during the growing season or late in the growing season during good seed production years to reduce competition coppice sprouting.

2. Harvests late in the growing season will result in the spread of seed for natural regeneration combined with a good seed crop.

3. Harvest the stand as completely as possible to allow maximum sunlight. Most residual trees should be cut to insure full sunlight to the forest floor. Leave several scattered standing dead trees or snags per acre to provide for wildlife habitat.

4. Where ground conditions permit, control residuals larger than 1½ inches in diameter by felling, girdling, or stump treatment or injection of chemical herbicides. Control residuals within six months of harvest to obtain benefit from the prevailing seed crop and from soil scarification resulting from logging.

FORESTED WETLANDS

PRE-HARVEST PLANNING

Definition

Pre-harvest planning is the collection and use of information about an area to determine the best time and method to harvest, and the ideal road and skid trail system.

Purpose

Planning provides an organized method for an efficient harvest operation while maintaining subsurface and surface water quality.

Condition Where Practice Applies

Where operations will involve the use of mechanized equipment to harvest forest products from wetlands sites.

Specifications

The wetlands pre-harvest plan should include the following points:

1. Identification of wetlands based on site review of mapped wetlands. Wetlands may need to be flagged, particularly where saturated soils exist.

2. Follow specifications for upland pre-harvest planning.

3. Establish the 50-foot Streamside Management Zone (SMZ) on each side of stream channels or along areas of open water.

4. Locate log decks on uplands whenever possible, and procure primary sources of road building or borrow materials used for road construction from upland sites.

5. Locate the main road system on the uplands and develop a tentative road system within the wetlands.

6. Identify any special equipment required for skidding and hauling or other harvesting methods (barge, cable, etc). Use machinery with adequate flotation to minimize degradation and impact on the soil surface and site quality. Flotation devices should keep rutting within acceptable limits.

7. Identify potential problems or events that may interrupt logging operations. Identify suitable alternative measures which protect water and soils.

8. Schedule operations that promote harvesting during extreme dry periods and during times that enhance regeneration.

FORESTED WETLANDS
AND RIPARIAN FORESTS

STREAMSIDE MANAGEMENT ZONE (SMZ)

Definition

An area on both sides of wetlands, intermittent and perennial streams adjacent to wetlands, and riparian forests where extra caution is required during harvesting or other forest practices to maintain water quality.

Purpose

Provides a relatively undisturbed zone to trap and filter out suspended sediments before particulates reach the wetland, stream channel, open water, or riparian forest stream.

Conditions Where Practice Applies

SMZs should be maintained along perennial and intermittent streams adjacent to wetlands and riparian forests, except as permitted by current rules and regulations (Delaware Seed Tree Law).

Forested Wetland Specifications

1. The SMZ should be a minimum of 50-feet wide. *Table 11* below lists the minimum width for SMZs based on slope. SMZ width is measured in linear feet horizontally from the perimeter of the water body. For tidal waters, the high-water line should be used as the perimeter. Where highly erodible soils exist, the SMZ width should be expanded to include the top of the slope, up to a maximum distance of 100 feet.

Table 11 - Minimum SMZ Widths for Forested Wetlands

Percent of slope	0-10%	11-20%	21-45%
Horizontal distance	50 feet	75 feet	100 feet

2. Limit the use of logging equipment by using dispersed skidding, cable and winch, and carefully planned skid trail locations. Leave the forest floor essentially undisturbed. The original litter layer should not be disturbed (i.e. expose mineral soil). When necessary to prevent erosion and sediment movement, stabilize bare soils utilizing the specification(s) needed for *Revegetation of Bare Soil Areas*, pg. 38, with the exception of the use of fertilizers due to pollution potential.

3 Retain at least 60 square feet of basal area per acre of trees well distributed throughout the area, or retain 60 percent of the overstory. The remaining trees should be equally divided among diameter classes. The landowner may desire to leave up to 80 percent of the crown cover to provide shading for streams.

4. Locate sawmill or log deck sites on well-drained areas a minimum of 50-feet outside the SMZ.

5. Remove all harvested tree laps, slash, tops, and other debris from streams, sloughs, drainage ditches, open water, and inundated wetlands.

6. Avoid construction of roads within the SMZ as well as roads crossing the SMZ. Where road crossings of SMZs and stream channels are unavoidable, they should be at or near a right angle. (See *Truck Haul Road* and *Stream Crossing* specifications, pgs. 4 and 15) Install energy absorbers such as brush rip-rap at cross-drained culvert outlets or discharge points when needed; use care not to block water flow.

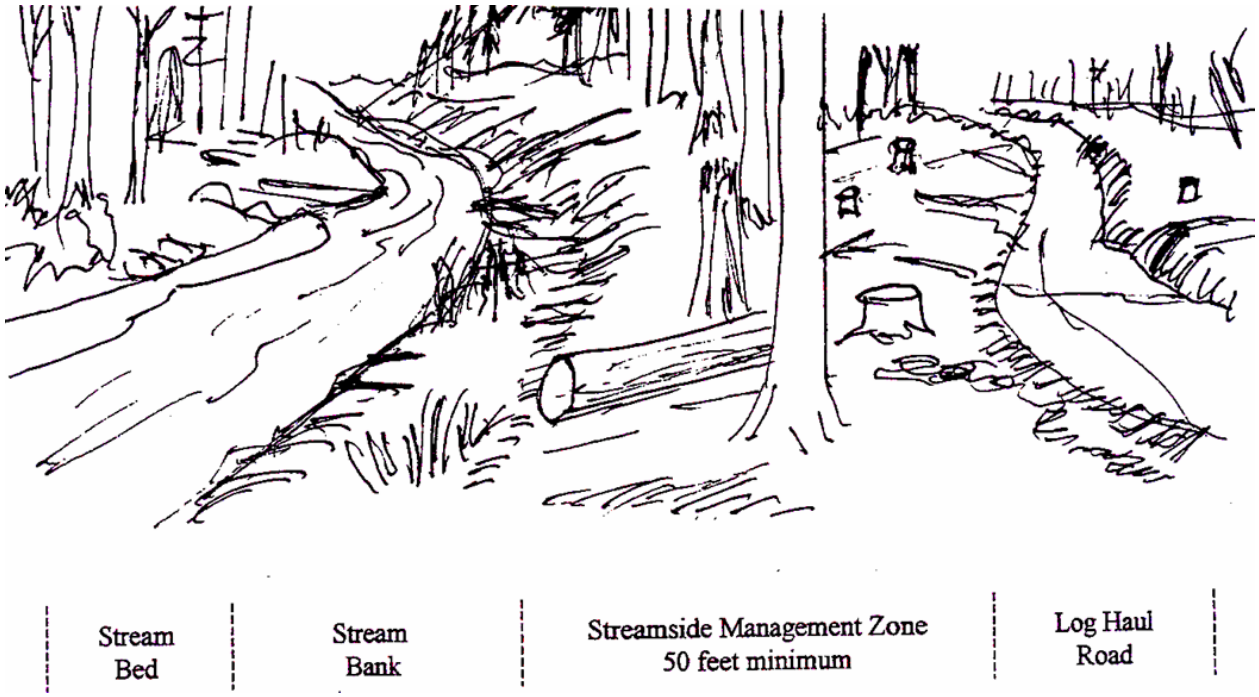
7. Drainage structures such as ditches (less than 2 feet deep), cross-drain culverts, waterbars, rolling dips, and broad-based dips should be used on truck and skid roads prior to their entrance into a SMZ to intercept and properly discharge runoff waters.

