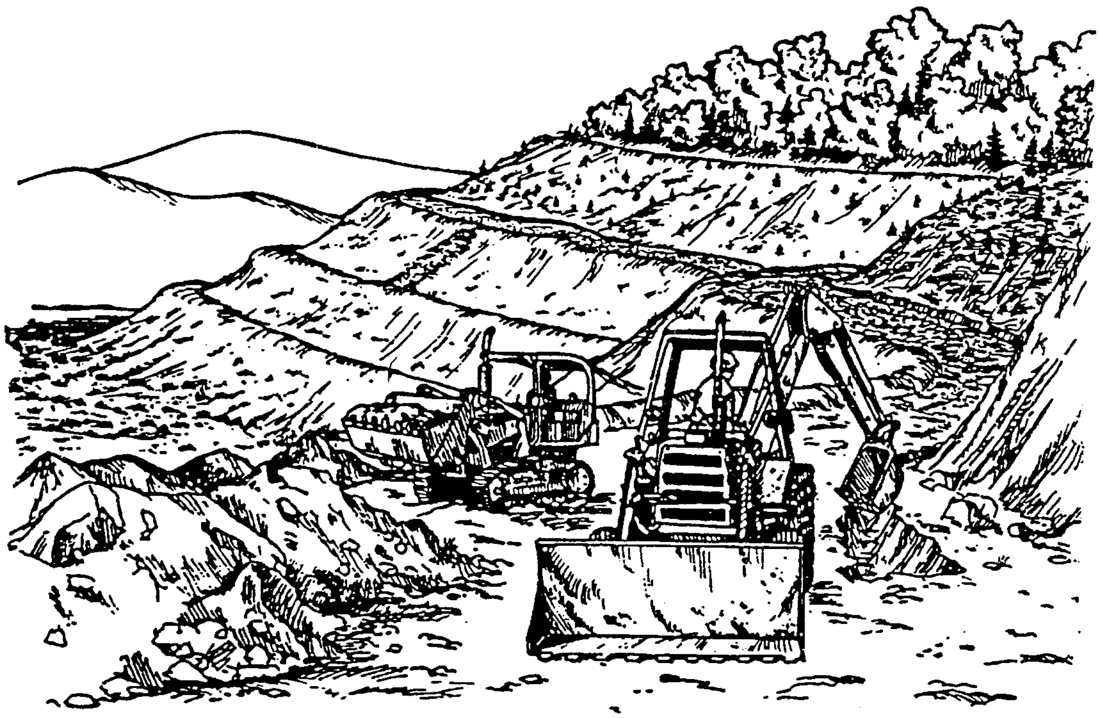
KENTUCKY COAL MINING PRACTICE GUIDELINES

FOR WATER QUALITY MANAGEMENT



Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Division of Water
and the Agronomy Department
University of Kentucky

March 1996

ABSTRACT

Current coal mining regulations require environmental protection measures to be taken before, during, and after mining. This handbook's purpose is to give coal mine operators the information needed to successfully meet those regulations. It also should be useful for those persons engaged in reclaiming abandoned mine sites as well. However, space does not allow detailed information often associated with site-specific conditions, but hopefully it does give all the basic principles involved. The first major section (III) introduces the problems of mine site preparation, erosion control, acid mine drainage, and related water pollution problems. The next three sections provide sources of information, guides, and principles of Best Management Practices as well as discussions related to pollution prevention and control measures. Section VII includes the specifications and details associated with drainage, roads, topsoil and overburden handling, and revegetation. The methods, called Best Management Practices, are presented in a manner hopefully understandable by the practicing mine operator. The last three sections include references to provide back-up and additional sources of information for further help. The glossary includes definitions of the terms used in the handbook, andt the last part is a complete index of the handbook.

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Acknowledgments

This manual on coal mining guidelines for water quality management represents an update and revision of the 1984 publication titled Best Management Practices for Coal Surface Mining. The text and graphics from the original document as written and developed by Sarah L. Cunningham were used as a springboard in the preparation of this manual. Revisions in the form of technical advances reported in the literature and regulatory updates were incorporated.

Thoughtful guidance, review, and recommendations were provided by the staffs of the following agencies through their participation as members of an Advisory Committee formed by the Natural Resources and Environmental Protection Cabinet:

Kentucky Department for Surface Mining
Reclamation and Enforcement
Kentucky Division of Abandoned Lands
U.S. Geological Survey
Kentucky Geological Survey
University of Kentucky Water Resources
Research Institute
MAPCO Coal
Kentucky Resources Council
Kentucky Division of Water.

The Department of Agronomy at the University of Kentucky prepared the document on behalf of the Kentucky Division of Water. Principal compilers of the revised manual were Richard I. Barnhisel and Judith M. Hower. Appreciation goes to Marsha Short for typing, to Gerald Haszler for assistance with the figures, and. Ray Harmon, Heather Vice and Karen Schell for their assistance with assembly of the final copies

STATEMENT OF PURPOSE

In order to protect the surface waters of the Commonwealth, the Natural Resources and Environmental Protection Cabinet established surface water standards under 401 KAR 5:031. This regulation sets forth water quality standards that consist of the designated legitimate uses of the surface waters of the Commonwealth and the associated water quality criteria necessary to protect those uses. These standards are minimum criteria that apply to all surface waters in order to maintain and protect designated uses. The Cabinet strives to meet these water quality standards through both mandatory and voluntary use of Best Management Practices (BMPs).

The purpose of this document is to provide a capsule presentation of the Best Management Practices for protecting water resources from nonpoint source water pollutants stemming from coal mining activities and reclamation of abandoned mine lands. Neither these practices nor this manual are in any way intended to prevent the mining of coal. Rather, these BMPs are provided to aid industry in meeting environmental standards and as a measure to help safeguard the quality of our water resources.

INTRODUCTION

Under Section 319 of the Federal Clean Water Act Amendments of 1987, states are required to develop management programs for the control of nonpoint sources of pollution from a variety of land uses, including mining. The Kentucky Nonpoint Source Management Program identifies Best Management Practices recommended for use in Kentucky to control mining-related nonpoint source pollution. Also described are steps by which to achieve implementation of BMPs.

Implementation of BMPs is often required as a part of a Water Quality Certification. The BMP plans are required as a part of all individual Kentucky Pollution Discharge Elimination System (KPDES) permits issued, as remedial actions resulting from enforcement actions and will be included on the reissuance of the General KPDES permit as of 1997. Such plans must be in accordance with NPDES Best Management Practices Guidance Document (EPA, 1981).

Best Management Practices as applied to coal mining and reclamation of abandoned mine sites are structural or nonstructural methods that minimize the movement of debris, sediment, and acid drainage from the land to surface and ground water. These practices have been developed to achieve a balance between water quality protection and coal production within natural and economic limitations.

This manual is intended for use by coal mine operators, engineering consultants, state regulatory personnel, landowners, land users, planners, and persons involved in reclamation as a technical reference. Methods are detailed for the identification, planning, and treatment of existing or potential nonpoint sources of pollution resulting from coal mining activities and reclamation of abandoned mine sites.

Physical disturbance and/or filling of wetlands and streams, both perennial and intermittent, are regulated by the Federal Clean Water Act under sections 404 and 401. Section 404 gives the U.S. Army Corps of Engineers primary regulatory responsibility over this area.

Most proposed discharges within streams or wetlands will require a Nationwide Section 404 permit or an Individual Section 404 permit from the U.S. Army Corps of Engineers. More often than not, Nationwide Permit numbers 21 or 26 will apply to mining operations for such disturbances. A 401 Water Quality Certification will be required from the Division of Water whenever a Section 404 permit is required; if more than 200 linear feet of a blue-line stream (as depicted on a U.S. Geological Survey 7.5 minute quadrangle map) will be impacted or more than one (1) acre of jurisdictional wetland will be impacted. In addition, for mining operations resulting in a permanent stream loss, a stream restoration/mitigation plan must be submitted to the division if the watershed above the toe of the farthest downstream permanent structure is greater than 450 acres. A restoration/mitigation plan must also be submitted for proposed disturbances of one (1) acre or more to jurisdictional wetlands.

The application of BMPs is required for active mine operation planning. Under the 1990 Kentucky Surface Mining Law (KRS 350) and the Permanent Program Regulations for Surface Coal Mining and Reclamation Operations and Coal Exploration Operations (405 KAR Chap. 7-24), certain BMPs are specified; other times operators may choose practices during the development of their permit application to ensure performance standards are met.

A valid permit is required for every coal mining operation. To obtain a permit, the operator must submit an application to the Department for Surface Mining Reclamation and Enforcement (DSMRE) of the Kentucky Natural Resources and Environmental Protection Cabinet. This application must contain a Mining and Reclamation Plan (MRP), which includes sections covering:

- topsoil handling
- backfilling and grading
- spoil disposal
- acid and toxic material handling
- surface water control and monitoring
- ground water control and monitoring
- revegetation

Note: For public lands, a permit will need to be obtained through the U.S. Office of Surface Mining.

Each section of the MRP specifies those BMPs the operator intends to use to meet regulatory performance standards. A variety of criteria are involved in the BMP selection process. These criteria are addressed within the context of technical considerations discussed under BMP specifications later in this manual. The terms of the permit and the MRP must be upheld throughout the mining process: site preparation, mining and reclamation, and the five-year period of extended responsibility.

The regulatory requirements reflect those current as of March 1994. Regulations change periodically in response to changes issued by the U.S. Office of Surface Mining. If doubt exists concerning the legal acceptability of any BMP specification discussed in this manual, the Kentucky Department for Surface Mining Reclamation and Enforcement should be contacted for resolution. The use of this manual does not relieve the operator of any responsibilities under state or federal regulations applicable to surface mining reclamation.

