CHAPTER 6

MOBILIZATION AND MINING OPERATIONS

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PROBLEM & PURPOSE

Many of the performance standards of the new Regulations are designed to prevent erosion and, subsequently, sedimentation. The problems of erosion and sedimentation on surface coal mining sites were described and quantified in Chapter 2. Preventing erosion and sedimentation solves or helps to solve three of the basic problems associated with surface mining.

1. Sediment in surface waters is a direct result of erosion and results in serious degradation of stream health and a reduction in the capacity of streams to handle flood flows and many other problems (9). Sedimentation will be reduced by erosion control measures.

2. Exposure of acid or toxic-forming spoil. A problem on abandoned mine sites was the continual exposure of acid-forming or toxic-forming spoil as a result of erosion of unstable slopes. Stabilization of slopes, topsoiling and revegetation coupled with effective erosion control measures will prevent the exposure of new acid-forming spoils to the atmosphere and hence result in improved control of acid mine drainage.

3. Revegetation. Erosion results in the loss of soil and hence reduces the ability of the site to support a vigorous vegetation cover. Reestablishment of an effective vegetation cover is one of the principles of effective erosion control and is emphasized in the new regulations.

"The universal soil loss equation" can be used to estimate the rate of erosion from surface mine sites. This equation was developed by the U.S. Department of Agriculture for use on agricultural land but gives a fairly accurate estimate for soil loss from any activities involving the removal of vegetation and the disturbance of the land surface. The use of this equation is described in the U.S. Department of Agriculture's Handbook No. 282 (1965).

$$A = RKLSP$$

Where:

- A = Soil loss (tons/acre)
- R = Rainfall factor (reflects intensity of rainfall)
- K = Erodibility factor (reflects soil characteristics affecting erodibility)
- L = Length of slope factor (reflects accumulation of runoff on long slopes)
- S = Steepness of slope factor (reflects increased runoff velocity on steep slopes)
- C = Cropping and management factor (reflects cover, plant residues, mulching, etc.)
- P = Erosion control practice factor

In some cases, the universal soil loss equation has been found to give unsatisfactory estimates of soil loss on surface mine sites. For instance, on long slopes of dumped spoil, it was found that runoff and erosion did not necessarily increase as was expected as it accumulated and gained momentum flowing down a slope. It has been suggested that this is because the coarser material, when dumped, tends to segregate on the lower part of the slope, and this increases the infiltration and consequently reduces the runoff at this point. However, for spoil which is selectively placed, consolidated and topsoiled, the universal soil loss equation gives a reasonable estimate and will probably remain in use until a more precise technique can be developed.

DISCUSSION & DESIGN GUIDELINES

Eight major principles in the control of erosion and sedimentation on surface mine sites are discussed here. For a detailed tabulation of the main requirements of the new Regulations [Part 816] relating to erosion and sedimentation control see Table I of the Appendix following Chapter 5.

1. Minimizing the area which is disturbed at any one time. As soon as protective vegetation is removed from the site, erosion will begin and will not stop until an effective vegetation cover is reestablished. Minimizing the disturbed area is addressed in Section 816.45(b)(1). The requirement of Part 780 that the operational plan indicate the phasing of operations and reclamation on surface mine sites is also in part designed to make sure that the minimum area is disturbed at any one time in the planned surface mining operation. Regulations require temporary protection of spoil piles and topsoil stockpiles that must remain in position for a long time.

2. Maintaining buffer strips of undisturbed land between the mine area and streams and bodies of surface water. The requirement of the regulations is that no land within 100 feet of perennial streams shall be disturbed without specific approval.

3. Diversion of clean water around the disturbed area. The regulations contain provisions for the diversion of both permanent and ephemeral streams around the planned operational area. The purpose is to prevent clean water picking up sediment and other pollutants when passing over the disturbed site. Careful attention to drainage is essential before any mining operations begin (5).

4. "Internalization" of drainage within the disturbed area. The regulations require sediment ponds at all points at which surface water drains from the site, and therefore, it is in the interest of the mine operator to try to internalize the drainage from the disturbed area and to minimize the points at which it flows from the site. Some practices such as dumping spoil on the downslope make it very difficult indeed to control surface water drainage and therefore this practice has been outlawed in the Regulations. It is much more difficult for an operator in hilly or mountainous terrain to internalize drainage than for an operator using the area mining method. Operators may find it especially difficult to control sediment caused by the erosion of excess spoil disposal sites. However, studies of Head-of-Hollow filling techniques have shown a significant reduction in the amount of sediment generation (Curtis, 1974). Haul roads (Sheet 6:2) also pose a difficult problem largely because of the difficulty of keeping drainage within the disturbed area, and long haul roads can involve the operator in heavy expenditures on sediment control measures.