Riparian Forest SMZ Specifications

1. The SMZ shall contain a 25-foot wide NO-HARVEST zone from the top edge of the stream. At the perimeter of the 25 foot NO-HARVEST zone, the SMZ should be a minimum of a 50-foot wide active management area for slopes of 0 to 10 percent. See *Table 11* for additional widths.

2. Within the 50-foot minimum wide active management area, retain at least 60 square feet of basal area per acre of trees well distributed throughout the area or retain 60 percent of the overstory. The remaining trees should be equally divided among diameter classes. The landowner may desire to leave up to 80 percent of the crown cover to provide shading for streams.

Streamside Management Zone (SMZ)



FORESTED WETLANDS

TRUCK HAUL ROADS

Definition

A road system, temporary or permanent, installed for transportation of wood products from the harvest site by truck. Usually a single-lane road system incorporating mats or a road base improved with stone or other material.

Purpose

To provide an efficient transportation system to remove forest products; maintain natural water flow patterns; and provide safety, higher vehicle speeds, and longer operating periods while reducing operating and maintenance costs.

Condition Where Practice Applies

Where area and volume make it necessary for an operator to install such a road system; also used in conditions where special practices are needed to maintain water levels and drainage patterns.

Specifications

1. Cross streams, sloughs, or existing drainage channels with properly sized culverts or bridges. (See *Stream Crossing* specifications, pg. 15 and *Table 3*, pg. 16.)

2. Use planking or wooden mats to improve the soil's ability to support traffic and heavy loads.

3. The use of oversized or balloon tires is encouraged to reduce compaction and rutting.

4. Construct fill roads only when absolutely necessary. Road fills should be no more than 2 feet above the natural ground level with cross drains (outlets) for surface water flow. Cross drains would be established at low areas and depressions and placed no more than 100 feet apart.

5. Remove culverts on temporary toads at completion of harvest as they tend to plug. Culverts, rip rap fords, and similar materials are suitable cross drains for unrestricted surface flow on permanent roads. Permanent roads should be stabilized to prevent erosion and sediment loss.

6. Roads should be constructed parallel to the flow of the main channel and no closer than 200 feet from the 50 foot SMZ along the main channel, except when the road is built for the purpose of crossing a main channel.

7. Travel widths should normally be 12 to 16 feet with turnouts placed at intervals to accommodate two-way traffic.

8. Gravel or crushed rock should be used as fill to provide movement of ground water and serve as a base for the road bed.

9. Use thick layers of large wood chips as a road bed to distribute load weight and limit the road's adverse effects.

10. A layer of poles, slabs, or logs laid side by side extending 3 to 4 feet on each side beyond the width of the road bed can provide a base for borrow or fill material.

11. Fabric materials may be used to increase soil-bearing capability. Borrow or fill material placed on top of fabric material will reduce soil failure and deep rutting. Fabric reduces the thickness of base material needed, reduces deep road bed compaction, and allows flow of ground water.

12. After harvesting, remove obstructions (e.g. culverts, pipes, logs) in channels and sloughs that restrict surface flows.

13. Move equipment to upland areas during periods of potential flooding and wet periods.

14. Control access with gates, tank traps, large obstructions, or other traffic-deterring materials.

LOG DECKS AND LANDINGS

Definition

An area where logs are assembled including decks at the end of skid and haul roads as well as concentration yards.

Purpose

To have a centralized location to assemble harvested timber products for sawing, sorting, and/or loading onto trucks.

Condition Where Practice Applies

Area which is large enough to require the concentration of materials for loading.

Specifications

This practice usually results in the disturbance and compaction of the surface. Care should be taken to locate decks properly to minimize deep rutting and/or concentration of surface water.

1. Locate log decks outside identified wetlands whenever possible and in advance of road construction.

2. Locate log decks on elevated areas of the uplands or higher elevations such as islands within large wetlands units.

3. Provide for adequate drainage on approach roads and trails so that surface-water drainage does not enter the log deck and cause "mud holes."

4. Service equipment on decks in such a way that oil, lubricants, etc. are drained into containers and disposed of in accordance with proper waste disposal guidelines (requirements). Remove all equipment at the end of the harvesting operation.

5. Locate residue piles (sawdust, slabs, etc.) outside of the wetlands and wet weather drainages so that water will not flow over or through the residue.

6. Gravel, borrow materials, slab materials, mats, fabrics, or other material can be used for adequate drainage and bearing capacity.

7. Stabilize landings within the first 15 days of the next seeding season after harvest completion.

8. When riparian forests are harvested, locate mill sites and log decks on uplands and following the specifications for Streamside Management Zones in *Wetlands and Riparian Forests*, pg. 53.

FORESTED WETLANDS

SKID TRAILS

Definition

An unsurfaced, single-lane trail, or road, narrower than a truck haul road, used for skidding harvested products to minimize disturbance.

Purpose

To skid logs, tree lengths, or other roundwood products from the stump to a common landing or concentration area.

Condition Where Practice Applies

Where harvesting requires centralizing the products for sawing or for loading onto trucks or trailers, and where the size of an operation makes skidding the primary–and most economical–means of collecting trees, logs, or other roundwood products.

Specifications

Major skid trails should be planned to minimize damage to the residual stand, reduce erosion and sedimentation, maintain surface and subsurface water flow, and provide the most economical method for skidding products.

1. Locate log decks first and lay out road approaches with good drainage.

2. The use of wide tracks on bulldozers (24 inches or more) and high-flotation or dual tires on skidders (38 inches or more) provides increased surface contact reducing soil compaction and rutting.