WATER POLLUTANTS

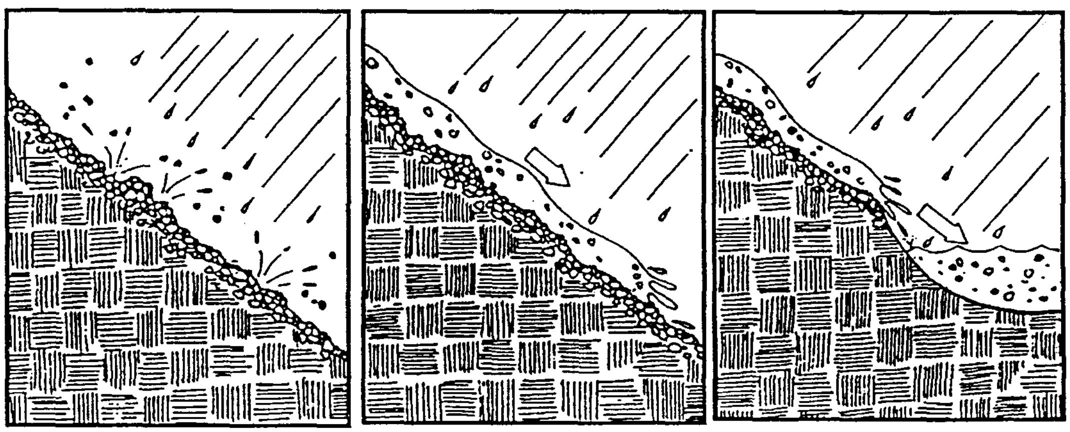
Without conscientiously applied management practices, three water pollutants can stem from coal mining activities and reclamation of abandoned mine sites: 1) debris, 2) sediment, and 3) acid drainage. A discussion of each of these pollutants and the processes involved in their formation follows.

Debris

Clearing and grubbing is the first stage of site preparation in the development of a coal mine. During this stage, trees and brush are removed. This debris is then sometimes disposed of by windrowing. Alternate forms of disposal include chipping for future use as mulch and controlled burning or incineration in accordance with 401 KAR 63:005. Improper placement of debris has the potential for clogging stream channels.

Sediment

Sediment deposited in stream channels is the consequence of the processes of soil erosion and sedimentation caused by rainfall (Figure 1). These processes are accelerated in disturbed watersheds. Disturbances that include the removal of vegetation and earth moving have the potential to accelerate erosion. According to the Kentucky Division of Water (1994), nonpoint sources linked with resource extraction comprise the largest source of siltation of Kentucky streams and waterways.



Raindrop Impact **Overland Flow** **Sedimentation**

Figure 1. The process of erosion and sedimentation

Erosion begins upon the impact of raindrops with the ground. The impact of the raindrop itself serves to detach the soil, destroys soil granulation, and initiates soil transport. Erosion by water can then be classified as 1) sheet, 2) rill, or 3) gully (Figure 2). In sheet erosion, soil is removed more or less uniformly across a slope. Small channels often develop in sheet erosion. These are referred to as rills. The formation of larger channels or gullies serves to further concentrate the runoff water.

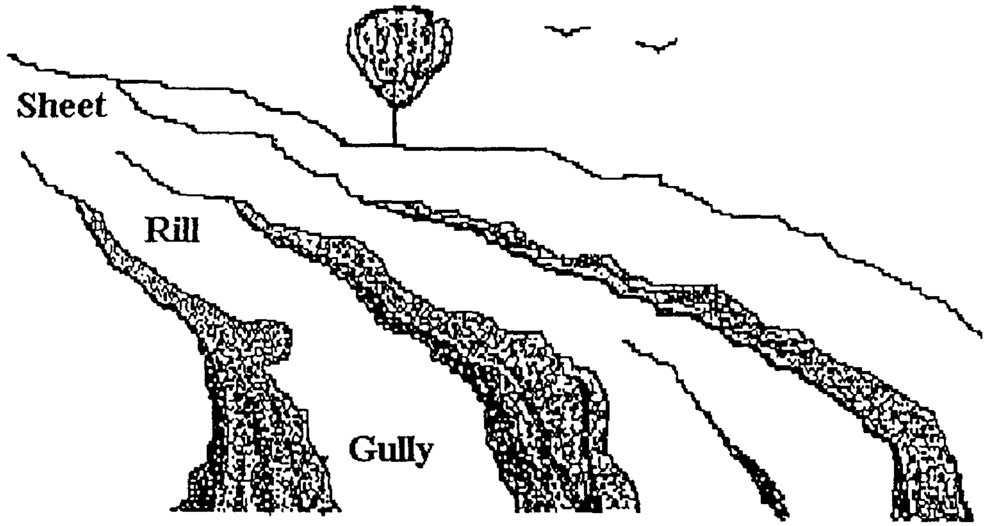


Figure 2. Three types of land-based erosion: sheet, rill, and gully

Soil that is being carried by runoff water during the erosion process can be referred to as suspended solids. When the speed of runoff water decreases, solids in suspension gradually settle to the bottom of the stream channel. At this time, the soil becomes sediment, and the process of soil deposition following erosion is known as sedimentation (Brady, 1990). Sedimentation problems can be minimized through the construction of sediment ponds, grass filter strips, and other BMPs. The suspension may enter a lake or sediment pond where the particles may be removed or a grass strip where the vegetation serves as a filter.

Many factors influence the rate of soil erosion on both undisturbed and disturbed soils. The Revised Universal Soil Loss Equation (RUSLE) has been developed to estimate quantities of soil lost via sheet and rill erosion. Predicted soil loss is calculated by taking the product of the series of factors as follows (Renard and others, 1991):

A = RKLSCP
A = computed soil loss
R = climatic erosivity (rainfall and runoff)
K = soil erodibility
L = slope length
S = slope gradient or steepness
C = cover and management
P = erosion control practice

A computer program to calculate the RUSLE is available through the U.S. Agricultural Research Service (ARS) and the Natural Resources Conservation Service (Renard and others, 1991).

The environmental consequences of soil erosion and sedimentation are substantial, especially with respect to the effects on water quality and aquatic habitat. Sediment from eroded lands causes significant damage to treatment plants for domestic water supplies, reduces the life span of water reservoirs, and fills in river channels (Brady, 1990). Suspended solids and sediment can decrease light, reduce water oxygen levels, smother stream bottom organisms, and cause reductions in food supplies. In addition to these water-related effects, soil losses diminish the agricultural value of lands affected through direct soil loss and associated reductions in essential plant nutrients such as nitrogen, potassium, and phosphorus.

Acid Drainage

The most frequent cause of acid drainage is the prolonged exposure of pyrite (FeS_2) to air and water. Pyrite is a mineral that is frequently found in association with coal seams. The oxidation of pyrite produces both ferric hydroxide ($Fe(OH)_3$) and sulfuric acid (H_2SO_4) according to the following series of equations (Caruccio and Geidel, 1990):

$$FeS_2 + H_2O + 7/2\ O_2 \text{ ---> } Fe^{+2} + 2SO_4^{-2} + 2H^+ \quad (1)$$

(Pyrite) ---> (Ferrous Sulfate) + (Sulfuric Acid)

$$Fe^{+2} + O_2 + 4H^+ \text{ ---> } Fe^{3+} + 2H_2O \quad (2)$$

$$3Fe^{+3} + 9\ H_2O \text{ ---> } 3Fe(OH)_3 + 9H^+ \quad (3)$$

$$FeS_2 + 14Fe^{+3} + 8H_2O \text{ ---> } 15Fe^{+2} + 2SO_4^{-2} + 16H^+ \quad (4)$$

(Pyrite) + (Ferric Iron) ---> (Ferrous Iron) + (Sulfate) + (Acid)

Decline in stream pH levels because of acid drainage can result in the destruction of aquatic biota. Low pH levels can result in the solubilization of heavy metals in stream channels further resulting in conditions toxic to aquatic life.

Coal mining activities and the reclamation of abandoned mine sites have the potential to accelerate the production of three pollutants in our environment: vegetative debris, sediment, and acid drainage. Conversely, aggressively applied management practices have the potential to control the production of these pollutants and safeguard the Commonwealth's water resources.

SOURCES OF INFORMATION

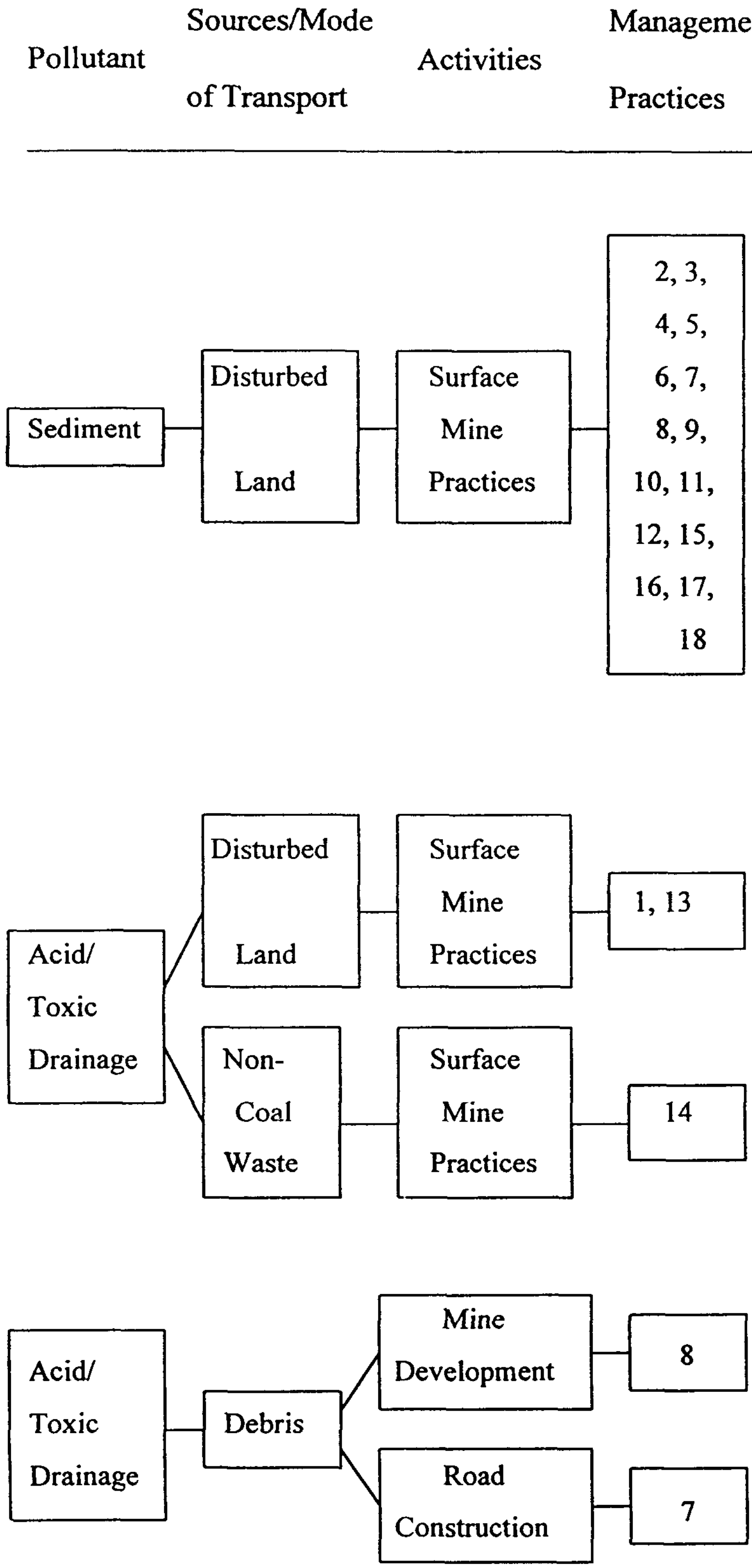
A considerable amount of information and assistance is available through state and federal agencies to help expedite the development of MRPs, and to selectively apply BMPs as appropriate. In particular, agencies knowledgeable in BMPs for the protection of water resources include:

- Kentucky Division of Water
- Kentucky Department for Surface Mining Reclamation and Enforcement
- Kentucky Division of Forestry
- Kentucky Soil and Water Conservation Districts
- Kentucky Agricultural Extension Agents
- Kentucky Department of Fish and Wildlife Resources
- Natural Resources Conservation Service
- Consolidated Farm Services Agency
- U.S. Forest Service
- U.S. Environmental Protection Agency
    - National Research Center, Mining Pollution Control Branch
- U.S. Geological Survey, Water Resources Division
    - (Coal Hydrology Program Report Series)
- University of Kentucky
    - Institute of Mining and Mineral Research
    - Water Resources Research Institute

Addresses and phone numbers of field offices of selected agencies within the eastern and western Kentucky coal fields appear in the Appendices.

GUIDE FOR BEST MANAGEMENT PRACTICES

The following chart (Figure 3) illustrates the relationship between coal mining activities and pollutants and identifies Best Management Practices which address each set of circumstances. It also applies to reclamation activities associated with abandoned mine sites. One or more BMPs may be necessary to adequately address a given set of conditions.



Legend

1. Mine Drainage Treatment
2. Construction of Diversions
3. Construction of Sediment Ponds
4. Protection of Channels
5. Installation of Silt Fences
6. Development of Vegetative Filters
7. Proper Construction of Access Roads
8. Removal and Storage of Topsoil
9. Temporary Storage of Spoil
10. Contemporaneous Back-filling and Grading
11. Scarification of Spoil Surface
12. Topsoil Redistribution
13. Burial of Acid/Toxic Spoil
14. Proper Storage and Disposal of Non-Coal Waste
15. Excess Spoil Disposal
16. Application of Soil Amend-ments for Reclamation
17. Seeding and/or Planting Seedlings
18. Application of Mulch

Figure 3. Guide for Best Management Practices selection.

BEST MANAGEMENT PRACTICE PRINCIPLES

The best way to prevent pollution of streams with debris, sediment, and acid drainage is to keep rainfall runoff and ground water away from debris, bare soil, and acid spoil. An operator can do this by using BMPs. BMPs can be vegetative, structural, or both. Basic principles to remember in the application of BMPs follow (Wang and Grubbs, 1990):

- Preplan water and sediment control strategies.
- Time grading and construction to minimize soil exposure.
- Retain existing vegetation whenever feasible.
- Vegetate and mulch denuded areas (including exposed C horizons of soils in advance of mining).
- Divert runoff away from disturbed areas.
- Install diversions and vegetated waterways in advance of mining to allow time for vegetation to mature.
- Minimize length and steepness of slopes.
- Minimize runoff velocity.
- Minimize size of disturbed area at any one time (both replaced spoil and soil).
- Trap sediment on site.
- Leave buffers or filter strips between land disturbances and natural waterways.
- Prepare drainage ways and outlets to handle increased runoff.
- Preferentially select local materials and native plant species in reclamation.
- Inspect and maintain erosion control structures

BEST MANAGEMENT PRACTICE SPECIFICATIONS

Technical specifications for Best Management Practices for coal mining follow. Four specific areas are identified: Drainage, Roads, Topsoil and Overburden Handling, and Revegetation. Under these general headings are more specific topics with BMPs outlined for each. Guidelines for the application of each practice are included, together with performance considerations. The format for discussion of each BMP is as follows:

- Definition
- Purpose
- Regulatory Requirements
- Implementation
- Maintenance

DRAINAGE

- **Mine Drainage Treatment**
- **Diversions**
- **Sedimentation Ponds**
- **Channel Protection**
- **Silt Fences**
- **Vegetative Filters**

MINE DRAINAGE TREATMENT

DEFINITIONS

Acid drainage is water with a pH lower than 6.0, which the total acidity exceeds the total alkalinity. Dissolved heavy metals are often associated with acid mine drainage (AMD) because the solubility of metals increases as pH decreases.

PURPOSE

Treatment of acid drainage is necessary to meet discharge standards applicable to the coal mining industry and to prevent degradation of water quality.

REGULATORY REQUIREMENTS

All surface drainage from disturbed areas must pass through a sedimentation pond (or series of ponds) and meet the requirements of 405 KAR 16:070 and 401 KAR 5:065. Adequate measures, along with sedimentation ponds, must be installed, operated, and maintained to ensure discharge from the permit area is in compliance with KPDES effluent limitations.

IMPLEMENTATION

Technology for the treatment of acid mine drainage typically includes:

- pH adjustment/metals removal
- aeration
- settling

The use of constructed wetlands also warrants consideration alone or in association with traditional technologies. Discussions of these technologies and their applications follow. Refer to the Mining and Reclamation Plan (MRP) for site-specific recommendations.

With all chemicals, use care in handling. Ask the mining engineer or chemical salesperson for detailed instructions about handling to prevent employee accidents and pollution of the environment. Large quantity storage on-site may require construction of spill contaminant structures.

pH Adjustment/Metals Removal

The first step in AMD treatment is the addition of an alkaline reagent (chemical) to increase the pH of the water. As the water pH rises, most metal ions become increasingly insoluble and precipitate out of solution. Available treatment reagents are primarily either calcium-containing or sodium-containing. In very general terms, the factors that influence the selection of a reagent from one of these two groups are summarized in Table 1.

The calcium- and sodium-based reagents, mechanisms of reaction, and quantities required to neutralize one pound of sulfuric acid are summarized in Table 2. A brief discussion of their potential use follows (Smith, 1991).

Table 1. Reagent Selection Considerations*

Factor	Calcium Compounds	Sodium Compounds
Solubility	Slow, Less Soluble	Fast, More Soluble
Application	Requires Mixing	Diffuses Well
Hardness	High	Low
Gypsum Formation	Yes	No
High Total Suspended Solids	Helps Settle Clay	Disperses & Keeps Clay Particles in Suspension
Chemical Cost	Lower	Higher
Installation and Maintenance Costs	High	Low

* Skousen (1989)

Table 2. Common Neutralization Reagents (adapted from Smith, 1991)

Reagent	Chemical Reaction	Wgt. Needed to Neutralize One Pound H_2SO_4
Hydrated Lime (calcium hydroxide)	$H_2SO_4 + Ca(OH)_2 \dashrightarrow CaSO_4 + 2H_2O$	0.76
Crushed Lime (calcium carbonate)	$H_2SO_4 + CaCO_3 \dashrightarrow CaSO_4 + H_2O + CO_2$	1.02
Quick Lime (calcium oxide)	$H_2SO_4 + CaO \dashrightarrow CaSO_4 + H_2O$	0.57
Caustic Soda (sodium hydroxide)	$H_2SO_4 + 2NaOH \dashrightarrow Na_2SO_4 + 2H_2O$	0.82
Soda Ash (sodium carbonate)	$H_2SO_4 + Na_2CO_3 \dashrightarrow Na_2SO_4 + H_2O + CO_2$	1.08

- **Hydrated Lime** is the reagent most commonly used (Smith, 1991). It can be applied in a dry or liquid form and is relatively inexpensive. As such, it is often used in situations where large amounts of AMD with high acidity must be treated over long periods of time (i.e., greater than 3 years). Figure 4 illustrates an example of a mechanism devised to mix lime with mine drainage as regulated by drainage flow rate. A fluffy sludge is produced with slower settling rate than that produced by crushed limestone.

- **Crushed Limestone** is the cheapest reagent on a "by weight" basis, but its usefulness is impaired by its limited solubility and low reactivity at upper pHs. Because crushed limestone is unable to raise the pH of AMD much beyond 7.5, it is inadequate to trigger the precipitation of most heavy metals. Nevertheless, it is less caustic than lime and cannot be overdosed. Therefore, the feed rate does not require exact regulation. Because it yields a much denser sludge, it settles faster.

  Passive treatment of acid mine drainage has been successfully accomplished (Turner and McCoy, 1990) through use of an anoxic alkaline drain treatment system. Such a system offers a low-cost AMD treatment alternative and is based on intercepting the drainage in a low dissolved oxygen state and directing it through limestone that contains a high percentage of calcium carbonate. Shallow trenches are excavated within mine backfill areas partially filled with limestone, covered with plastic sheeting, and capped with clay at the surface. Treatment using such a system is expected to extend greater than 20 years.

- **Quick Lime** is seldom used in industry because the formation of gypsum ($CaSO_4$) in the neutralization process can result in the clogging of conduits used in the discharge of drainage following treatment. Handling is more difficult because large quantities of heat can be generated as it reacts with water. Dust may cause serious eye injuries.

- **Caustic Soda** offers a benefit over the calcium-based compounds discussed previously in that it can raise drainage pH above 10.0 thus fostering the precipitation of manganese where necessary. Conversely, caustic soda produces a ferric hydroxide sludge with gel-like characteristics.