5. Slope stability. Placement and compaction of spoil in such a way as to avoid instability, slides and slips is clearly very important in erosion and sediment control. The continued erosion from abandoned surface mine sites is caused partly by instability due to slips and steep slopes where fresh spoil is continually exposed to erosion and where effective vegetation cover cannot get established. Many of the performance standards in Part 816 are designed directly or indirectly to prevent these problems.

6. Sedimentation ponds. Section 816.42(a)(1) "All surface drainage from the disturbed area, including disturbed areas after being graded, seeded or planted shall be passed through a sedimentation pond or a series of sedimentation ponds before leaving the permit area." Sedimentation ponds are required at appropriate locations before any mining activities start and they must be retained until after revegetation is complete [816.46(u)]. Generally the approach is to prevent erosion occurring whenever possible, but to trap sediment from erosion which does occur, in sedimentation ponds before drainage leaves the site. Section 816.46 contains specific

DISCUSSION & DESIGN GUIDELINES (CONTINUED)

details on the design of sedimentation ponds including the sediment storage volume required, the detention time and discharge structures. For further details on the design and construction of sediment ponds see Sheet 6:3. In the past, the performance of sedimentation ponds has been erratic, but this has been very largely due to poor construction, poor maintenance, failure to remove accumulated sediments and also the failure to remove the pond after the site has been revegetated.

7. Landforms. The amount of erosion will vary with both steepness and length of regraded slopes. Even if land is to be restored to the "approximate original contour" there are measures which can be taken to reduce slope length (terracing, diversions) on regraded areas [816.102] and cultivation techniques to improve infiltration and to reduce the runoff (see Sheet 7:3).

8. Revegetation. Performance standards requiring prompt revegetation are designed to reduce erosion and sedimentation and other standards are designed to ensure the quick establishment of effective vegetation. These include the requirement to remove and replace topsoil, to break up excessive compaction [816.24], and to apply soil amendments, etc. Only after effective vegetation has been established may sedimentation ponds and other control measures be removed. Note that suggestions that earthmoving operations should be programmed to occur during periods of low rainfall are not realistic on surface mining sites. However it should be realistic to program reclamation operations to fit in with seasonal requirements for revegetation (or temporary cover).

Hydroseeding to Attain Prompt Revegetation

Breaking Up Excessive Compaction

REFERENCE

(1) Curtis, W.R. and Superfesky, M.J., Aug 1977, "Erosion of Surface Mine Spoils," Proceedings of Soil Conservation Society of America, Richmond, VA.
(2) Curtis, W.R., Oct 22-24, 1974, "Sediment Yield from Strip Mined Watersheds in Eastern Kentucky," Second Research and Applied Technology Symposium on Mined Land Reclamation, Coal and Environment Technical Conference, National Coal Association, Louisville, KY.
(3) West Virginia DNR, 1975, "Drainage Handbook for Surface Mining," Charleston, WV.
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(5) Hamilton, L.W., Sep 1974, "Reclamation in Steep Slope Surface Mining," Mining Congress Jour., Vol. 60, No. 9.
(6) Hill, R.D., Aug 1978, "Methods for Controlling Pollutants," Proc. Reclamation of Drastically Disturbed Lands Symposium, ASA, CSSA, SSSA, Madison, WI.
(7) Curtis, W.R., 1977, "Hydrologic Aspects of Surface Mining in the East," Proceedings Society of American Foresters, Berea, KY.
(8) U.S. Forest Service, undated, "Toward a Quality Water Supply," Photostory 10, USDA, Forest Service, Northeast Forestry Experimental Station, Upper Darby, PA.
(9) Mills, T.R. and Clar, M.L., October 1976, "Erosion and Sediment Control--Surface Mining in the Eastern U.S.--Planning," Environmental Protection Agency Technology Transfer Seminar Publication 625/3-76-006.
(10) Glover, F. et al., 1978, "Grading & Shaping for Erosion Control and Rapid Vegetation Establishment in Humid Regions," Proc. Recl. of Drastically Disturbed Lands Symp., Schaller, F.W. & Sutton, P. (Eds.) Madison, WI.
(11) Curtis, W.R., 1971, "Strip Mining, Erosion and Sedimentation," Transactions of the ASAE, Minneapolis, MN.

