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Nonpoint Pollution Control: Best Management Practices Recommended for Virginia

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INTRODUCTION

The magnitude of water quality degradation from nonpoint source pollution is immense. It is equal to or greater than the total effect from all point sources. The Environmental Protection Agency (EPA) has estimated that 15 percent of the nation's waters are failing to meet water quality standards because of nonpoint sources. Another 35 percent are degraded by a combination of point and nonpoint source discharges. Further degradation is predicted unless action beyond point source control is taken.[1]

Nonpoint source pollution is defined as "any pollutant whose specified point of generation cannot be traced to any discrete, identifiable facility and whose exact point of entry into a watercourse cannot be defined."[2] Origins for such pollution include percolation, seepage, and runoff from urban areas and from agricultural, silvicultural, construction-related, and mine-related activities.

The Clean Water Act recognizes the impact of nonpoint source pollution in setting an objective "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The act sets as a national goal "that the discharge of pollutants into the navigable waters be eliminated by 1985" and "that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the waters be achieved by 1983." These objectives and goals were established by the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500)[3] and remain intact in the 1977 amendments.[4]

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Illustrations by Gail Schenk.

Section 208 of P.L. 92-500 requires the development and implementation of areawide waste treatment management planning processes, including both point and nonpoint source control programs. In accordance with this section, the Governor of Virginia has identified five intrastate and two interstate areas as having those critical water quality control problems requiring 208 Areawide Waste Management Plans. These regional planning units are located in the areas of Richmond, Roanoke, Fredericksburg, Hampton Roads, Northern Virginia in the Washington metropolitan area, the Cumberland Plateau vicinity of southwest Virginia, and Bristol. The Governor also has designated a single representative organization within each area to assume responsibility for the waste treatment management planning.

In 1975 a court decision changed the scope of 208 Planning. *Natural Resources Defense Council v. Trains* resulted in a decision that each state must act as the 208 Planning agency for all areas of the state that are not designated as having substantial water quality problems. The state, the court said, must meet the same planning requirements for these nondesignated areas as planning agencies operating in areas which have been so designated.

In Virginia, the State Water Control Board (SWCB) has the responsibility for 208 Planning in these areas. The writing of handbooks on Best Management Practices (BMP's) has been a major part of the statewide 208 Planning effort. BMP's are practices or combinations of practices which have been determined by the state to be the most effective and practicable means of preventing or reducing nonpoint sources of pollution in order to accomplish water quality goals. Each handbook was written under the guidance of its respective Technical Advisory Committee of state and federal agencies and a Citizens Advisory

Committee composed of special interest groups. The handbooks were reviewed by the 208 State Policy Advisory Committee (SPAC) and the general public before public hearings in May 1979.

BMP's have been developed in six categories: agriculture, forestry, surface mining, urban, hydrologic modifications, and sources affecting groundwater. Separate lead agencies wrote each handbook with overall coordination provided by the SWCB (see *Table 1).*

Pursuant to the Clean Water Act, the SWCB has begun the preparation of an implementation handbook outlining Virginia's nonregulatory strategy for implementing the BMP's recommended in the six technical handbooks. This management handbooks will include for each nonpoint source category sections on institutional and financial arrangements, incentives and disincentives, and an inventory of available assistance at the federal, state, and local levels.

Implementation of the BMP's will rely on voluntary compliance since sufficient information presently is not available concerning the effectiveness of an individual practice in improving water quality. Dale F. Jones, director of the Bureau of Water Control Management, SWCB, has pointed out that the two major constituents of runoff-nutrients and sediment-are not subject to either federal or state stream standards at the present time. "Before a mandatory BMP program can be mandated, officials must know that a problem exists, that it is coming from a specified watershed, and that the BMP's required will measurably improve the water quality."[7] If progress is not made using the BMP's under a nonregulatory program, a regulatory program would then become necessary in those areas where nonpoint pollution problems are shown to exist.[8]

TABLE 1

BMP Handbooks and
Their Respective Lead Agencies

Handbook	Lead Agency
Agriculture	Soil & Water Conservation Commission (SWCC)
a. Erosion & Sedimentation	SWCC
b. Pesticides & Chemicals	Department of Agriculture & Consumer Services
c. Animal Wastes	Department of Agriculture & Consumer Services
Forestry	Division of Forestry
Surface Mining	Division of Mined Land Reclamation
Urban	SWCC
Hydrologic Modifications	State Water Control Board (SWCB)
a. Channel Modification	SWCB & Department of Highways
b. Dredging & & Dredged Spoil Disposal	Marine Resources Commission
c. Impoundments	SWCB
Sources Affecting Groundwater	SWCB

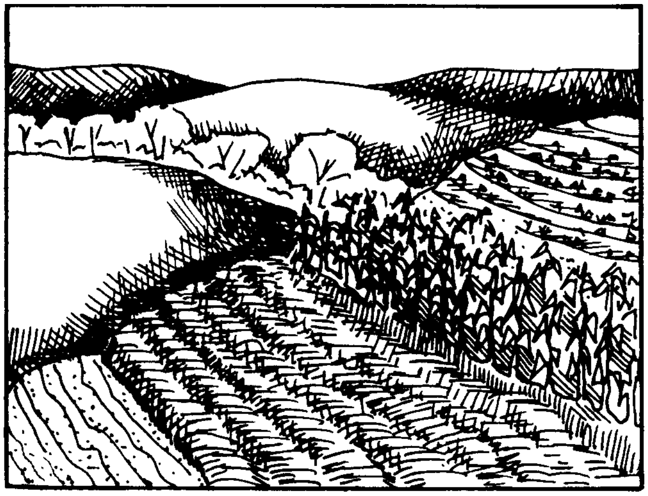
The BMP's are subject to change. The Statewide 208 Plan will be reviewed, revised, and updated periodically as technology improves and there is a better understanding of nonpoint source problems in the state. The draft handbooks published in November 1978 have been revised following public hearings and will be available for mass distribution in early 1980. Summary versions of the revised handbooks are expected to be completed this fall and may be obtained from Vicki Maddox, 208 Information Officer, P.O. Box 11143, Richmond, VA 23230. Until the revised handbooks are available, the 1978 draft versions may be inspected at the following offices: SWCB Regional Offices, Soil and Water Conservation Districts, Planning District Commissions, Agricultural Stabilization and Conservation Service, and Extension Service.