3. Locate skid trails outside the Streamside Management Zone.

4. Skid trails should not cross perennial streams, intermittent streams with well-defined stream channels, sloughs, or saturated wetlands unless absolutely necessary. When skid trails cross these areas, a bridge or culvert of acceptable design should be used. See *Stream Crossing* specifications, pg. 15.

5. Approaches to water crossings should be at or near a right angle to the stream direction and of sufficient length to allow logs to orient behind the skidder.

6. In peat and muck swamps (organics), the use of sandy sloughs as skid trails reduces severe rutting. These sloughs have deep accumulation of sands and provide greater support than peat and muck. They should be used only during the dry season and never when surface water is present.

FORESTED WETLANDS

CROSS ROAD DRAINAGES

Definition

Corrugated metal pipe or other suitable material placed under truck haul roads or skid trails to permit uninterrupted surface water flow.

Purpose

To collect and transmit water flows and reduce obstruction of surface flow.

Conditions Where Practice Applies

Cross drainages can be used where drainage is necessary to reduce ponding and to insure the flow, circulation, or reach of the waters or wetlands are not impaired or reduced.

Specifications

Streams:

1. Both ends of the pipe should extend at least 1 foot beyond the edge of the fill material.

2. Fill material should be a minimum of 1 foot or more over the pipe. Fill material should be more than 1/2 the pipe diameter between multiple pipe installation.

3. Pipe diameter should be a minimum of 15 inches. Multiple pipes may be used to meet the minimum required diameter culvert (see *Table 12 - Culvert Pipe and Equivalent*).

4. Pipe slope should be just below the stream bed gradient with the same alignment as the stream course. A headwall of logs, concrete, sandbags, or hand-placed rip-rap will help guide water into culvert and hold pipe in place.

Cross Drainage:

1. Both ends of the pipe should extend at least 1 foot beyond the edge of the fill material.

2. Culverts are placed on grade and in depressions to prevent ponding.

3. Erosion protection should be provided for outflows of culverts to minimize erosion downstream from the outfall. Protection may also be needed on the upstream end of culverts in flowing streams. This can be in the form of rip-rap, plastic filter cloth, large stones, etc.

Table 12 - Culvert Diameter Sizes
for Wetland and Riparian Forests with 0-5% Slopes

(Pipe diameter in inches)

Acres Drained	Light soils	Medium soils	Heavy soils	Organic soils
2	15	15	18	18
4	15	15	21	18
6	15	15	21	21
8	15	15	24	21
10	15	18	27	24
20	15	21	30	24
30	15	21	36	27
40	15	24	42	27
50	15	27	42	30
60	15	27	42	30
70	15	27	48	36
80	15	30	48	36
90	15	30	48	42
100	15	30	48	42
150	18	36	54	42
200	21	36		
250	21	42		
300	21	42		
350	24	42		
400	24	48		

Hydric Soils of Delaware

The following is a list of the hydric soils of Delaware as determined by the USDA Natural Resource Conservation Service (formerly Soil Conservation Service). The list was current as of September 1995. Each county's soils are listed separately. Please note that several of the soils below are considered hydric only when they are found in depressions or under other specific conditions.

Hydric Soil List - New Castle County, Delaware

Map Unit Symbol	Map Unit Name
The following soil types are normally considered hydric:	
Ba	Bayboro silt loam
El	Elkton sand loam, 0 to 2 percent slopes
Em	Elkton silt loam, 0 to 2 percent slopes
Fa	Fallsington sandy loam
Fs	Fallsington loam
Wc	Watchung and Calvert silt loams, 0 to 3 percent slopes
Ha	Hatboro silt loam
Hb	Hatboro silt loam, local alluvium, 0 to 3 percent slopes
Jo	Johnston loam
Tm	Tidal marsh
Po	Pocomoke loam
Kr	Kinkora silt loam 0 to 3 percent slopes
Ot	Othello silt loam
Mv	Mixed alluvial land
The following soil types are only hydric when they are found in depressions:	
Mt	Mattapex silt loam, 0 to 2 percent slopes
KrB	Kinkora silt loam, 3 to 8 percent slopes
Ke	Keyport silt loam, 2 to 5 percent slopes, moderately eroded
St	Silty and clayey land, gently sloping
Ke	Keyport silt loam, 0 to 2 percent slopes
Ws	Woodstown loam, 0 to 2 percent slopes
Wc	Watchung and Calvert silt loams, 3 to 8 percent slopes
Wo	Woodstown sandy loam, 0 to 2 percent slopes
Gp	Gravel pits and quarries. The floor of gravel pits are hydric.

Hydric Soil List - Kent County, Delaware

Map Unit Symbol	Map Unit Name
	The following soil types are considered hydric.
As	Askecksy loamy sand
Ca	Carmichael loam
Co	Corsica mucky loam
Em	Elkton silt loam
Fa	Fallsington sandy loam
Fg	Fallsington loam
Fz	Fallsington-Urban land complex
Ho	Hammonton-Fallsington-Mullica complex
Hu	Hurlock loamy sand
Hv	Hurlock sandy loam
Im	Ingleside-Hammonton-Fallsington complex
Kf	Keyport fine sandy loam
Le	Leipsic silt loam
Lf	Lenni sandy loam
Lh	Lenni silt loam
Lk	Lenape mucky peat
Ln	Lenape-Nanticoke complex
LO	Longmarsh and Indiantown soils
Ma	Manahawkin muck
Mc	Marshyhope loam
Md	Marshyhope sandy loam
Mm	Mullica mucky sandy loam
Ot	Othello silt loam
Pk	Puckum muck
Su	Sunken mucky silt loam
Te	Tent silt loam
Wd	Woodstown sandy loam
Wh	Whitemarsh silt loam
Za	Zekiah sandy loam
	The following soil types are considered hydric only in depressions.
Cs	Crosiadore silt loam, 0 to 2 percent slopes
Hm	Hammonton loamy sand
Hn	Hammonton sandy loam
Kg	Klej-Galloway complex
Kn	Kentuck mucky silt loam
Kp	Keyport silt loam
Ks	Klej loamy sand
Mt	Mattapex silt loam
Ns	Nassawango silt loam
Py	Pineyneck loam
Ru	Runclint loamy sand
Ub	Udorthents, borrow area
Wd	Woodstown sandy loam
Wo	Woodstown loam

Hydric Soil List - Sussex County, Delaware

The following soil types are considered hydric.