- **Soda Ash** is most commonly used to treat AMD characterized by low flow rate and low acidity. Soda ash can be used in a solid or slurry form. Commonly, AMD is channeled to flow over briquettes contained in a box or other structure.

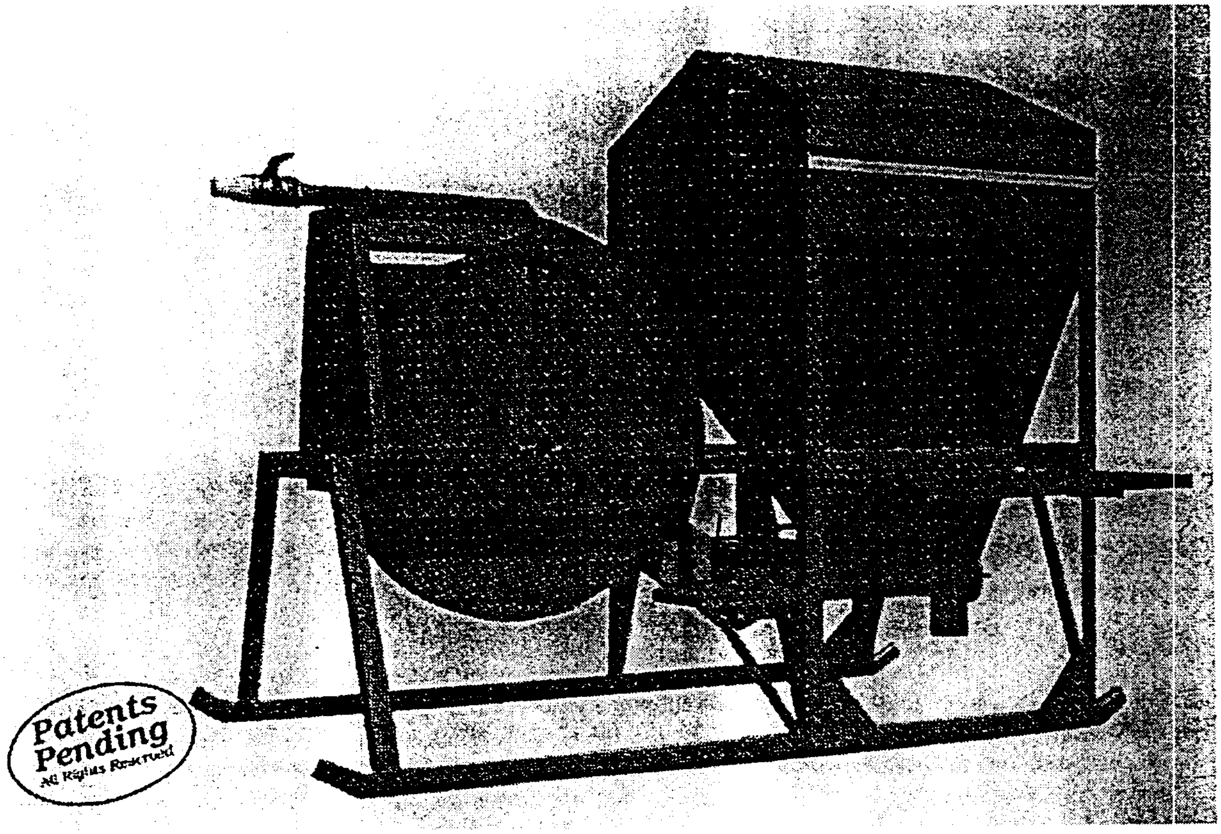


Figure 4. Example of mine drainage neutralizing device -- AquaFix

Metals Removal

For metals remaining in solution after neutralization is complete, potassium permanganate ($KMnO_4$) is the chemical of choice for removing iron (Fe) or manganese (Mn), which occur in concentrations that exceed effluent limitations. In instances where Mn concentrations are especially high, briquettes composed of both soda ash and $KMnO_4$ are available. Otherwise, $KMnO_4$ can be used alone following the neutralization process.

In the application of an anoxic alkaline drain treatment system, metals are oxidized and precipitate out at the drain outlet.

Aeration

During the neutralization process, oxidation of soluble metal compounds occurs, which acts to accelerate the formation of insoluble metal precipitates. For this reason, any activity that increases the oxygen transfer rate, and in turn the oxidation rate, is desirable. Aeration is the term applied to such activities.

Aeration is usually accomplished by spraying water through air or by allowing water to flow or cascade down a staircase trough or sluice way. This can be done during or following neutralization. Larger systems may employ the use of diffused air systems, submerged turbine generators, or surface aerators.

Settling

The Division of Waste Management should be consulted to determine if treatment product sludge should be analyzed to determine if it is hazardous prior to use as backfill. The treatment of AMD necessitates the settling of insoluble metal precipitates and sludges. The quantity and settling characteristics of any sludge produced will be dependent on the neutralization reagent used. The sedimentation process can be accomplished in a sedimentation pond or pond series or by means of a clarifier. Clarifiers allow increased control over detention time.

Chemical additives called flocculants are sometimes used to settle particles in an efficient manner. These are especially useful in settling fine particles. Synthetic polyelectrolytes are most frequently used for this purpose. Consult the MRP for site-specific recommendations.

Sludge is usually disposed of on mined out sections of the active mine. Typically, containment areas are excavated, which afford the opportunity for drying the sludge before backfilling and regrading. Site-specific decisions related to sludge disposal are dependent on land costs, hauling distances, slope, and equipment, labor, and maintenance costs. Under select circumstances, rather than discharging treated water directly into streams, some operators have obtained permission to reuse the water for irrigation purposes. This can provide a number of benefits for the operator and the environment, including water for dust control of haul roads.

Constructed Wetlands

Construction of an artificial wetlands system has the potential for reducing post-mining and mine drainage treatment costs although its use is currently not sufficient in itself for achieving bond release. Such a system would use the microbes contained in a wetland ecosystem to trigger the deposition of heavy metals from mine drainage. Metals would be removed from solution and fixed in the underlying soils in an insoluble state. If correctly designed and constructed, such a system makes use of indigenous cultures in a balance that is self-sustaining and thus ideally capable of providing long-term passive treatment (Davison, 1994).

Constructed wetlands are not a proven technology at this time and alone are not fully effective under all conditions. For these reasons, conventional back-up technology must be available if effluent limitations are not met.

Considerations in the design of constructed wetlands include the following (Pennsylvania DER, 1988):

- Methods for site preparation, including clearing and grubbing, grading and stabilization. All outslopes should be mulched and seeded upon construction.
- Number and dimensions of wetland cells.
- Base construction materials and the thickness and order in which these materials should be placed.

- Water depth and freeboard.
- Baffle design and flow routes within and between cells.
- Location of discharge points.
- Species to be planted, spacing, and method of planting, and chemicals to assist plant colonization.
- Water quality monitoring plans for the periods of:
  - construction
  - plant community establishment
  - long-term maintenance.

MAINTENANCE

Water quality should be monitored regularly and more frequently than minimum KPDES self-monitoring equipment provides. Be proactive in identifying problem areas as they may arise. Promptly adjust drainage treatment as required and maintain water level. Monitor condition of vegetation; remove accumulated solids, as necessary. Add conventional treatment to constructed wetlands system if necessary.

DIVERSIONS

DEFINITION

A diversion is a channel, embankment, or other manmade structure constructed to route water from one area to another (405 KAR 8:001). Diversions may be temporary (installed as an interim measure to control runoff and soil erosion) or permanent (approved for post-mining land use). Diversion ditches are point sources if they divert water that falls within the permit area to a water of the Commonwealth without passing through a sedimentation pond.

PURPOSE

Diversions are used to minimize contact of runoff with disturbed surfaces and acid spoils:

- Upslope from the mining operations, diversions are built on disturbed surfaces to route runoff around surface disturbances and thus reduce the size and number of sediment ponds required (Figure 5). Runoff from undisturbed areas may be directed to the normal receiving stream.
- Within disturbed areas, diversions are used to reduce slope length and minimize velocity of runoff (Figure 6).
- Around the downslope periphery of the operation, diversions are used to collect untreated water in sediment ponds for overland flow and ephemeral streams.