As noted previously, the BMP's have been developed in six categories of activities. The following sections briefly discuss the nonpoint pollutants generated by these activities and summarize the BMP's presented in the respective handbooks for control of these pollutants.

AGRICULTURE

Nationally, nonpoint pollution from agricultural sources is staggering. From more than 400 million acres of cropland an estimated 2 billion tons of sediment are washed into streams and lakes annually.[9] It is estimated that 50 percent of thetotal sediment entering our inland waterways comes from cropland. This sediment is also a carrier of plant nutrients, pesticides, organic and inorganic matter, and other pollutants-farm uses account for 55 percent of the total domestic use of pesticides, 75 percent of the total use of commercial fertilizer. Other agricultural activities add to plant nutrients in surface and ground water. An estimated 2 billion tons of animal wastes are produced annually.[10]

Virginia is heavily involved in agricultural activities, with 11 million acres being used for crop and animal



Strip-Cropping

production. The *Agriculture Best Management Practices Handbook* lists those nonpoint sources of pollution from these systems resulting in diffuse runoff, seepage, and percolation of pollutantsto surface and ground waters. The nature and amount of pollutants are dependent on several factors, including type of soil, topography, types of crops and/or animals, prior moisture conditions, and methods of crop and animal production. The pollution is also dependent on the type of activities related to crop and animal production which are in progress during times of rainfall and snowmelt.

Five general categories of crop production activities which have the potential to result in nonpoint source pollution are identified. These include (1) soil disturbance (e.g., tillage or compaction), (2) alteration of natural vegetation (e.g., crop plant substitution or removal of vegetation), (3) commercial fertilizer or animal waste application, (4) pesticide application, and (5) irrigation by surface or ground water. Three such categories of animal production activities are listed, including (1) concentrations of animals in holding areas for extended periods of time, (2) overgrazing, and (3) concentrations of animals on streambanks.

These agricultural activities result in several principal pollutants. Sediment, by volume the largest agricultural pollutant, smothers bottom organisms; retards fish reproduction; reduces light penetration, thus interfering with photosynthesis; transports other pollutants; impedes stream channels and fills lakes; and increases water treatment costs. High nutrient concentrations, the result of fertilizer applications and animal wastes, cause rapid growth in aquatic plants. This results in clogged water treatment filters, upsets ecological balances, causes oxygen deficiencies in shallow water, and impairs recreational water use. Excess nitrogen also poses a health hazard in a water supply system when it is oxidized to nitrates. Pesticides may be toxic to aquatic life or water users, and persistent organic pesticides can accumulate in living organisms, concentrating through the food chain. Organic matter resulting from animal waste and crop debris reduces oxygen in streams when it decays. This process also may result in taste, odor, color, and nutrient enrichment problems. Animal waste also can result in potential disease-causing microorganisms being transmitted through water.

Four general categories of measures to reduce or prevent agricultural water pollution are listed:

1. Structural measures-physical methods of reducing erosion and pollutant runoff,

2. Vegetative measures-establishing or improving vegetative cover to prevent erosion or filter out pollutants,

3. Conservation cropping and animal management systems-spatial and sequential arrangement of crops and animal populations, and

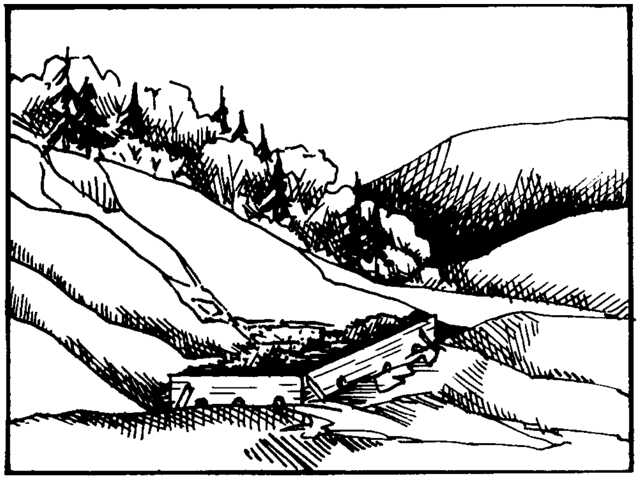
4. Quantitative and qualitative management of cropping system inputs-practices to prevent excessive nutrient and pesticide applications.

The agricultural BMP's incorporate these measures into specific practices designed to control the discharge of the principal pollutants from animal and crop production activities. These BMP's for agriculture are divided into three main categories: (1) erosion and sediment control, (2) animal waste and fertilizer control, and (3) pesticides and other toxic substances control.

Erosion and Sediment Control BMP's

BMP's in this category are based on the premisethat not all erosion and sedimentation can be prevented but that they can be reduced to tolerable levels. The 31 individual practices contained within this category cover a wide range of agricultural activities.