Map Unit Symbol	Map Unit Name
Ba	Broadkill=Appoquinimink complex
Bh	Berryland mucky loamy sand
Br	Broadkill mucky peat
Bu	Brockatonorton-Urban land complex
Co	Corsica mucky loam
Fa	Falsington sandy loam
Fg	Fallsington loam
Fz	Fallsington-Urban land complex
Hu	Hurlock loamy sand
Im	Ingleside-Hammonton-Falsington complex
Kf	Keyport fine sandy loam
Lf	Lenni sandy loam
Lk	Lenape mucky peat
Ln	Lenake complex
Ma	Manahawkin muck
Mc	Marshyhope loam
Md	Marshyhope sandy loam
Mm	Mullica mucky sandy loam
Mu	Mullilca-Berryland complex
NM	Nanticoke and Mannington soils
Pa	Pawcatuck mucky peat
Pk	Puckum muck
Pu	Purnell peat
Sp	Saltpond mucky sand
SSD	Sassafras soils
TP	Transquaking and Mispillion soils
Za	Zekiah sandy loam

The following soil types are considered hydric only in depressions.

As	Askecksy loamy sand
Ca	Carmichael loam
Hm	Hammonton loamy sand
Hn	Hammonton sandy loam
Ho	Hammonton-Fallsington-Mullica complex
Hv	Hurlock sandy loam
Kg	Klej-Galloway complex
Kp	Keyport silt loam
Ks	Klej loamy sand
Lh	Lenni silt loam
LO	Longmarsh and Indiantown soils
Py	Pineyneck loam
Rs	Runclint sand
Ru	Runclint loamy sand
Ub	Udorthents, borrow area
Wd	Woodstown sandy loam
Wo	Woodstown loam

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GLOSSARY

The list of terms that follows is a representative sample of those used by foresters, lumbermen, loggers, soil scientists, biologists, engineers, conservationist planners, and other conservation professionals. The terms may not be used in the text but are commonly used in conservation matters.

Access road: A temporary or permanent route which allows vehicles into forest land.

Barriers: Obstructions to pedestrian, horse, and/or vehicular traffic. They are intended to restrict such traffic to a specific location.

Bearing capacity: The maximum load that a material (soil) can support before failing.

Bedding: A site-preparation method in which special equipment is used to concentrate surface soil and forest litter into a ridge 6 to 10 inches high on which forest seedlings are to be planted.

Bottomlands: A term often used to define lowlands adjacent to streams.

Broad-based dip: A surface drainage structure specifically designed to drain water from an access road while vehicles maintain normal travel speeds.

Brood trees: Trees that harbor reproducing insect pest populations. They often serve as sources of infection for neighboring trees.

Channel: A natural stream that conveys water. A ditch or channel excavated for the flow of water.

Check dam: A small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.

Contamination: The introduction of micro-organisms, chemical, organic and inorganic wastes or sewage into water, thus rendering the water unfit for its intended use.

Contour: An imaginary line on the surface of the earth connecting points of the same elevation. A line drawn on a map connecting points of the same elevation.

Culvert: A conduit through which surface water can flow under roads.

Cut: Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

Cut-and-fill: Process of moving earth by excavating part of an area (the cut) and using the excavated material for adjacent embankments or areas which need more soil (the fill).

Diversion: A channel with a supporting ridge on the lower side constructed across or at the bottom of a slope for the purpose of intercepting surface runoff.

Diversion ditch: A drainage depression or ditch built across the top of a slope to divert surface water from that slope.

Erosion: The process by which soil particles are detached and transported by water, wind, and gravity to some downslope or downstream point. The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep, and detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

Erosion classes (soil survey): A grouping of erosion conditions based on the degree of erosion or on characteristic patterns. Applied to accelerated erosion; not to normal, natural, or geological erosion. Four erosion classes are recognized for water erosion and three for wind erosion.

Fill slope: The surface area formed where earth is deposited to build a road or trail.

Firebreaks: Naturally occurring or man-man barriers to the spread of fire.

Fireline: A barrier used to stop the spread the fire constructed by removing fuel or rendering fuel unflammable by use of water or fire retardants.

Ford: Submerged stream crossing where tread is reinforced to bear intended traffic. A place where a perennial stream may be crossed by vehicle.

Forest chemicals: Chemical substances or formulations that perform important functions in forest management. (e.g., fertilizers, herbicides, repellents)

Forestland: Land bearing forest growth, or land from which the forest has been removed but which shows evidence of past forest occupancy (now in other use).

Forest landowner: An individual, combination of individuals, partnership, corporation, foundation, non-governmental agency, or association that holds an ownership interest in forest land.

Forest practice: An activity relating to the growing, protecting, harvesting, or processing of forest tree species on forest land and to other forest management aspects such as wildlife, recreation, etc.

Grade: The slope of a road or trail expressed as a percent of change in elevation per unit of distance traveled.

Gully erosion: Erosion process whereby water accumulated in narrow channels, and over short periods, removed soil from this narrow area to considerable depths (one foot or more).

Harvesting: The felling, loading, and transportation of forest products, roundwood, or logs.

Herbicide: Any substance, or mixture of substances, intended to prevent the growth of or to kill any tree, bush, weed, or algae and other aquatic weeds.

Herbicide mobility: The ease with which the active ingredients of an herbicide can move away from the area of application. This movement can be by drift, evaporation, rain, runoff, or through the soil.

Intermittent streams: A stream or portion of a stream that flows only in direct response to precipitation. It is dry for a large part of the year (usually more than three months). Watercourses shown as a dashed blue line on the United States Geological Survey 7.5 Minute Series (topographic) quadrangle map.

Logging debris: That unwanted, unutilized, and generally unmarketable accumulation of woody material in the forest such as large limbs, tops, cull logs, and stumps that remain as forest residue after timber harvesting.

Mineral soil: Organic free soil that contains rock less than 2 inches in maximum dimension.

Mulch: A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Mulching: Covering forest soil with any loose cover of organic residues, such as grass, straw, bark, or wood fibers, to check erosion and stabilize exposed soil.

Non-point source pollution: Pollution that enters a water body from a diffuse origin on the watershed and does not result from discernable, confined, or discrete conveyances.

Nutrients: Mineral elements in the forest ecosystem such as nitrogen, phosphorus, or potassium that are naturally present or may be added to the forest environment by forest practices such as fertilizer or fire retardant applications. Substances necessary for the growth and reproduction of organism. In water, those substances that promote growth of algae and bacteria, chiefly nitrates and phosphates.