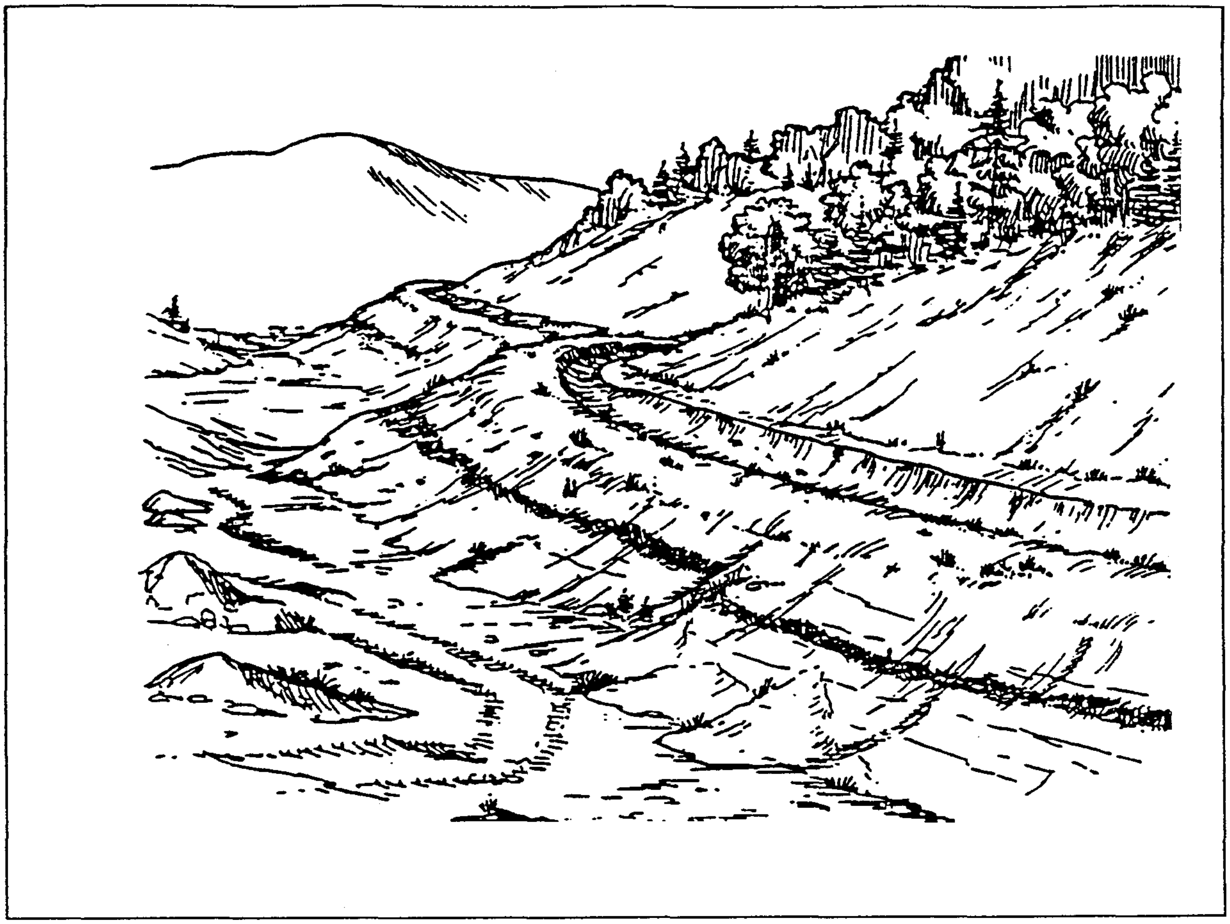


Figure 5. Upslope diversion ditches route runoff from undisturbed surfaces around disturbed areas.

REGULATORY REQUIREMENTS

State coal mining regulations (405 KAR 16:080 and 18:080) set forth standards for the design, construction, and maintenance of diversions for overland flow and ephemeral streams. Diversions are also subject to water quality regulations 401 KAR 5:031 and 5:066.

Diversion of perennial and intermittent streams that flow year-round may be done only with prior approval by the Cabinet. Permanent diversions or restored channel ways must establish or restore:

- the natural stream bank vegetation.
- an environmentally acceptable alignment.
- a longitudinal profile and cross-section, including aquatic habitats (using a pattern of riffles, pools, and drops rather than uniform depth) that approximates the pre-mining stream channel characteristics.

Should the Cabinet approve the placement of a coal refuse pile, coal waste impoundment, or an excess spoil fill in an intermittent or perennial stream, then the diversion of the stream channel must comply with the requirements for diversions set forth in the performance standards for those structures (405 KAR 16:080, Section 2, and 18:080, Section 2).

Should the permitted activity require issuance of a U.S. COE permit, 401 Water Quality Certification by the state would be required to ensure stream protection.

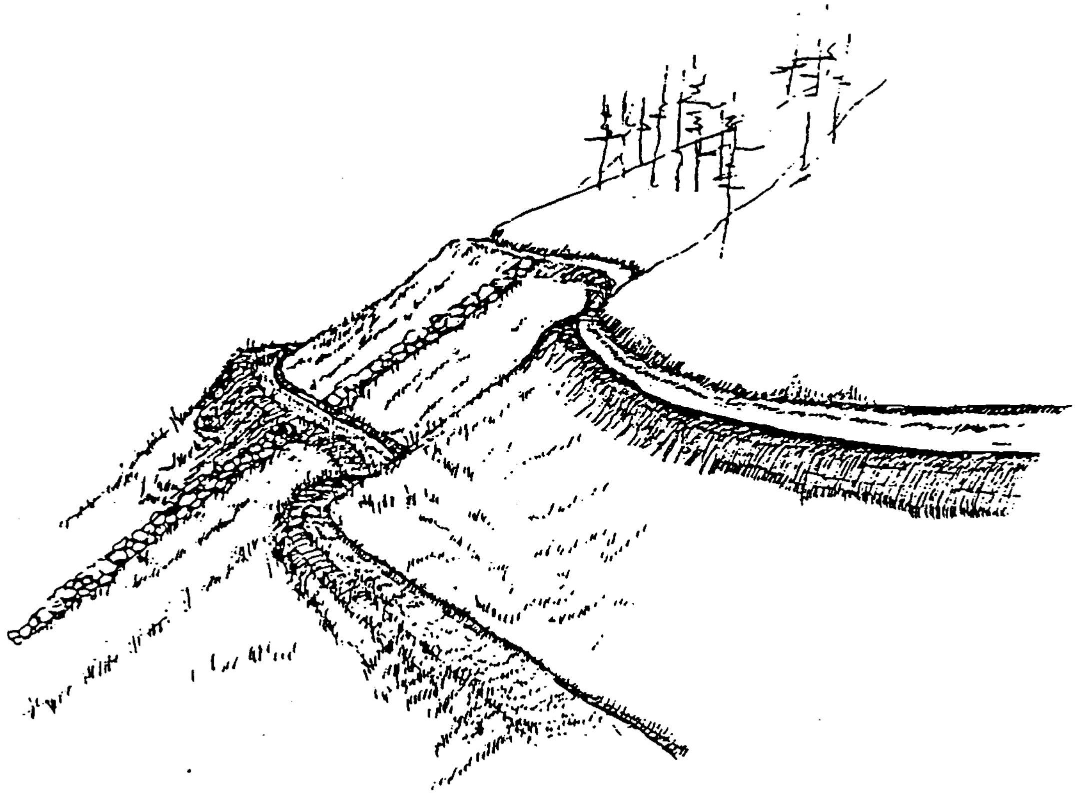


Figure 6. Diversions within the disturbed area reduce slope length and minimize velocity of runoff.

IMPLEMENTATION

Diversion channels that redirect overland flow and ephemeral streams must be adequate to pass the peak discharge of a 2-year, 24-hour storm in the case of temporary ditches, and a 10-year, 24-hour storm for permanent ditches. Under special conditions, diversions may be required to accommodate the hydraulic capacity of water control structures they circumvent (405 KAR 16:080 and 18:080).

Diversions should not be built where landslides could occur. This consideration is especially important on the upslope side of a head-of-hollow or valley fill.

Construction

To prepare for construction, the diversion should be laid with stakes. From a key point, such as an outlet, the diversion area should be divided into reaches of similar slope. Where the slope is uniform, stakes should be placed approximately 100 feet apart. Stakes may need to be set closer than 100 feet when abrupt changes in slope are encountered.

Land on which the diversion is to be built should be cleared and grubbed. If possible, outlets should be constructed prior to channel construction. The channel outlets should be constructed to the prescribed grade, width, height, and shape as specified in the permit package.

When constructed on a slope, diversions have a berm on the downslope side to contain the flow of water. Diversions on flat land have berms on either side of the channel. The height of the ditch sides must be 0.3 feet in excess of the water level during peak storm events. This excess height is referred to as the freeboard.

Three cross-sectional geometrys are commonly used in the construction of diversions: v-shaped, trapezoidal, or parabolic (Figure 7). The v-shaped and trapezoidal are the simplest to construct. However, parabolic diversions can carry large volumes of water with the least erosive damage. Side slope steepness is limited in the regulations according to the channel lining as follows:

- no steeper than 1h:4v for solid rock
- no steeper than 1h:1v for riprap
- no steeper than 2h:1v for grass-protected.

where h is horizontal run and v is vertical rise.

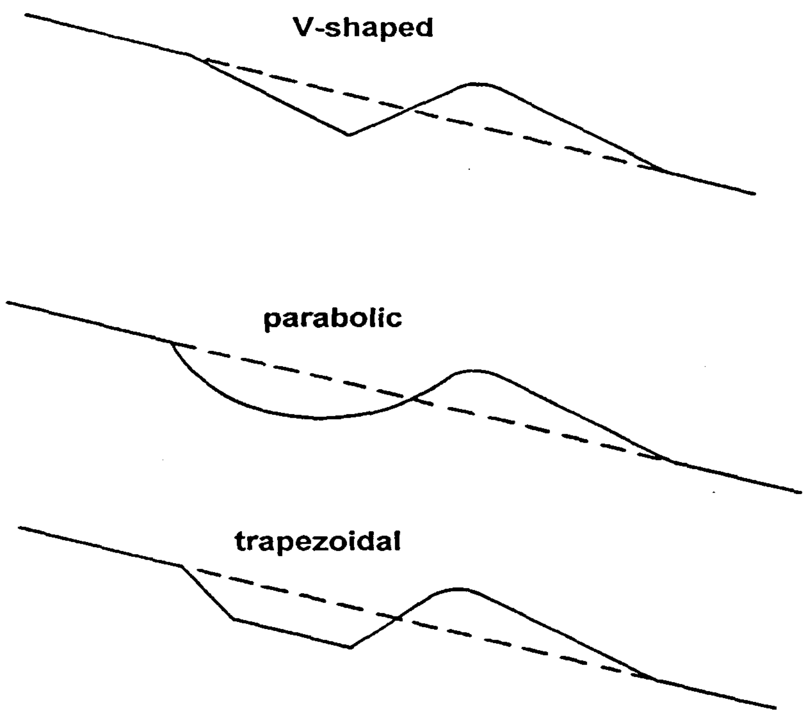


Figure 7. Cross-sectional geometry of diversion ditches.

In the excavation of diversions, disposal of excess material should be in compliance with 405 KAR 16:130 and 405 KAR 16:190. Topsoil should be handled in accordance with 405 KAR 16:050.

Erosion Control

Channel protection is essential in order to prevent erosion of diversions. Linings are the primary means of protection. Unless a channel is located on solid rock or lined with riprap or other non-erodible, non-degradable materials, diversions should be fertilized, seeded in grass, and mulched (see Revegetation, pg. 61-82). Native species are recommended as first choice for erosion protection and reclamation in general.

When channel linings are not sufficient to curb the erosive velocity of the runoff, the use of additional BMPs may be necessary (see Channel Protection, pg. 21-26).

Removal

Temporary diversions should be removed immediately upon completion of mining. Upon removal affected land should be , regraded and revegetated in accordance with 405 KAR 16:050, Sections 4 and 5; 405 KAR 16:190; and 405 KAR 16:200. If required, ephemeral stream channels shall be restored to approximate pre-mining characteristics.

MAINTENANCE

After each storm, diversions should be inspected for erosion damage to channels, linings, and/or check dams. Necessary repairs should be made promptly.