Cropping practices are the subject of several BMP's. Cropping systems are listed which provide for rotation and management practices to control soil loss. Methods of tillage to reduce runoff and erosion are described, including guidelines for successful minimum and no-tillage methods. Detailed are subsoiling techniques which loosen restrictive layers of soil below normal plow depth to increase infiltration and reduce runoff. Contour farming methods are described, both for annual crops and orchards. Guide-



Debris Basin

lines are presented for row arrangements and strip cropping. Practices are also described for planting and managementof pasturesand haylands, including the establishment of planned grazing systems that provide for alternate resting of grazing units over a period of years.

Special use of vegetation or plant materials to supplement the erosion control benefits of proper cropping practices is also detailed in several BMP's. Included are use of cover crops; filter strips of perennial vegetation; and special plantings of trees, shrubs, vines, grasses, or legumes to stabilize soil in highly erodible areas. Using crop residue and other mulching techniques to stabilize soil are described.

Several systems for animal management are discussed. Described are various types of fences which will prevent livestock from gaining access to streams or areas that should not be grazed. Guidelines are given for the dispersion of water to distribute grazing.

There are a number of physical methods which can be employed to reduce erosion. The proper design, construction, and maintenance of access roads will minimize soil loss from such roads. Terraces, or earth embankments, can be used to control runoff. Debris basins, formed by constructing a barrier or dam across a drainageway, trap sediment and detritus. Diversions take water away from highly erodible or contaminated areas. Grade stabilization structures can be used to control erosion in channels to prevent the formation of gullies. Ponds, when properly designed, can be effective for trapping sediments as well as providing additional water supplies and recreational opportunities. Streambanks can be protected by vegetation, riprap, or structures. Another agricultural BMP involves the use of vegetation to control erosion. Included is the establishment of windbreaks (belts of trees or shrubs) around open fields.

Animal Waste and Fertilizer Control BMP's

Animal waste is the principal contributor of agricultural pollution from organic material. BMP's have been set up to reduce this pollution by controlling the waste through proper management. Guidelines are provided regarding site selection for waste disposal, timing and methods of animal waste application, and transportation of the waste to storage or disposal areas. General guidelines are given for selecting areas to absorb the waste. The design and construction of ponds, structures, and lagoons for the storage and treatment of animal waste are contained in the BMP's. Preventing runoff from entering these waste-handling facilities is detailed. Temporary storage of the waste must be provided when permanent storage or land application is not possible. Methods for keeping animals-and thereby their waste-from certain areas involve planned travelways, fences, filter strips, dispersal of water supply and feeders, and development of shade areas. Methods for disposing of dead animals also are given.

The BMP's for fertilizer control recommend slow-release types and provide guidelines for the application of fertilizer. It is also recommended that soil testing be conducted every two to three years to determine fertilizer and lime needs.

BMP's for Control of
Pesticides, Other Toxic Substances

The BMP's in this area are directed primarily at the proper management and use of pesticides and application equipment. General guidelines are provided for determining optimum pest control practices, including the description of pest control methods not involving use of chemicals. With regard to pesticide application, attention isgiven to certification of pesticides to reduce the potential of water contamination and the prevention of excessive use of pesticides. Other aspects covered include storage, cleaning of application equipment, disposal of unused pesticides, and disposal of pesticide containers.

FORESTRY

Some type of forestry activity occurs on an estimated 400,000 acres of forest land in Virginia each year. These forests contain headwaters for many streams which serve as sources of municipal water supplies and recreational sites. The *Forestry Best Management Practices Handbook* discusses pollution problems resulting from forestry activities and recommends BMP's to reduce or alleviate the problems at their sources. The pollution-producing activities are divided into four classes:

1. Access system. In the forest access system, logging roads and skid trails are the primary contributors of sediment pollution.

2. Harvesting procedure. This includes felling trees, delimbing and cutting trees into desired lengths,and moving them to a central accessible point for transport out of the forested area. Erosion depends on the size of the area disturbed and the topography. Organic pollution problems also can result from debris and slash washed from the forest floor. Thermal pollution can result from the removal of the canopy over streams.

3. Crop regeneration. Included are both the natural regenerative process and man's activities in revegetation. The use of fire, chemicals, and soil-disturbing machinery increasesthepotential for pollution.

4. Intermediate practices. Such activities as tree-thinning, fertilizer applications, and pesticide treatment can lead to nonpoint source pollution.

Several pollutants are generated by forestry activities. Sediment is the greatest source of pollution resulting from forestry operations. In addition to the problems listed under Agriculture, sediment builds up during logging activities and can reach surface water through direct dumping, wash off, and leachate from log storage and sawdust piles. Logging debris left in streams can impede streamflow and disturb aquatic life. Organic wastes, which can result from the application of fertilizers and fire retardants,

Filter Strip

can add excessive nutrients with resultant problems. With the removal of the tree canopy from streams, water temperatures rise and thermal pollution occurs. Higher temperatures decrease the saturated dissolved oxygen concentrations and also impair the growth, vigor, and disease resistance of fish.

There are two general types of measures which can be applied to forestry activities to prevent or reduce nonpoint source pollution. Management decision measures incorporate water quality considerations in the planning and design stages of timber management, e.g., logging access road locations, harvesting methods, and reforestation decisions. The proper use and disposal of chemicals are also included under this measure. Structural measures such as culverts, ditches, and slope stabilization, are used to reduce erosion and prevent runoff pollution.

Forestry BMP's

Nine separate activities for which forestry BMP's have been developed are listed:

1. Woodland access roads and trails. The BMP sets minimum standards in building and maintaining these roads, including the control of sedimentation and surface water.