Organics: Particles of vegetation or other biologic material which can degrade water quality by decreasing dissolved oxygen and by releasing organic solutes during leaching.

Oxidization: The process of breaking down organics into basic chemicals.

Perennial stream: A stream that maintains water in its channel for a majority of the year. They are shown as a solid blue line on the United States Geological Survey 7.5 Minutes Series (topographic) quadrangle maps.

Persistence: The relative ability of a pesticide to remain active over a period of time.

Pesticides: Chemical compounds used for the control of undesirable plants, animals, or insects. The term includes insecticides, herbicides, and rodenticides, but as used in this handbook, does not include nontoxic repellents or other chemicals.

Pollutant: "Dredged soil, solid wastes, incinerator residue, sewage, garbage, sewage sludge, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water". (P.L. 92-500, Section 502(6).

Pollution: The presence in a body of water (or soil or air) of substances of such character and in such quantities that the natural quality of the environment is impaired, rendered harmful to health and life, or offensive to the senses.

Puncheon: A structure used to cross wet locations on a trail constructed of logs and/or lumber.

Regeneration: The process by which a young tree crop replaces older trees removed by harvest.

Residual trees: Live trees left standing after the completion of harvesting.

Rill erosion: An erosion process in which numerous small channels only several inches deep are formed. Occurs mainly on disturbed and exposed soils.

Rip-rap: Aggregate placed on erodible sites to reduce the impact of rain or surface runoff on these areas.

Rolling dip: A shallow depression built diagonally across a light-duty road or trail for the purpose of diverting surface water runoff from the road or trail.

Runoff: In forest areas, that portion of precipitation that flows from a drainage area across the land surface or in open channels.

Ruts: A depression in access roads made by continuous passage of vehicles.

Salvage harvest: Removal of trees that are dead or imminently threatened with death in order to use wood before it is rendered valueless by natural decay agents.

Sanitation harvest: Removal of trees that are under attack by or highly susceptible to insect and disease agents in order to check the spread of such agents.

Sediment: Solid material that is in suspension, is being transported, or has been moved from its site of origin.

Seedbed: The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings.

Sheet erosion: The removal of a fairly uniform layer of soil from the land surface by water runoff.

Silvicultural activities: All forest management activities, including logging, log transport, and forest roads.

Site preparation: A forest activity to remove unwanted vegetation and other material; to cultivate or prepare the soil for reforestation.

Skid trails: A temporary pathway over forest soil to drag felled trees or logs to a landing.

Slope: Degree of deviation of a surface from the horizontal measured as a numerical ratio, percent, or in degrees. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), as 2:1. A 2:1 slope is a 50 percent slope. Expressed in degrees, the slope is the angle from the horizontal plane with a 90 degree slope being vertical (maximum) and 45 degree being a 1:1 slope.

Soil: The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

Soil conservation: Using the soil within the limits of its physical characteristics and protecting it from unalterable limitations of climate and topography.

Soil dispersion: The breaking down of soil aggregate into individual particles, resulting in single-grain structure. Ease of dispersion is an important factor influencing the erodibility of soils. Generally speaking, erodibility increases with soil dispersion.

Soil permeability: The quality of a soil horizon that enables water or air to move through it. The permeability of a soil may be limited by the presence of one nearly impermeable horizon even though the others are permeable.

Soil productivity: The output or productive capability of a forest soil to grow healthy and vigorous trees.

Stream: A permanently or intermittently flowing body of water that follows a defined course.

Streamside Management Zone (SMZ): An area of 50 feet or more on both sides of the banks of perennial and intermittent streams and bodies of open water where extra precaution is used in carrying out forest practices in order to protect bank edges and water quality.

Streambanks: The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

Susceptibility: The likelihood of attack or infection by a destructive insect or disease organism.

Susceptible species: A type of tree or plant that has a high probability of attack by a given insect or disease agent.

Switchback: A 180 degree direction change in a trail or road used to climb steep slopes.

Thermal pollution: A temperature rise in a body of water sufficient to be harmful to aquatic life in the water.

Toxicity: The characteristic of being poisonous or harmful to plant or animal life; the relative degree or severity of this characteristic.

Tread: Load-bearing surface of a trail or road.

Turnout: A widened space in a road to allow vehicles to pass one another; a drainage ditch which drains water away from roads.

Turnpike: Tread made stable in wet, boggy areas by placing mineral soil between parallel side logs or rocks; may include ditches alongside the trail.

Waste: Materials and substances usually discarded as worthless to the user.

Water bar: A diversion ditch and/or hump across a trail or road tied into the road's uphill side for the purpose of carrying water runoff into vegetation, duff, a ditch, or dispersion area to minimize its volume and velocity. Reducing volume and velocity reduces soil movement and erosion.

Water body: An area where water stands with relatively little or slow movement (ponds, lakes, bays).

Water course: A definite channel with bed and banks within which concentrated water flows continuously or intermittently.

Water pollution: Any introduction of foreign material into water or similar impingement which produces undesirable changes in the physical, biological, or chemical characteristics of that water.

Water quality: A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Water quality standards: Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonate, pH total dissolved salts, etc.

Watershed area: All land and water within the confines of a drainage divide or a water problem area consisting in whole, or in part, of land needing drainage or irrigation.

Wetlands: Geographic areas characteristically supporting hydrophytes, hydric soils, and some saturation or flooding during the growing season.

Wildfire control: Actions taken to contain and suppress uncontrolled fires.

Wildfires: Uncontrolled fires occurring in forestland, brushland, and grassland.

APPENDIX A

DEPARTMENT OF AGRICULTURE
Statutory Authority: 3 Delaware Code
Section 1101 (3 Del.C. § 1011)

Forest Service Regulations

1.0 AUTHORITY

These regulations are promulgated under the authority of Section 1011 of Title 3 of the Delaware Code.

2.0 PURPOSE

The purpose of these amendments to the Forest Service's Erosion and Sedimentation Control regulations is to streamline the process for responding to potential or existing water quality problems and to establish an enforcement scheme for dealing with operators who do not file the proper permits prior to commencing a timber harvest. These rules and regulations apply to silvicultural operations, as defined, being conducted on private, state, and federal lands within the State of Delaware, unless otherwise stated in the regulations.