SEDIMENTATION PONDS

DEFINITION

Sedimentation ponds are water detention storage structures designed to detain storm flow. Ponds may be permanent (approved for post-mining land use) or temporary (removed and reclaimed prior to bond release).

PURPOSE

The purpose of sediment ponds is twofold:

- to create opportunity for the removal of settleable solids from non-point source (NPS) storm water.
- to collect NPS flow and transform it into point source discharge.

REGULATORY REQUIREMENTS

Sedimentation ponds must be established individually or in series prior to mining and must be designed and certified by a registered professional engineer. The design must provide for water retention time adequate to meet the requirements of 405 KAR 16:070. Ponds should be located in close proximity to the disturbance and out of perennial streams unless otherwise approved. They must meet the requirements specified under 405 KAR 16:090 and 16:100 and are subject to approval by the Cabinet on a case-by-case basis. Permanent impoundments are subject to the requirements specified under 405 KAR 16:060.

IMPLEMENTATION

Sedimentation ponds should be located immediately below the disturbance in low-lying areas. Materials from proposed pond locations should be tested for the absence or presence of toxic-forming or acid-forming materials. The type of pond selected is dependent on the topography. Embankment ponds are built on steeper slopes; dugout ponds are used on sites that range from level to shallow slopes.

The sediment storage volume of the pond is the anticipated volume of sediment that will be collected by a pond between scheduled clean-out operations. The amount of sediment that accumulates in any given period of time is dependent on the particle size distribution of the incoming suspension. For example, larger, heavier particles tend to settle faster than smaller, lighter particles.

Ponds must be designed so that water detention time is sufficient during a 10-year, 24-hour precipitation event to ensure that pond discharge will meet KPDES effluent limitations (405 KAR 16:070 and 401 KAR 5:065 and 40CFR434) regardless of rainfall amount, unless alternate precipitation-based limits are granted by the Kentucky Division of Water on a case-by-case or event-by-event basis.

In the case of fine, clay-sized particles, the use of special chemicals called flocculants may be necessary to enable settling. Flocculants bind smaller particles into clumps or "flocs," which then settle.

Site Preparation

The intended pond site should be cleared of vegetation. Trees should be removed and the remaining vegetation should be scalped, and stumps and roots should be grub out. Topsoil should be removed and stored or redistributed as appropriate (see Topsoil Removal and Storage).

In the case of an embankment pond, all surfaces should be sloped to no steeper than 1v:1h and the entire foundation surface should be scarified. If acid-forming or toxic-forming materials are present, crushed lime should be incorporated by disking into pond substrate and the pond lined with clay or geotextile membranes.

Embankments

Embankment construction specifications are addressed in SEDCAD$^+$ (Warner and Schwab, 1992). Excavation of a cutoff trench (to bedrock, if possible) is advised upstream of the proposed embankment centerline. Fill material used in the construction of embankments must be free of vegetative material, frozen soil, or coal processing waste. If quantities of suitable materials are insufficient, fill may be borrowed from stockpiles. Borrow pits should be excavated in a manner that prevents steep or unstable side slopes. Surfaces should be further stabilized with vegetation (see Revegetation).

Using the cleanest available fill material first, placement should begin at the lowest point of the foundation. The fill should be spread in horizontal layers six to eight inches deep and then compacted.

The entire embankment including the surrounding areas disturbed by construction should be immediately stabilized with a vegetative cover (see Revegetation). The active upstream face of the embankment where water will be impounded should be rip-rapped one foot higher than the level of the emergency or open spillway. Riprap should also be placed to a depth of 1.5 feet over the emergency spillway such that 25 percent of the rock is at least 18 inches in diameter.

Pond Removal

Temporary sedimentation ponds may be removed with approval by the Cabinet once all disturbed areas in the drainage area above the structure have been backfilled, graded, and revegetated. Such vegetation must have successfully survived two years from the last augmented seeding and have met the ground cover requirements of 405 KAR 16:200. Water discharged from the reclaimed area must be in compliance with effluent limitation guidelines for coal mining under 40 CRF 434 or the KPDES permit from the operation. The Division of Water should be notified at the time of pond removal of the determination of the point source discharge.

MAINTENANCE

A proposed sediment clean-out schedule is to be included with every pond design submitted to the Cabinet. Regulatory requirements do not require sediment removal until the pond has reached the maximum sediment storage level. However, it is often advisable to remove sediment at the 60-percent level in order to ease the meeting of effluent limitations. In most cases, sediment accumulation levels can be determined via visual inspection.

Depending on pond size and location, clean out is often best accomplished using a clamshell or dragline. If neither is available or well-suited, a long-arm backhoe can be used. For operators who rent equipment, it may be less costly to build larger ponds requiring fewer clean outs.

Dredged material should be dried before it is backfilled and regraded. Often "drying beds" are planned alongside the ponds (away from drainage ways) within the context of the permit. Once materials are dried, they may be disposed of in accordance with 405 KAR 16:090.

The pond embankments should be regularly inspected for signs of erosion and be repaired and revegetated in accordance with 405 KAR 16:090, Section 6. Embankments should be kept free of woody vegetation which could cause weakening of the structure by root channels and subsequent failure. Vegetative covers should be maintained through mowing, fertilizing, and reseeding as needed.

CHANNEL PROTECTION

DEFINITION

Channel protection refers to those measures used for stabilizing channels to protect against the erosive forces of water. Channel linings and check dams are two means by which to protect channels. Channels can be lined with grass, rock, riprap, or concrete. Check dams can be constructed with straw bales, lumber, or rock.

PURPOSE

The primary purpose of channel protection practices is to reduce the velocity of storm water flow. Small amounts of sediment may be trapped in the process. However, channel linings and check dams are not sediment trapping practices per se and should not be regarded as such.

REGULATORY REQUIREMENTS

Kentucky coal surface mining regulations (405 KAR 16:080 and 16:220) and water quality regulations (401 KAR 5:031 and 5:065) require that the design, construction, and maintenance of diversion ditches and road drainage systems prevent additional contribution of suspended solids to stream flow or runoff outside the permit area. Channel protection in the form of channel linings is mandated to prevent ditch erosion.

There are no regulatory requirements for the use of check dams. However, use of check dams can be effective for short-term erosion and sedimentation control, especially during the construction phase of water containment structures, stream crossings and encroachments, or haul roads, or during revegetation.

IMPLEMENTATION

Channel Linings

For channels with a peak discharge design velocity less than five feet per second, grass linings are allowable. In those cases where velocities are five feet per second or greater, riprap or other non-erodible, non-degradable materials must be used in lining unless the ditch is located on solid rock. Lining restrictions are also based on channel configuration as follows:

- side slopes can be no steeper than 1h:4v f or channels lined with solid rock;
- side slopes cannot exceed 1h:1v if the use of riprap is planned; and
- grass-protected ditches may have side slopes no steeper than 2h:1v.

Grass Linings

As appropriate, diversion ditches (Figure 8) should be limed and fertilized, seeded, mulched, and maintained in compliance with 405 KAR 16:200 (see Revegetation). Grass species especially effective in protecting against erosion include Tall Fescue, Reed Canarygrass, Bermudagrass, and Kentucky Bluegrass.

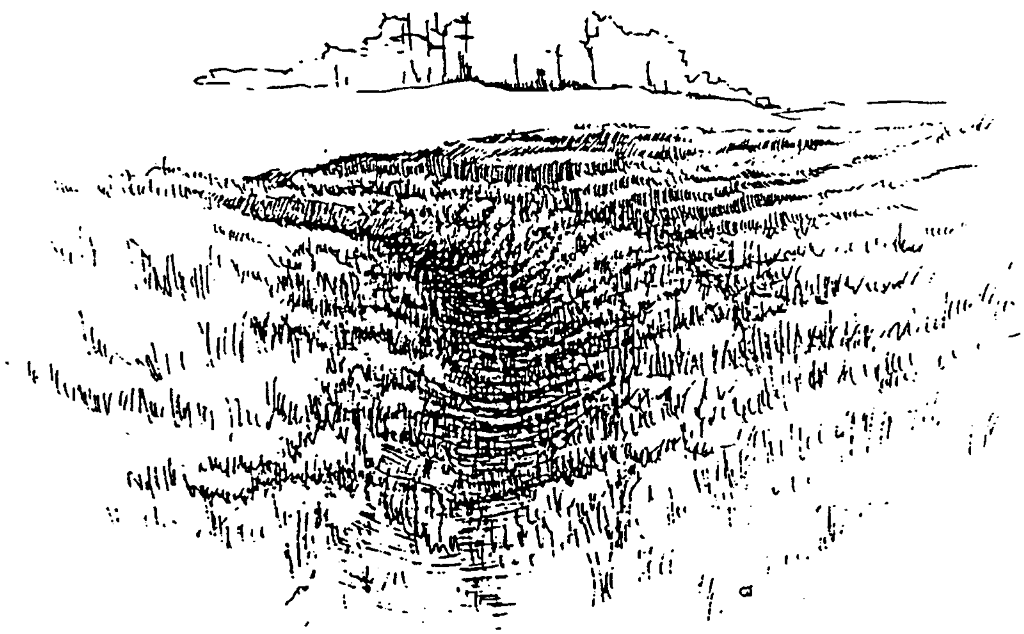


Figure 8. Grass Linings

Riprap Linings

Riprap linings (Figure 9) must be free of acid-forming and toxic-forming material and comply with the durability requirements of 405 KAR 16:130. That is, the Cabinet considers rock to be durable if the rock has a Slake Durability Index value of 9 or greater as determined via the Kentucky Method 64-513-79. Sand and gravel may not be used for channel lining.

The size of stones comprising riprap can be either uniform or graded. Generally graded riprap, that is, stones of varying size, is preferred because it forms a self-sealing cover. Consequently, installation of graded riprap is less expensive because stones can be dumped and be expected to remain in a well-graded mass. Uniform riprap requires individual placement of stones.

Riprap size can be specified by stone diameter or weight. Composition of a well-graded mixture down to the one-inch particle size such that 50 percent of the mixture by weight is no larger than the median stone size is preferred.