2. Site preparation. Methods of reducing soil erosion, soil compaction, and site quality deterioration are listed.

3. Tree planting. Since pollution problems can result from machine planting, this BMP recommends special techniques when machines are used such as planting on the contour to prevent ditch formation.

4. Pesticide use control. Herbicides, insecticides, nutrient fertilizer, and other chemicals that reach a watercourse are ineffective in their intent and cause pollution. Proper choice, application, and disposal of these chemicals are described in this practice.

5. Forest harvesting. Techniques of harvesting that minimize water quality degradation are discussed.

6. Revegetation. Re-establishing a vegetative cover in disturbed areas isa measure in reclamation. Tables give ratesof fertilization, lime, and seed mixtures for revegetation.

7. Forest recreation. This section provides techniques for avoiding pollution arising from heavy concentrations of people in and near forest rec-

reation sites (e.g., planning and management of garbage and sewage disposal).

8. Wildfire control and reclamation. The hazards of wildfire and rehabilitation methods to avert water quality degradation following wildfires are covered in this BMP.

9. Filter strips. Criteria are given for providing a filter strip adequate to remove sediment from thevolume of runoff that can be expected from a given disturbed forest area.

SURFACE MINING

The *Surface Mining Best Management* Practices *Handbook"* looks at the mining activitieswhich are potential causes of nonpoint pollution and describes control practices for reducing or eliminating this pollution. The practices for the surface mining of minerals other than coal conform to state regulations and will become part of the Drainage and Sedi-ment Control Handbooks12 which accompany state regulations in this area; the BMP's for controlling nonpoint pollution from the surface mining of coal conform to the goals of federal regulations.

Nonpoint water pollution resulting from mining activities occurs when dissolved, suspended, or other solid mineral wastes and debris enter receiving streams or groundwater. Natural drainage patterns for surface and subsurface waters are altered, thus affecting water quality. Processes involved in locating seams or deposits cause surface denudation and erosion, mineralized groundwater discharge, leaching of exposed minerals,and chemical seepage or release. Construction of the mine and access roads contributes to pollution. Failure to revegetate or reclaim inactive surface mines can result in highly polluted drainage from the area.

Primary pollutants from the mining of coal and minerals other than coal are sediment, acidity, alkalinity, and heavy metals. Land which hasbeen disturbed by surface mining can be a major source of sediment and the resulting problems discussed in previous sections. The oxidation of pyrite and other iron-bearing minerals causes acid mine waters. A sulfuric acid solution, formed by the reaction of exposed sulfur-bearing minerals with atmospheric oxygen and water, reacts with soil and rock to leach out other pollutants. This acidic water, heavy concentrations of dissolved minerals in mine water, and deadly combinations of heavy metals are all toxic to aquatic life.

There are two general types of measures which can be applied to surface mining activities to reduce or prevent pollution: mechanical or structural practices and vegetative measures. These practices have four main objectives:

1. Preventing an increase in the mineralization of surface and ground waters,

2. Minimizing erosion and sediment transport,

3. Managing the residuals of mining waste to prevent leaching and erosion, and

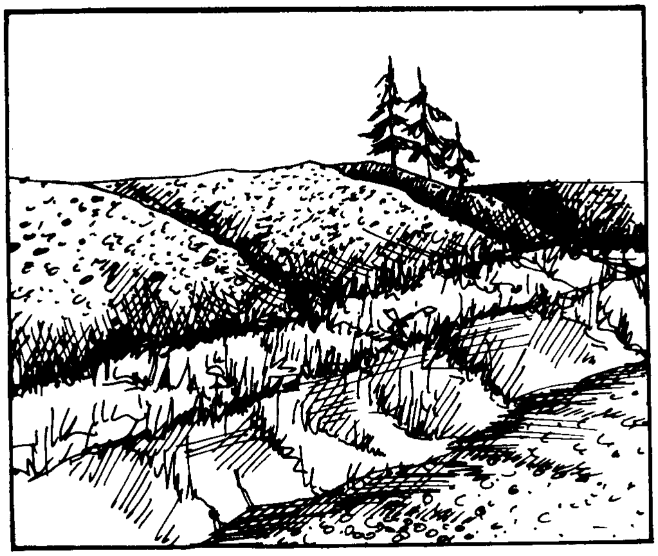
4. Preventing post-operative pollution through proper mine reclamation measures.

Because of the physical differences between types of mining activities, BMP's are presented for two categories of mining: (1) surface mining of coal and (2) surface mining of minerals other than coal.

BMP's for Surface Mining of Coal

Discussed are 13 practices which will aid in the control of erosion and sedimentation in surface coal mining. Most of these BMP's involve structural modifications. Bench drainage deals with the control of runoff and sediment originating on or above a bench or shelf. A check dam, or barrier, can be established across drainageways to trap sediment. A diversion, or an earthen channel with a supporting ridge on the lower side, can intercept and convey runoff to stable outlets. The construction or improvement of haul roads can minimize erosion. A level spreader, an outlet constructed at zero percent grade across the slope, converts the concentrated flow of sediment-free runoff into sheet flow which slows the velocity of the runoff. Where the flow of surface runoff over slopes would cause excessive erosion and pollution of receiving streams, a paved chute or flume of non-erodible material or a rock riprap flume can be used

Benches Cut in a Slope



Toe Berm

to conduct the runoff. Sediment basins and sediment channels are both involved with sediment control, and technical details for their construction are listed in the BMP's. Valley fill is a practice involving the construction of a controlled earth and rock fill across the head of a valley to form a stable, permanent storage space for surface mine spoil material.