The intent of these rules and regulations is to ensure that silvicultural activities do not cause erosion and sedimentation to Delaware's waters. The Delaware Forest Service has determined that timber harvests and shearing & piling are the two silvicultural activities that pose the greatest potential for producing erosion and sedimentation. Therefore a notification system is required for these two activities. Other silvicultural activities, such as but not limited to, root raking, chemical application, installation and maintenance of firebreaks, do not require prior notification but operators are to follow best management practices (BMPs) as outlined in Delaware's Forestry BMP Manual (DE Dept. of Ag. Document #65-01-04/95/09/01)

3.0 DEFINITIONS:

3.1 **Acceptable sediment control and stormwater management techniques** are equivalent/synonymous to/with both erosion and sediment control measures and forestry Best Management Practices (BMP).

3.2 **Business days** are defined as any day Monday through Friday.

3.3 **Buyer** is defined as "any individual or firm that regularly purchases standing trees for harvest by himself or herself or a subcontractor."

3.4 **Department** is the Delaware Department of Agriculture.

3.5 **DFS** is the Delaware Forest Service

3.6 **DNREC** is the Delaware Department of Natural Resources and Environmental Control.

3.7 **Forest management activities** are herein defined as practices, techniques or activities which are designed for purpose of conserving, protecting and enhancing the land as forest land over the long-term. Forest management includes but is not limited to perpetuation of tree species; improvement of trees' and forest growth, health and vigor; protection from fire, and insects and diseases.

3.8 **Forester** is defined as a Forester, Senior Forester, Regional Forester, Assistant Forestry Administrator, or Forestry Administrator currently employed by the Delaware Forest Service.

3.9 **Intermittent Stream with a well-defined channel** is a defined as a water body which is naturally occurring, and maintains a seasonal flow of water under typical climatic conditions.

3.10 **Normal rainfall** is an inch of liquid precipitation in a 24 hour period.

3.11 **Open water body** is a bay, lake, or pond where water is present throughout the year. This does not include man-made water channels such as ditches.

3.12 **Operator** is defined as "any person that operates or exercises control over any silvicultural activity."

3.13 **Perennial stream** is defined as a water body with a well-defined channel which maintains a continuous flow of water throughout the year under typical climatic conditions. This does not include man-made water channels such as ditches.

3.14 **Permittee** is defined as "any individual or firm that has a Delaware Erosion and Sediment Law Notification Form and Permit that has been approved by the DFS."

3.15 **Pollution** is defined as the "alteration of the physical, chemical or biological properties of any waters of the State resulting from sediment deposition that will or is likely to create a nuisance or render such waters (a) harmful or detrimental or injurious to the public health, safety or welfare or the health of animals, fish or aquatic life; (b) unsuitable with reasonable treatment for use as present or possible future source as a public water supply; or unsuitable for recreational, commercial, industrial, agricultural, or other reasonable uses."

3.16 **Secretary** is the Delaware Secretary of Agriculture

3.17 **Shearing and Piling** is defined as preparing a site for reforestation by using a crawler tractor with a shear blade, commonly known as a "K-G blade" to cut off at ground level any trees or shrubs that remain after a timber harvest. This brush and debris is then piled in rows by a crawler tractor with a root raking blade. The spacing between the rows of debris is determined on site, and tree seedlings are planted between the rows.

3.18 **Silvicultural activity** is defined as "any forest management activity, including but not limited to harvesting of timber, the construction of roads and trails for forest management purposes, and the preparation of property for reforestation."

4.0 RULES AND REGULATIONS INTENT AND GOALS

The intent of the Rules and Regulations is to establish a system of notification and referral that quickly and easily provides the Forestry Administrator with the information needed to administer Delaware's Forestry Practices E&S Law without causing undue hardship on operators and landowners. The goals of these Rules and Regulations are:

4.1 to protect the waters of the State from erosion and sedimentation resulting from silvicultural activities; and

4.2 to provide the Forestry Administrator the authority to:

4.2.1 track the use and effectiveness of Forestry BMPs,

4.2.2 develop close working relationships with forest operators and landowners through site visits,

4.2.3 permit the Delaware Forest Service to rapidly address inquiries from citizens, agencies, and other organizations concerning ongoing silvicultural operations, and

4.2.4 document the positive benefits of properly managed forests.

5.0 REGULATORY PROCEDURES

5.1 Operators and buyers will provide written notification to Delaware Forest Service (DFS) at least five (5) business days prior to the initiation of covered silvicultural operations greater than or equal to 43,560 square feet of area (1 acre).

5.2 Operators and buyers will notify the Department by completing and signing Delaware's Forestry Practices Erosion and Sediment Law Notification Form and Permit, as provided by the Delaware Forest Service (DFS). No covered silvicultural activity will start prior to the date that an Erosion & Sediment Control Permit is approved.

5.3 This notification form will include, but is not limited to:

5.3.1 the forest land acreage and type of covered silvicultural activity planned,

5.3.2 statement that land will remain under forest management,

5.3.4 signed statements stating the operators' intent to use forestry BMPs to prevent pollution,

5.3.5 specific Forestry BMPs to be used on the site,

5.3.6 maps of the site, including location of any water bodies, streams, ponds, Streamside Management Zones, roads, stream crossings, landings, and other pertinent site specific information as appropriate, and

5.3.7 estimated start and completion dates

5.3.8 county tax parcel identification number

5.3.9 If the property is covered by the Delaware Seed Tree Law and, if so, how the owner intends to reforest the property.

5.4 Notification forms will be sent to the local Delaware Forest Service office for the county in which the activity is to occur. Technical assistance, forms, topographic maps, and other assistance are available at these offices as well.

5.4.1 Kent County:
Forestry Administrator
Delaware Department of Agriculture Forest Service
2320 South Dupont Highway
Dover, DE 19901
(302) 698-4500 In-state 1-800-282-8685
FAX (302) 697-6245

5.4.2 Sussex County:
Southern Regional Forester
Redden State Forest
18074 Redden Forest Drive
Georgetown, DE 19947
(302) 856-2893
FAX (302) 856-5039

5.4.3 New Castle County:
Northern Regional Forester
Blackbird State Forest
502 Blackbird Forest Road
Smyrna, DE 19977
(302) 653-6505
FAX (302) 653-2869

5.5 The Delaware Forest Service will approve, approve with modifications, or deny all applications within five (5) working days of their receipt. In cases where denial of the application is issued, the Delaware Forest Service will provide technical assistance to the landowner, buyer and/or operator to develop modification(s) necessary to bring the application into compliance.

5.6 The operator on the site is responsible for following BMPs as indicated on the Erosion and Sediment Law Notification Form and Permit until a forester has made a final inspection of the site and issued a final inspection report on form BMP-02.