Riprap layers should have a minimum thickness of 1.5 times the maximum stone diameter, and not less than six inches. Rectangularly shaped stone is preferred for its durability, and the specific gravity of individual stones should be equal to or greater than 2.5. Channel banks should be protected to a height equal to the maximum depth of flow.

Check Dams -- General Construction

Check dams can be constructed where needed to reduce the velocity of concentrated storm water flow. Large rocks that might interfere with the functioning of the structure should be cleared, grubbed and removed. Building materials for check dam construction should be selected on the basis of expected flow rate and economics. Check dams should stretch from bank to bank. Water should cross only through a weir outlet and never over or around the sides of the check dam. The weir outlet itself should be at least six inches below the top of the embankment. The height of the dam should not exceed two feet. The maximum drainage area of the ditch or swale protected should not exceed 10 acres. For check dams built in series, the toe of the upper dam should be no lower than the crest or height of the lower check dam.

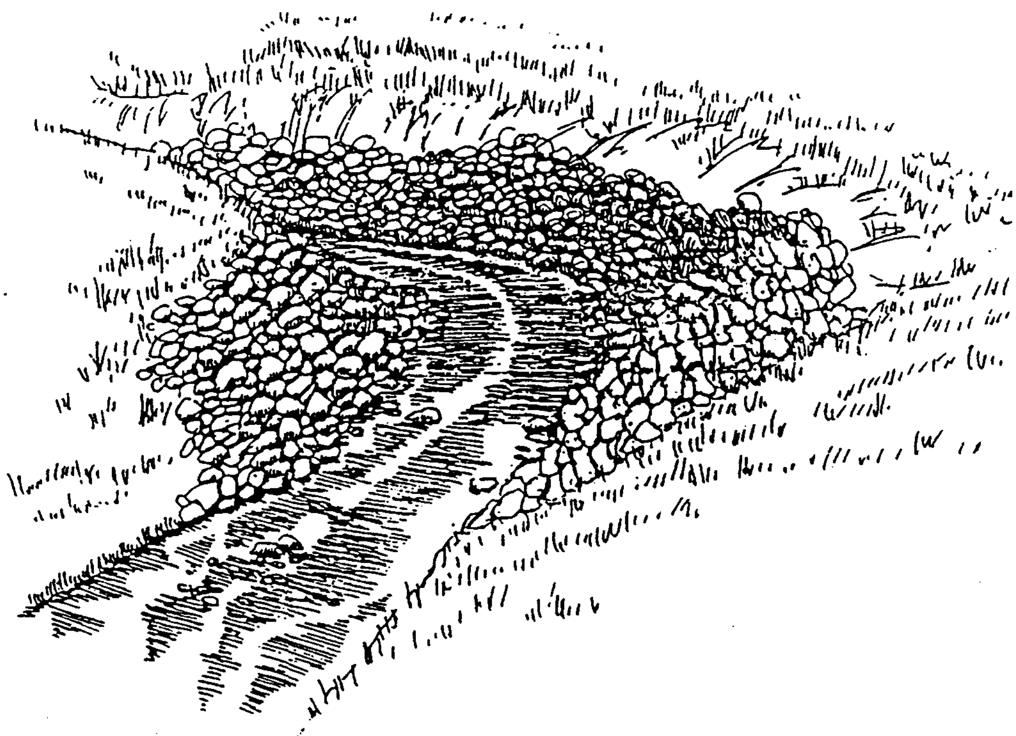


Figure 9. Riprap linings

Straw Bale Check Dams and Barriers

Straw bales are appropriate for use in erosion and sedimentation control on slopes and minor channels where concentrated flow will not develop.

The straw bale barrier should be built on a zero percent grade and parallel to topographic contours. Effectiveness of such barriers is limited by slope length and gradient. Limits on slope length are presented in Table 3.

Straw should be tied with plastic or hemp string (not wire) to form bales. Straw bales should be entrenched to a depth of four inches and staked to a depth of 18 inches (Figure 10).

Table 3. Maximum Slope Lengths for Straw Bale Check Dam (Smith, Jr., J.W., 1991)

Percent Slope	Maximum Slope Length (ft) Above Barrier	Percent Slope	Maximum Slope Length (ft) Above Barrier
2 or less	250	30	15
5	100	35	15
10	50	40	15
15	35	45	10
20	25	50	10
25	20		

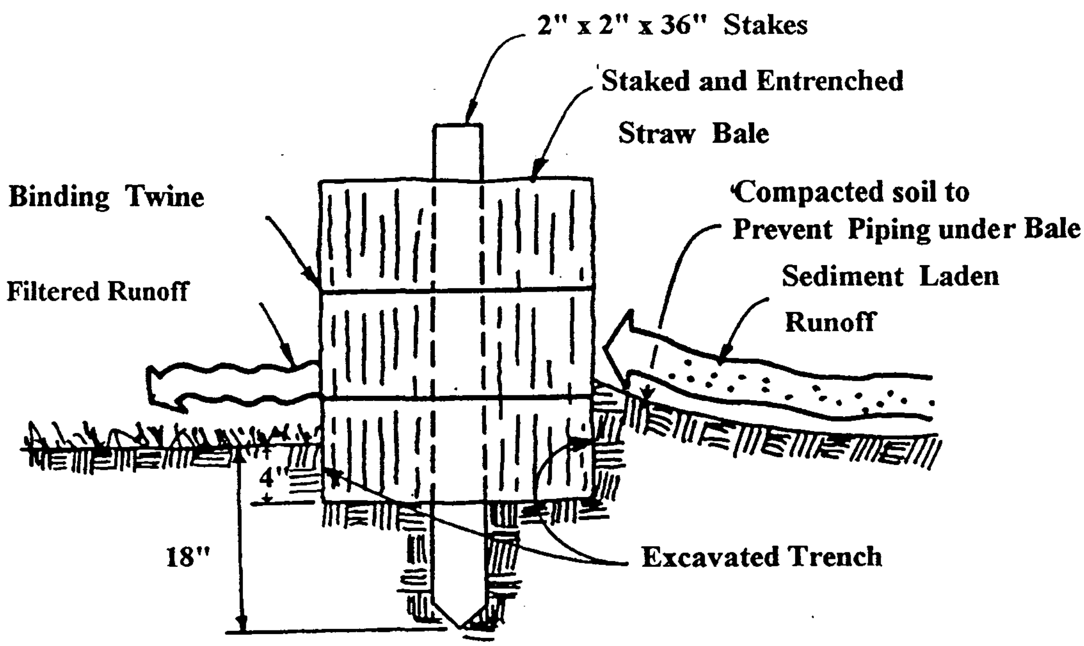


Figure 10. Cross-section of straw bale barrier

Log Check Dams

Because log check dams are more effective and stable than straw bale barriers, they can be used in channels. Typically, from a materials standpoint it may be less expensive to construct a check dam from logs rather than from rock. In terms of labor requirements, log dams require more time and hand work to build. Logs should be four to six inches in diameter and be driven 18 inches beneath the channel floor. Logs should stand perpendicular to the plane of the channel cross section, with no space between logs (Figure 11). Center logs should be driven deeper into the ground to provide a six-inch weir. Place riprap or shorter, wider logs on the downstream side of the weir to stabilize the outlet.

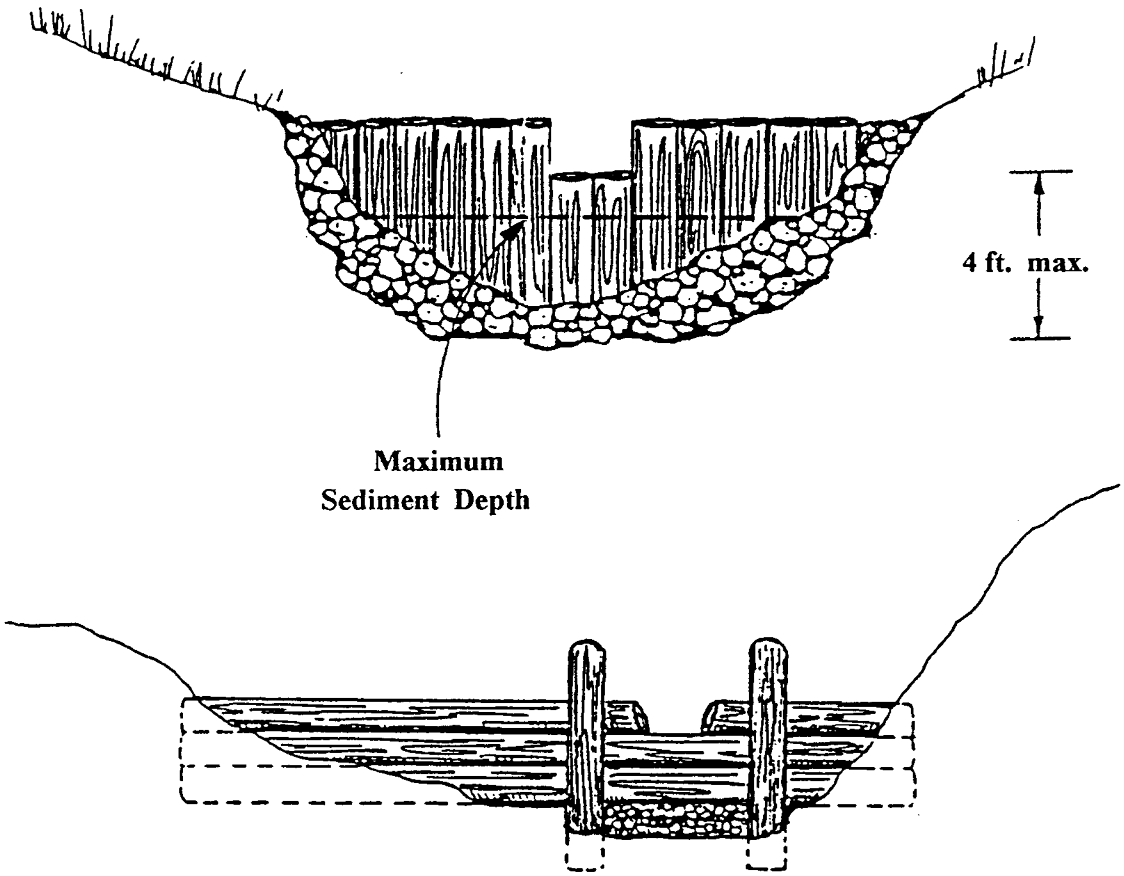


Figure 11.   Log check dams

Rock Check Dams

Water passes over and through rock check dams (Figure 12). In small channels, loose rock may be dumped to form a check dam. In such cases, stone two to three inches in diameter can be used.