Vegetative practices involve the use of filter strips, vegetation, and toe berms. Filter strips are protective strips of vegetation between a disturbed area and a watercourse. These strips help filter out sediment and control erosion. In revegetation, grasses, trees, shrubs, and legumes can be planted in disturbed areas for stabilization and erosion control. This BMP gives specifications for selecting suitable planting mediums and determines proper fertilization levels and seeding times. A toe berm is a bench of compacted and vegetated soil constructed at the toe of an outer spoil slope. Its function is to diminish the velocity of runoff, thereby controlling excessive erosion until the slope has been revegetated.

BMP's for Surface Mining of Materials Other Than Coal

Twenty-three BMP's are detailed in thesurface mining of materials other than coal. A number of these practices are identical or similar to those used in the surface mining of coal, including check dams,diversions, filter strips, level spreaders, paved chutes or flumes, rock riprap flumes, sediment basins, sediment channels, revegetation, and the construction and maintenance of haul roads. In addition to these BMP's, several other practices can be employed to aid in the control of nonpoint pollution. Land grading can improve surface drainage, control erosion, and reduce sediment transport to receiving streams. Outlet protection involves the placement of deenergizing devices and erosion-resistant channel sections between pipe flow and channel flow, reducing the velocity of the water. A pipe slope drain or a waterway are two methods which can be used where a concentrated flow of surface runoff must be conveyed down a slope without causing erosion and sedimentation. Riprap, a layer of loose rock or aggregate, can be placed over an erodible soil surface to prevent erosion. The installation of a conduit below ground surface is beneficial in areas having a high water table. A stone stabilized pad constructed at any point where traffic enters or leaves a construction site reduces or eliminates the transport of sediment from the site.

There are several practices which can provide temporary aid in the control of erosion and sedimentation. Sediment traps are temporary basins for intercepting runoff. Temporary dikes, interceptor dikes, and perimeter dikes reduce the potential for erosion and sedirmentation. A temporary sediment trap-an impounding area-prevents sediment from being transported from a site. These traps are usually excavated or installed at storm drain inlets. Straw or hay bale barriers can be placed across the toe of a slope to intercept sediment and prevent it from entering unprotected areas.

URBAN

Fallout from the air, residue from transportation, debris from human carelessness, and construction washoff are identified in the *Urban Best Management Handbook* as the four main sources of nonpoint pollution in urban areas. These pollutants collect on the land surface, on roof tops, in streets, and in parking lots where precipitation sweeps them to secondary collection systems (roads, gutters, and drains): The polluted surface water then flows into separate storm sewers and isdischarged into streams or it flows into combined sewers where it discharges into treatment plants, unless the plant is overloaded with storm flows (in which case, it is discharged untreated into the receiving stream). The quality and quantity of storm overflows depend on a number of variables, e.g., storm characteristics, antecedent dry periods, and degree of urbanization.

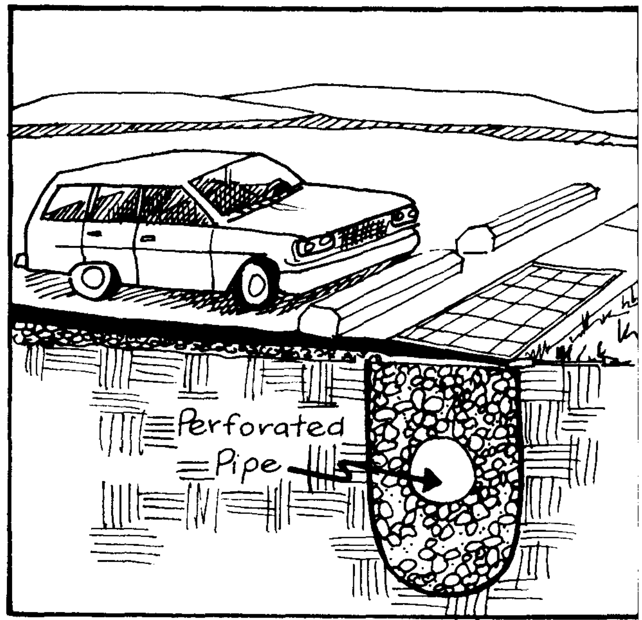
Urban activities generate the following principal pollutants: sediment, organic matter, nutrients, pesticides, heavy metals, petrochemicals, and microorganisms. Problems caused by these pollutants have been discussed in previous sections.

The two general categories of measures which can be used in urban areas to prevent or reduce pollutants from reaching surface and ground waters are source management and collection system management. Source management involves stopping the pollution where it starts, e.g., street cleaning, refuse collection, and control of fertilizers and pesticides. Collection system management is concerned with reducing the amount and rate of runoff and the number of overflows in combined sewers. Included are such practices as urban impoundments, parking lot storage, and sewer system controls. Those practices for controlling erosion and sedimentation from development-related, land-disturbing activities are included in the *Urban Handbook* and may be found in the *Virginia Erosion and Sediment Control Handbook,* 13 published by the Virginia Soil and Water Conservation Commission.

Nonpoint pollution control in urban areas must encompass management of both the sources of pollutants and drainage collection systems. In thosedeveloped areas where structures and pavement are completed and drainage is accomplished mainly by sewering,the housekeeping-type techniques are most applicable. Improved sanitation and maintenance practices are effective in reducing the pollutants entering the drainage system. In newly developing areas, there is a higher degree of flexibility and probabilityof success in controlling the pollution because control can still be built in. Managing the new devel-opment to assure runoff quantity and quality as close to natural conditions as possible is the goal in pollution control.