5.7 A copy of the approved Erosion and Sediment Law Notification Form and Permit shall be kept on the site at all times during the harvest operation, and shown on demand to any forester or DNREC Environmental Protection Officer.

5.8 The permittee/operator shall provide the DFS with the following notifications of intent:

5.8.1 starting a permitted harvest operation — not less than two (2) days prior to desired start date.

5.8.2 completion of the harvest operation — not less than one (1) day prior to completion.

5.8.3 returning to a site if the operator has vacated the site for weather-related or similar reasons — not less than one (1) day prior to return.

5.9 Special Consideration - Streamside Management Zones:

5.9.1 All open water bodies, perennial streams, intermittent streams with a well-defined channel, and streams that have been hydrologically modified by dredging or straightening, and have no established maintenance right-of-way, **shall** have a Streamside Management Zone (SMZ), unless the property or a portion of the property is covered by an approved Delaware Seed Tree Law application (Title 3, Chapter 10, Subchapter V) and is located on slopes of less than three (3) percent.

5.9.2 A Streamside Management Zone shall not be required on any water bodies not specified in Section 5.9.1 as long as Best Management Practices are followed to prevent the movement of sediment and debris into the ditch. The alteration of any berm or bank, structure, or control inlet culvert in or adjacent to tax ditches, as defined by Delaware Code Title 7, Chapter 41, is prohibited unless written approval from both the appropriate tax ditch managers and the Department of Natural Resources and Environmental Control (DNREC), Division of Soil and Water Conservation, Drainage Section is obtained. The use of a tax ditch right-of-way, as defined by Delaware Code Title 7, Chapter 41, as a skid trail is prohibited.

5.9.3 The minimum width for an SMZ is 50 feet, measured in lineal feet perpendicular from the edge (top of the bank or channel) on either side of a qualifying water body as defined in 5.9.1. Listed below are the minimum SMZ widths based on slope. Slope shall be defined as average slope of 100 contiguous feet measured on a horizontal plane perpendicular to the water body. All slope measurements shall begin at the crest of the water body, thus measurements adjacent to channelized streams will begin at top of the channel. SMZ width is measured in linear feet perpendicular from the perimeter of the water body. For tidal waters, the high water line should be used as the perimeter. The SMZ must be plainly designated with surveyors ribbon or durable paint ***before*** submitting the permit application.

Minimum Streamside Management Zone Width

	Percent Slope		
	0-10%	**11-20%**	**21-45%**
Horizontal distance	**50 feet**	**75 feet**	**100 feet**

5.9.4 Within a Streamside Management Zone, at least sixty (60) square feet of basal area per acre of trees well distributed throughout the area shall be retained, or at least sixty (60) percent of the overstory. These trees should be equally divided among diameter classes. The landowner may desire to leave up to eighty (80) percent of the crown cover to provide shading for streams.

5.9.5 Felling trees across a perennial or intermittent stream, or hydrologically modified channel, and dragging any part of the tree over or through the stream channel is not permitted. Any occurrence shall result in the operator making immediate repairs to the waterway bank. All trees will be felled away from the SMZ to avoid depositing logging debris in the SMZ.

5.9.6 The remainder of the specifications for Streamside Management Zones is found in **Delaware's Forestry Best Management Practices Manual, September 1995, Document Control No. 65-01-04/95/09/01. Copies of this manual and current topographic maps are available at all Delaware Forest Service offices.**

5.10 Special Consideration - Multiple Silvicultural Practices:

5.10.1 If more than one silvicultural activity is covered by an approved Forestry Practices E&S permit, the landowner will notify the local Delaware Forest Service office at least five (5) working days prior to the initiation of the subsequent operation. For example, if an E& S permit is approved for the harvesting operation and shearing and piling, the local DFS office must be notified five (5) days before starting the shearing and piling operation.

5.11 Special Consideration - Adverse Weather Conditions:

5.11.1 The notification form, which becomes the E&S permit once approved, requires projected start and completion dates. Should environmental conditions create circumstances which either delay or accelerate the projected start or completion of operations, the operator or landowner will verbally notify the local DDAFS office. One example of such a circumstance is excessive rain causing saturated soils during forest harvest operations; as a result to comply with BMPs, operations are terminated with plans to resume the operations in the drier summer months.

6.0 LAND USE

6.1 Timber harvesting is the primary silvicultural activity which enables landowners to initiate change in the land use from forest land to another land use, such as agricultural cropland, residential development, and industrial or commercial development. Delaware's Forestry Practices E&S rules and regulations are designed for silvicultural activities where the land is to remain under forested land use.

6.2 However, should the landowner choose to change the land use, the new land treatment activity would no longer fall within the jurisdiction of the Delaware Forest Service. Land clearing activities are regulated under the Department of Natural Resources and Environmental Contol's (DNREC) Sediment and Stormwater Management law. For conversion to agricultural cropland use, the designated agencies are the local Conservation Districts in each county. For conversion to other non-forest uses, the DNREC Division of Soil and Water Conservation, Sediment and Stormwater Section has regulatory authority. Thus, the owner or operator will be required to receive approval from the appropriate agency prior to initiating any activity on the site.

6.3 Therefore, as enumerated above, a land use intent declaration is required to receive approval under this law. However, in cases where the land use is to change, the Delaware Forest Service, in accordance with a Memorandum of Understanding with DNREC Division of Soil and Water Conservation, will notify in writing the appropriate agency(ies) of the landowner's intention and provide a copy of this correspondence to the landowner.

6.4 These rules and regulations as well as those of the Stormwater and Sediment law relate to erosion and sedimentation control. Any local, county, state, or federal laws which regulate land use changes, such as wetlands conversion, should be investigated thoroughly prior to initiating conversion of forest land to other uses.

7.0 PROCEDURES AND PENALTIES

7.1 To establish an inspection procedure which reinforces and compliments the regulatory authorities contained within Subchapter VI, the Delaware Forest Service has established the following framework.

7.1.1 Informal field visits

7.1.2 Formal hearing

7.1.3 Superior Court.

7.2 If at any time during the enforcement process any water quality problem is corrected, all proceedings will be terminated, and a letter will be provided to the landowner and operator reflecting compliance with the law.

7.3 Informal Field Visits

7.3.1 The Forester will visit a tract, perform a BMP inspection, and complete a BMP inspection form, a copy of which will be provided to the operator and landowner. During the course of this inspection, the field person will determine the status of the effectiveness of BMPs in protecting water quality and record this determination on the inspection form.