Larger channels may require the use of gabions (cages made from heavy wire fence and filled with rock). These check dams (Figure 13) are most effective if anchored three feet into the ground. Nine-inch diameter stone is sufficient for use when water velocities do not exceed eight feet per second.

Both the upstream and downstream faces should be no steeper than 1v:3h for loose rock and 1v:2h for gabions.

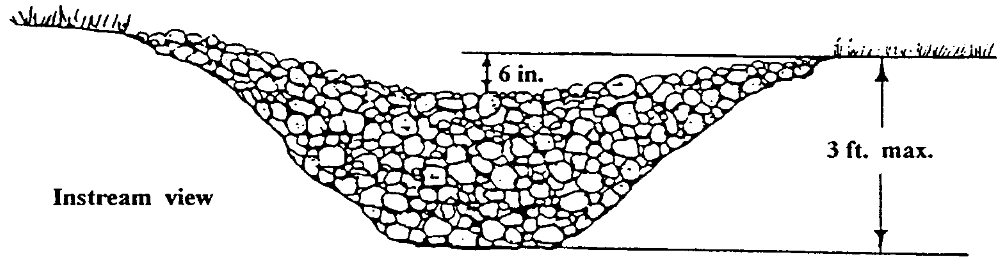


Figure 12. Rock Check Dam

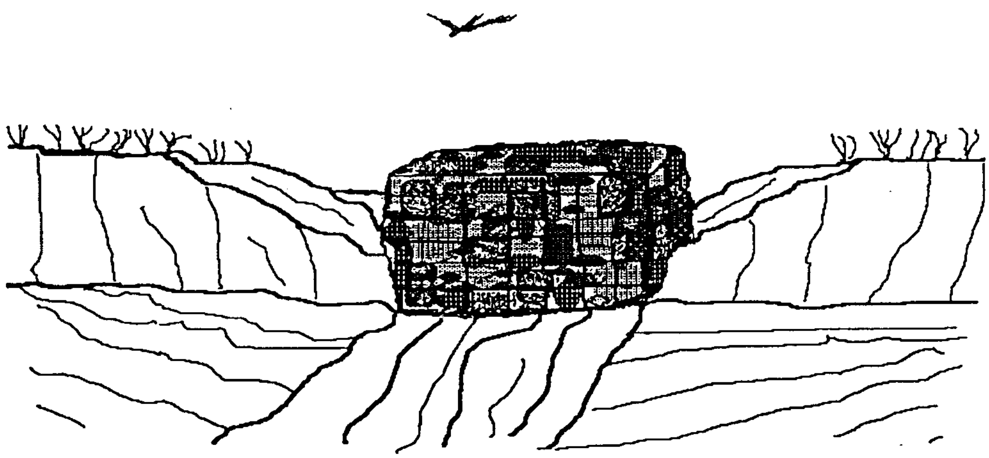


Figure 13. Gabion

Check Dam Removal

Check dams should be removed when temporary diversion ditches are regraded and revegetated. Stones in permanent grassed waterways should be removed to prevent damage to mowers.

For permanent channels, check dams should be removed once permanent linings are installed or grass has adequately matured to protect the ditch or swale.

MAINTENANCE

After each significant rain storm, check dams should be inspected for damage and sediment accumulation. Sediment should be removed when it accumulates to one-half the height of the dam or sooner. Sediment that has been removed should be backfilled, graded, and revegetated in accordance with 405 KAR 16:190 and 16:200.

Vegetative covers should be maintained through mowing, fertilizing, and reseeding as needed.

Riprap stone that has moved should be replaced by hand, and additional stone should be placed where undercutting has occurred.

SILT FENCES

DEFINITION

A silt fence is a temporary sediment barrier constructed of a semi-permeable fabric (burlap or synthetic) stretched between and attached to supporting posts.

PURPOSE

Silt fences trap sediment while allowing runoff water to pass through the fence.

REGULATORY REQUIREMENTS

There are no regulatory requirements for the use of silt fences on active mine sites. Nevertheless, silt fences can be effective in short-term erosion and sediment control, especially during the construction phase of other control structures, haul roads, and as a control for use in small drainage basins.

IMPLEMENTATION

Failure rates of silt fences are generally lower than those of straw barriers if fences are properly installed. Fences constructed of synthetic materials generally have a much lower permeability than those constructed of burlap. Screen sizes will vary according to the manufacturer. For that reason, synthetic barriers are usually limited to control of overland runoff flow. Usually these fabrics do not have the structural strength to support the weight of water impounded behind the fence line. The life expectancy of a silt fence under these conditions is generally expected to be about six months.

Silt barriers can sometimes be employed in minor channels (flow less than one cfs) when the area drained does not exceed two acres.

Planning/Installation

The following guidelines are offered to encourage the effective use of silt fences in erosion and sediment control:

1. The filter cloth should be able to filter 20 gallons of water per hour per square foot of fencing and retain at least 75 percent of the sediment.

2. Fence posts must be strong and durable. Suitable materials include 2x2 lumber, reinforcing rod (rebar), stamped steel posts, or hog fence T-posts. Do not attach filter cloth to trees.

3. The fence should preferably be constructed parallel to topographic contours, at a zero percent grade (Smith, 1991). A fence post spacing not to exceed six feet is recommended.

4. The size of the drainage area should be no more than ¼ acre per 100 feet of fence.

5. Maximum slope length should be 100 feet. When slope length exceeds 100 feet, a second installation of fence should not be installed behind the first.

6. Fences should be installed in undisturbed ground. Drive fence posts one foot deep along the fence line. Dig a six-inch by six-inch trench on the upslope side (Figure 14). Attach self-supporting filter cloth or a combination of wire fencing and filter cloth to the poles with durable large head nails.

7. The bottom six to eight inches of the filter fabric should be buried in the trench. The trench is then backfilled and compacted to aid in anchoring and minimize piping. The trench line should be revegetated immediately with a temporary seed mixture.

8. Considerations should be given to increasing the stability of the fence posts by using staked rope or wire tie-backs. Tie-backs are especially important when silt barriers are constructed in minor channels. In such instances, it is advisable to cut a v-notch weir outlet (Figure 15) in the filter cloth's upper edge at the lowest edge at the lowest point in the fence line. Beneath the v-notch, place riprap in the channel below the outlet.

Removal

Silt fences are intended as temporary erosion and sediment control devices and should be removed when no longer needed. Filter fabric can sometimes be recycled for use at a new location. The disturbed area should be regraded and revegetated in accordance with the revegetation plan.

MAINTENANCE

Silt fences should be inspected, especially following significant rain or windstorm events. Fence reanchoring or patching may be necessary.

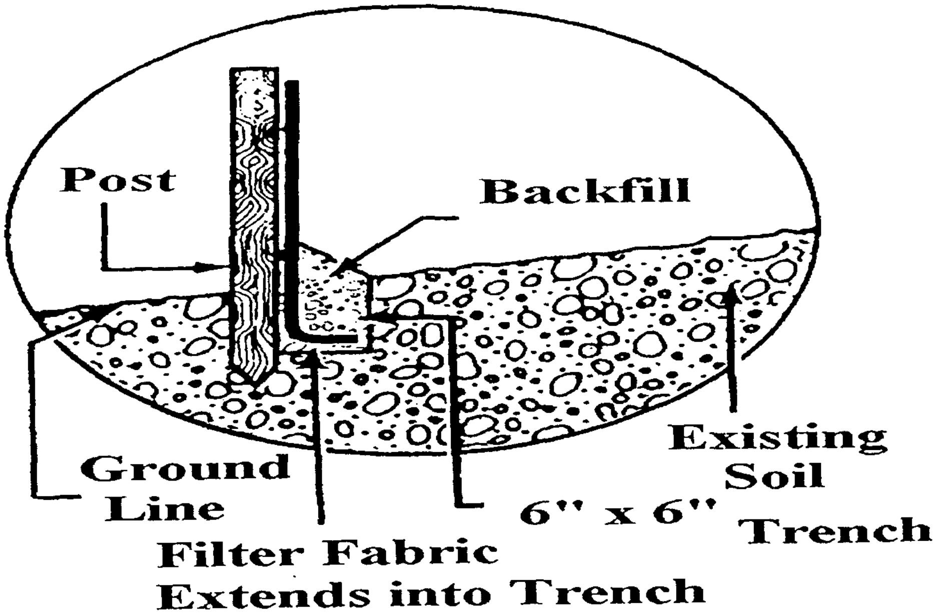


Figure 14. Silt fence installation

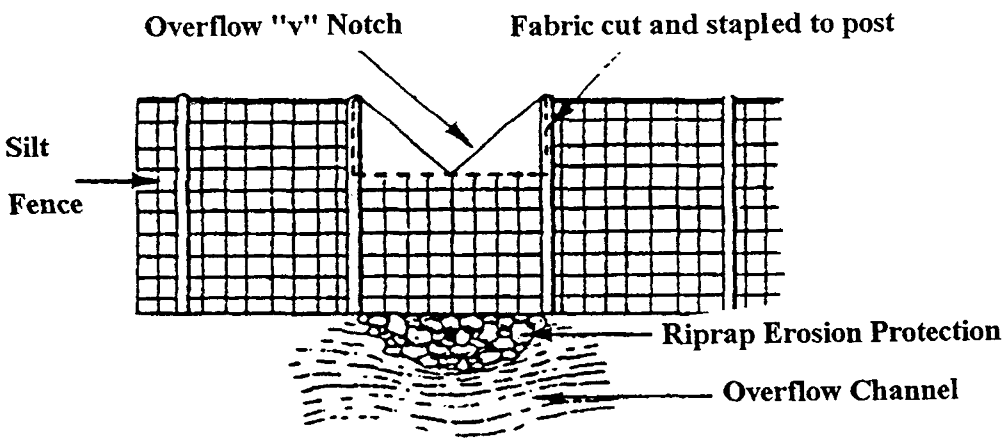


Figure 15. Silt fence weir