BMP's for Pollution Source Control

The BMP's for pollution source controls are intended to reduce the generation and accumulation of potential runoff contaminants at their sources, thereby improving runoff quality. There are several methods for accomplishing this goal. Street cleaning, including sweeping, vacuuming, and flushing, removes dry-weather accumulations of pollutants before wash off can occur. The routine management and handling of urban refuse, litter, and fallen leaves can prevent these wastes from becoming water pollutants. The proper storage and application of highway de-icing compounds and the control of fertilizer applications and pesticide use reduce the quantity of these contaminants entering waterways through stormwater runoff. Utilizing the natural capacity of plant materials to intercept and absorb pollutants and to reduce flow rates of runoff is the goal of the BMP involving use of vegetation. Another practice encourages the use of good management and housekeeping techniques on construction sites. The use of preventive measures to lower the amounts of nonpoint source pollutants originating from motor vehicle traffic is encouraged.



Infiltration Trench

BMP's for Runoff Control

Runoff controls are aimed primarily at controlling the volume and discharge rate of runoff. In orderto accomplish this goal, nine BMP's are listed. Urban impoundments to hold surface waterand temporary impoundments for parking lots will protect downstream areas from water quality degradation and stream channel erosion. Stormwater falling onto flat roof surfaces can be ponded and gradually released, and rooftop runoff systems can avoid taking the runoff to sewer systems. The purpose of these BMP's is to reduce the impact of runoff on sewer systems. Cistern storage and collecting and storing Stormwater runoff can be put to later use for lawn watering or fire protection. Pits and trenches can be excavated for the detention and infiltration of Stormwater runoff. A special pervious paving material can be used in low traffic areas and a porous asphalt pavement can be used in other areas to allow stormwater to infiltrate at a higher speed. Grassed waterways, filter strips, and seepage areas reduce runoff velocities, improve infiltration, and remove runoff pollutants.

Collection and Treatment BMP's

Collection and treatment practices deal with urban runoff after it has become polluted. Sewer system control involves planning, designing, and managing alternate methods for the collection and transport of urban wastewater, e.g., sewer separation, inflow/infiltration control, polymer injection, design and construction considerations, and sewer and catch basin maintenance operations. This BMP would result in increased waste treatment efficiency and reduced amounts of untreated wastewater reaching receiving waters. Stormwater conveyance system storage would provide temporary storage capability within combined sewer systems and controlled release of the stormwater in order to reduce the sewer overflows and to increase the amount of stormwater receiving treatment. Conventional and innovative flow regulators can be installed in stormwater conveyances and storage facilities to control the volume, velocity, and direction of water flows. The use of some water treatment unit operations which are less involved and cheaper than traditional waste treatment plants can be used independently or in conjunction with other BMP's to remove contaminants from collected stormwater.

HYDROLOGIC MODIFICATIONS

The population of the state hasgrown rapidly in the last decade, bringing with it the demand for new roads, new shopping centers, flood control structures, impoundments, and other improvements. These facilities have required thealteration or modification of the natural courses of rivers and streams. It is these changes resulting in nonpoint source pollution which have necessitated the guidelines issued in the *Hydrologic Modifications Best Management Practices Handbook.*

Control practices are provided in three areas: channel modification, dredging and dredged material disposal, and impoundment operation. Channel modifications are those changes in a stream which affect its physical characteristics-width, depth, gradient, or substrate composition. Dredging involves large-scale deepening practices. Impoundments included in this handbook are those formed by dams 25 feet or higher with storage capacities of 100 acre-feet or more.

Channel modifications can affect water quality by increasing erosion, turbidity, and water temperature. They can cause the destruction of benthic life, reduction of aquatic species diversity and abundance, blockage of fish migrations, and removal of spawning substrate. Terrestrial life along streams can be affected by the loss of riparian vegetation, the lower abundance of food, and the drainage of wetlands. Recreational pursuits and groundwater quality can suffer.

Degradation of water quality from dredging is related to the type and content of the material being dredged. Water quality problems are compounded when the bottom sediment contains nutrients, heavy metals, pesticides, oil, or greases.

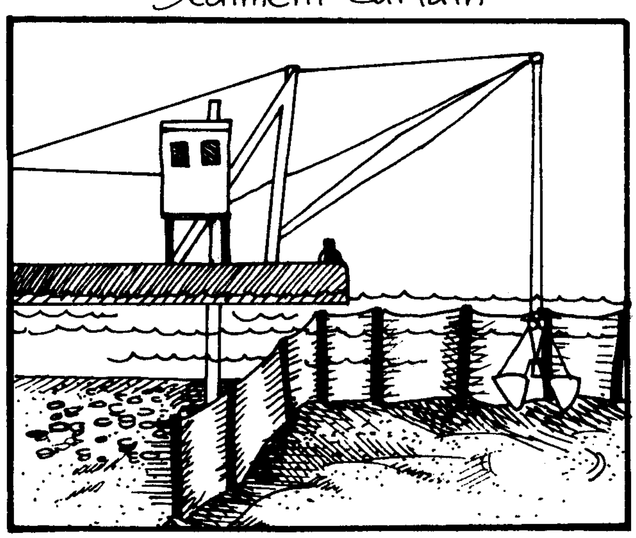
Problems in water storage impoundments include low dissolved oxygen levels, eutrophication, and contamination by toxics and pathogens. Anaerobic conditions lower the levels of aquatic life and lead to the leaching of heavy metals and other undesirable materials from bottom sediment.