7.3.2 If, during a routine inspection of a harvest operation, it is discovered that the operator on the site does not have an approved harvest permit for the operation, the Forester will, at his or her discretion, issue a verbal or written warning to the operator. The Forester will immediately assist the operator in completing a permit form to bring the operation into compliance with the E & S rules and regulations. If failure to have an approved permit is a second offense, the Forester can, at his or her discretion, halt all harvesting operations until a permit has been completed and approved. If more than two offenses of this nature within a 12 month period, are on record for the operator/buyer, a fine, not to exceed $2,000.00 may be levied as specified in Title 3, Chapter 10, Subchapter VI, Paragraph 1077.

7.3.3 On the BMP inspection form, three categories of water quality classifications will be used: 1) *no Water Quality (WQ) problem*; 2) *potential WQ problem;* and 3) *severe WQ problem.* A potential WQ problem is defined as a typical problem that would cause excessive sedimentation and erosion during a normal rainfall. Examples may include undersized culverts and improper log road or deck stabilization on highly erodible soils. A severe WQ problem is defined as any silvicultural activity which is causing sediment deposition or will immediately create serious sediment deposition in a rainfall event.

7.3.4 If no WQ problem exists, the landowner and operator are notified on site, if possible, and in writing within five (5) business days following the inspection.

7.3.5 If a potential WQ problem exists on an initial field visit, the Forester will note the problem on the BMP inspection form, including written directions to alleviate the potential problem, to the operator and landowner, and a time limitation of up to five (5) business days to correct the problem. The Forester will notify his/her immediate supervisor of the existence of a potential WQ problem. When the time limitation specified in the recommendation for a potential WQ problem has elapsed, the Forester will return for a second visit. If the problem persists with no extenuating circumstances such as bad weather, all operations will be halted until specified corrective actions have been made to the satisfaction of the Forester.

7.3.6 If a severe WQ problem exists, such as skidding logs across a stream or ditch with no bridge, the Forester will cause all operations to cease immediately, issue a written warning containing instructions how to immediately correct the problem.

7.3.7 In the event that an operator vacates a harvest site and WQ problems have not been corrected or resolved, the following actions may be taken at the discretion of the Forestry Administrator. 1) No further E & S permits will be issued for that permittee (operator), nor may that operator legally operate under any existing DFS E & S permits, until all corrections have been made to the satisfaction of the DFS. 2) A fine, not to exceed $2,000.00 may be levied as specified in Title 3, Chapter 10, Subchapter VI, Paragraph 1077.

7.4 Formal Hearing

7.4.1 If the parties cannot agree to corrective actions as determined by DFS, a formal hearing will be convened and conducted in accordance with Title 29 Chapter 101 of the Delaware Code, the Administrative Procedures Act (APA). All silvicultural operations on the site will cease until the results of the hearing are known.

7.4.2 Twenty (20) days prior to the hearing, formal notice will be given to the parties and such notice will contain the following information:

7.4.2.1 A description of the subject matter of the proceedings;

7.4.2.2 Notice of the opportunity to proceed with informal fact-finding procedures (a second informal conference) and of the date by which this election must be made;

7.4.2.3 The date, time, and place the formal hearing will be held if informal fact-finding is not elected;

7.4.2.4 Citation to the law or regulation giving the DFS the authority to act;

7.4.2.5 Notice to parties of their right to present evidence, to be represented by counsel, and to appear personally or by other representative, and

7.4.2.6 Notice to the parties of the agency's obligation to reach its decision based upon the evidence received.

7.4.3 The hearing may be conducted by the Secretary of Agriculture or his or her designee.

7.4.4 Any party may request a pre-hearing conference, to discuss, among other things, issues in dispute, documents to be relied upon, witnesses to be called, and any procedural matters.

7.4.5 The proceedings shall be recorded to ensure accuracy. A recorded transcript will be taken by a court stenographer upon request and this procedure will be paid for by the requesting party. All testimony shall be taken under oath as administered by the hearing officer. The names and addresses of all interested parties present shall be noted on the official record of the hearing.

7.4.6 Any party may present any competent evidence in its behalf and request subpoenas for testimony or production of documents and other tangible evidence. Non-parties shall not present evidence.

7.4.7 Strict rules of evidence shall not apply. All evidence having probative value commonly accepted by a reasonably prudent person in the conduct of his or her affairs shall be admitted. Objections to the admission or the exclusion of evidence shall be brief and shall state the ground for objection. Evidence which is plainly irrelevant, immaterial, insubstantial, cumulative, or unduly repetitive may be excluded.

7.4.8 The parties may be represented by counsel. The hearing shall open with a brief statement from each party of what such party intends to establish at the hearing.

7.4.9 Following opening statements, each party shall have an opportunity to produce evidence in support of such party's position. The owner/operator shall produce evidence first followed by DFS. After initial testimony and cross-examination by the parties, any witness may be examined by the hearing officer. Following the presentation of the main case, the owner/operator shall have an opportunity to produce rebuttal evidence, subject to cross-examination. Following the presentation of the rebuttal evidence, DFS shall have an opportunity to present surrebuttal evidence, subject to cross-examination.

7.4.10 If no procedure is specifically prescribed by these Rules, the hearing officer may proceed in a manner not inconsistent with these Rules.

7.4.11 At the conclusion of the hearing, the Secretary of Agriculture or designee may issue a **Special Order** within twenty (20) days from the date of the hearing. The Special Order shall describe evidence on which the Order was based. Upon issuance of a Special Order, the landowner and operator will implement specified corrective measures within a specified period of time.

7.5 Penalties

7.5.1 Any owner or operator who violates, fails, or refuses to obey any Special Order may be assessed a civil penalty by the Forestry Administrator. Such penalty shall not be less than $200 or more than $2,000 for each violation. Each day of a continuing violation may be deemed a separate violation for purposes of assessing penalties.

7.6 Superior Court

7.6.1 If the Special Order has not been complied with, the Forestry Administrator may file a complaint in the Superior Court which has jurisdiction over all offenses under this statute. However, within three (3) working days of the inspection and prior to the filing of a complaint with the Superior Court, the Forestry Administrator may, at his or her discretion, agree to engage in an informal conference process with the landowner and operator to discuss and resolve violations of the Special Order.

7.6.2 Any person who intentionally, knowingly, and after written notice to comply violates or refuses to comply with any notice issued by the DFS shall be fined not less than $500 or more than $10,000 for each offense. Such penalty may only be assessed after owner or operator has had the opportunity for a hearing as specified herein. Each day the violation continues shall constitute a separate offense.

DELAWARE DEPARTMENT of AGRICULTURE
FOREST SERVICE

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