Three types of measures-vegetative, structural, and management-are discussed. Each can reduce the adverse water quality and biological impacts of hydrologic modifications. Vegetative measures involve the establishment or improvement of vegetation to prevent erosion. Structural measures make use of physical methods to reduce erosion and sediment, to increase low dissolved oxygen levels, and to improve aquatic habitat. Management measures are concerned with planned considerations such as timing, location, and extent of channel ization, dredging, and impoundment operations.

BMP's for Channel Modifications

Modifications of streams should be kept at a minimum, if possible. However, if such changes are nec essary, the following BMP's will lessen pollution problems: (1) habitat retention, or leaving a belt of natural vegetation along channelized streams, thus limiting impacts to the natural ecosystem; (2) construction of devices to provide more coverand living space for fish, thereby improving the habitat; (3) controls and restrictions applied to construction activities on streambanks to lessen erosion; (4) technical knowledge for bridge construction which will minimize stream disturbance; and (5) techniques for mimicking the natural conditions of a stream, such as revegetation, riffles, and use of proper substrate materials, which will minimize the adverse effects of channel relocation.

Sediment Curtain



BMP's for Dredging
and Dredged Material Disposal

The 11 BMP's in this section deal with the use of proper dredging equipment; site location for disposal of dredged material, its transport to the site, and its containment on the site; environmental restrictions; modifications for keeping adverse impacts to a minimum; reduction of turbidity; and filtration of hydraulic dredged material effluent.

Two methods of dredging are discussed-hydraulic and mechanical-and practices are recommended to lessen their adverse impacts. Techniques for reducing the turbidity associated with hydraulic dredging are given. The use of sediment curtains to restrict the transport of sediment is recommended.

Factors which should be considered in choosing a disposal site for the dredged material are discussed. Disposal sites covered by the BMP's include tidal water areas and uplands or locations away from natural drainage patterns, ground and surface water supplies, and wildlife habitats. Methods of conveying the dredged material to the site are given. The design and construction of retaining dikes to contain the material are outlined. Specificationsand examples of filtering systems to be used in certain containment areas are given. It is recommended that unnecessary dredging be curtailed and that necessary dredging be performed only certain times of the year.

BMP's for Impoundments

These BMP's, limited to storage impoundments, deal with the effects of impoundments on erosion, vegetation, and aquatic life and on local hydraulics. The removal of vegetation from the area to be inundated is recommended to reduce the oxygen demand from decomposing organic matter. Techniques for algae control are addressed. Details of hypolimnetic aeration and reaeration of release water are given. The mixing of water from different temperature levels to ensure uniform temperatures and dissolved oxygen profiles is recommended. Another method for achieving this result is a release structure with several outlets placed at different reservoir depths. Methods for downstream erosion control are given. Structural and management techniques to enhance fish production are presented.

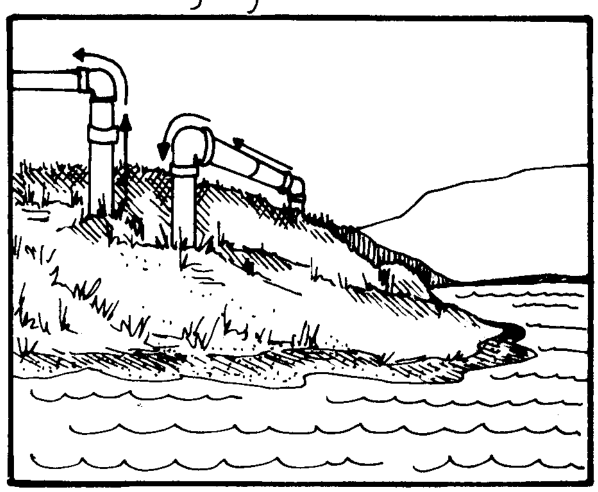
SOURCES AFFECTING GROUNDWATER

There are many sources of groundwater contamination, but the *Sources Affecting Groundwater Best Management Practices Handbook* concentrates only on saltwater intrusion. Contamination from specific land-use activities is covered in the other BMP handbooks; however, an appendix is included in *Sources Affecting Groundwater* which liststhose practices in the other handbooks that could affect groundwater quality. As contamination problems for groundwarer are identified that are not now covered in the other handbooks, additions will be made to future editions of the *Sources Affecting Groundwater Handbook.*

Saltwater intrusion is the invasion of salty water into potable water aquifers. It can result from several conditions: (1) When coastal aquifers are lowered through pumping, natural drainage, or the blockage of natural recharge, the freshwater flow to the ocean is reduced, allowing the heavier saline water to move into the area. (2) The deepening of navigation channels, construction of sea level canals, and reduction of stream flow result in the encroachment of sea water. (3) Natural bodies of saline groundwater may exist near fresh groundwater sources, even in inland areas. When changes are induced by man in the hydraulic pressure, the saline waters may migrate into the freshwater aquifers. (4) Contamination of fresh water can result from wind-blown sea salt, road deicing salt, spilled brines, industrial waste-settling ponds, stockpiles, and landfill leachate. (5) Deep injections of saltwater heat pump wastes and oil and gas well brines can contaminate freshwater aquifers.

The most common salts present include chlorides, sulfates, carbonates and bicarbonates of sodium, potassium, calcium, and magnesium. Their effects on the total dissolved solids of the receiving water must be considered. Acceptable levels of salinity will depend on the use of the water, e.g., public water supplies, fish and wildlife production, or agricultural uses. Suitable water supplies in Virginia contain less than 500 mg/l total dissolved solids; water with greater than 5,000 mg/l total dissolved solids is un-

Recharging Fresh Water



suitable for irrigation. Maximum salinity concentrations for livestock consumption vary, depending on animal type. High salinity concentrations increase corrosion and shorten the duration of engineering structures.

A number of BMP's have been developed fordealing with saltwater intrusion including prevention, control, and correction measures. Many of these methods require the use of fresh water for dilution or for driving out the salty water by force. Other methods involve ways to prevent the salt water from percolating into the subsurface. Most of the BMP'swill be expensive and will require application for extended periods of time.

BMP's for Saltwater Intrusion

Well systems can be used in the control of saltwater intrusion. Practices are recommended for recharging fresh water to an aquifer to replace that being pumped out. Methods are also provided for determining the proper pumping rate for freshwater production. Locating single or multiple wells to remove salt water which has already invaded an aquifer is described. Freshwater injection wells can be used to block movement of salt water into an aquifer. Technical data is given for the design and construction of a system of wells to force salt water from an aquifer to a production well for removal. Injection wells can also be used to inject a barrier into an aquifer in order to block lateral transmissions of salt water. Another practice describes the location and construction of wells which can be used to detect the presence and movement of salty groundwater.

The problem of saltwater intrusion caused by manmade construction and by leakage through wells is addressed. Tide gates and locks are recommended in those areas of intrusion where canals or drainage ditches have been dug deeper than sea level. Specifications are given for correcting the problem of saltwater intrusion through improperly constructed or deteriorated wells.

The control of salt stockpiles and stored salty water is detailed in several BMP's. Guidelines are provided on keeping salt stockpiles from dissolving and percolating into the subsurface. Preventing salty water from tailings lagoons and brine ponds from entering groundwater is addressed, as well as the disposal of unwanted salty water generated by industrial processes. The BMP for the control of highway de-icing salts is included in this handbook as well as the *Urban Handbook.*

Special practices in irregular conditions of stratigraphy and sedimentation and technological methods are described which can be used in the battle against saltwater intrusion. The special practices are' applicable in situations where certain suspected stratigraphic conditions might cause conventional methods of controlling intrusion to fail, i.e., where unexpected saltwater travel paths or unexpected invasion velocities are encountered.

CONCLUSION

The Best Management Practices in each handbook must be tailored to the needs of the particular pollution source and the prevailing physical conditions. Because of the variability in such factors as source, topography, climate, and soils, no single BMP in any section will cover all activities or situations in that category. Nor will the BMP's have universal application for all operations involved. In some cases only expensive practices may be effective, while at other times, relatively inexpensive practices may suffice.

It will be necessary for the BMP's to be implemented in conjunction with currently existing regulatory procedures that apply to the activities in question. For example, anyone wishing to perform dredge, fill, or construction activities in the waters or wetlands of the Commonwealth first must obtain permits from the U.S. Army Corps of Engineers, the State of Virginia (SWCB and the Virginia Marine Resources Commission), and local wetlands boards. Applicants are required to listthe practicesthey will use to protect the natural environmental and water quality. Though the BMP's contained in the *Hydrologic Modifications Handbook* do not have to be among those practices specified, they are recommended as effective measures in reducing the pollution and its resultant problems in this area. Surface mining is another area where selection of BMP'swill be influenced by regulations.

Planning for water quality management can be effective only if the involvement of the various pollutants is understood, and if the effects of these pollutants on water can be reliably assessed. Regardless of the BMP's used to control nonpoint source pollution, public education'[4] and community commitment to clean water will be the keys to success in achieving voluntary implementation of the program.

FOOTNOTES

1. Mark A. Pisano, "The Federal Perspective," *Proceedings: Workshop on Non-Point Sourres of Water Pollution (I I-*linois Institute for Environmental Quality Document No. 75-16), August 1975, p. 10.

2. Virginia State Water Control Board, *Best Management Practices Handbook* series (in production), 1980. Unless otherwise specified, all material in this Special Report was taken from the six BMP handbooks on agriculture, forestry, surface mining, urban, hydrologic modifications, and sources affecting groundwater and the summaries of these handbooks (Fall 1979).

3. Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. 1251 *et seq.* (1978).

4. Clean Water Act, P.L.95-217 (1977), amending the Federal Water Pollution Control Act Amendments of 1972.

5. *Natural Resources Defense Council v. Train,* 7 *ERC* 1881 (DC DC 1975).

6. Virginia State Water Control Board, *Management Handbook,* currently being prepared for publication with an expected release date of January 1980.

7. Dale F. Jones, "Land-Issues Involved in 208 Planning for Non-Designated Areas." Paper presented at the Conference on Current Land- and Water-Resource Management Issues in Virginia, December 1977.

8. Virginia State Water Control Board, Bureau of Water Control Management, *Waterlogue, Vol. I,* No. 6 (May-June 1979), p. 2.

9. Pisano, "The Federal Perspective," p. 10.

10. Earl R. Swanson, "Agriculture," *Proceedings: Workshop on Non-Point Sources of Water Pollution* (Illinois Institute for Environmental Quality Document No. 75-16), August 1975, p. 14.

11. Due to pending litigation brought by the Commonwealth of Virginia against federal regulations in the area of surface mining of coal, the 208 SPAC has decided not to print or distribute the *Surface Mining Best Management Practices Handbook* at the present time.

12. Division of Mined Land Reclamation, *Drainage andSediment Control Handbook.*

13. Virginia Soil and Water Conservation Commission, *Virginia Erosion and Sediment Control Handbook,* April 1974. The practices in this handbook are regulatory.

14. A general brochure describing the BMP's in the areas of agriculture and forestry is being developed by the Extension Service at Virginia Tech and should be available from SWCB in December 1979.

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