PROBLEM & PURPOSE

As much as 10% of the total area affected by surface mining is devoted to coal haulage roads (1). Haul roads extend beyond the actual mine area and they tend to intercept clean runoff and contaminate it with sediment. In the past, poor construction practices of haul roads and attempts to bed down the roads after completion of mining operations led to serious and prolonged erosion and sediment problems from these sources. In many respects, coal haulage roads are similar to logging roads in mountainous regions. Experiments at Coweeta Hydrologic Laboratory near Franklin, NC showed that the erosion from lumbering operations in Appalachia was mostly due to erosion from logging roads and skidding operations (6).

Mine haulage costs often represent up to 50% of the total mining costs in surface mining and hence the construction and maintenance of good haulage roads is critical to the economics of a surface mine. The quality of a road also depends very largely upon how well drained it is, but there is also an important relationship between the operating speed and the safety of operation. "The benefits to be derived from safe haulage road design and construction quite often lie unseen as the intangible factors of reduced accidents and injuries. However, in many cases, the incorporation of correct design principles can increase mine productivity "(9).

Some erosion and sedimentation from haul roads will occur on the run sites, even on the well-managed sites. There are 4 sources of sediment from roads: the road surface, the cut slope, the roadside ditches, and the fill slope (13).

APPLICABILITY

Applicable to all mining operations. Roads within the mining pit area are not subject to the performance standards in Sections 816.150-816.176. But all other roads within the permit area are.

RELEVANT SECTIONS OF THE REGULATIONS

Section 780.37 requires that each application contains a detailed description of all roads to be constructed within the proposed permit area. It should be noted that the term "road" does not include roadways within the immediate mining pit area (Definitions, 701.5).

The drainage from roads within the pit is covered by performance standards dealing with drainage water and the control of sediment from the pit. The stringency of performance standards for roads outside the pit area is due to 1) the high rates of erosion and sedimentation caused by dirt roads in constant use by heavy vehicles and a high runoff from these roads due to extensive consolidation; and 2) the difficulty of treating runoff from a road because the runoff tends to be dispersed over a wide area.

It should be noted that Section 816.42(a) requires that surface drainage from all disturbed areas be passed through a sedimentation pond, but that "disturbed areas" in this section does not include roadways if they are installed in accordance with the performance controls and the upstream area is not otherwise disturbed by mining activities.

This sheet covers Sections 816.150-816.176 which apply to roads. This handbook contains general guidelines only and designers should check each case for conformance to the regulations. There are three classes of roads covered by the regulations, these are:

Class I - These are roads used for the transportation of coal. Generally, these roads remain in place for the whole working life of the site and the design criteria for their construction are the most stringent.

<u>Class II</u> - These are roads other than Class I roads which are to be used for 6 months or longer.

<u>Class III</u> - These are roads other than Class I roads which are to be used for 6 months or less. (These definitions can be found in Part 701.5.)

The performance standards for all classes of roads emphasize the importance of the design, location, construction, maintenance and reclamation of roads to minimize erosion and sedimentation problems. All classes of roads have to be removed and restored after mining operations unless approved for post-mining land use or for controlling erosion [816.150(c)]. Class I roads have to be designed by a registered professional engineer. In the case of Class II roads, a qualified engineer need only be used if alternative specifications for the road design other than those specified in the performance standards are to be used. A registered professional engineer need not be used by mine operators for the design of Class III roads.

DISCUSSION & DESIGN GUIDELINES

Some of the design criteria described on this sheet are not specific requirements of the performance controls. The following references are suggested for basic design guidelines for haul roads: (9), (7) and (10).

I. LOCATION [815.151, 816.161 AND 816.171]

The performance standards require roads to be located so as to minimize erosion, sedimentation, and downstream flooding as a result of the construction. Generally, fords are prohibited for stream crossings by haul roads. If roads can be located along ridgelines, stream crossings will be minimized and the amount of overland flow intercepted by the road will also be minimal. Though this won't be possible in most cases, careful location to avoid seeps, wet areas and to minimize stream crossings can save a lot of money.

II. HORIZONTAL AND VERTICAL ALINEMENT

Horizontal and vertical alinement are important factors in insuring safe operating speeds and stopping distances.

The small operator should understand the relationship between grade steepness and haulage costs. Sometimes longer slopes covering the same vertical distance can give substantial improvement in truck performance. Curves just before or after a grade can reduce truck performance also.

Horizontal and vertical alinement are important factors in insuring safe operating speeds and stopping distances. Skelly and Loy's report gives the design for horizontal and vertical alinement of haul roads including stopping distances for various weights of vehicles (Figure 1). The maximum grades as required in the new Regulations are similar to most of the state regulations pre-1977 and are shown in Table 1. Slopes of less than 3% should be avoided, if possible as they will not drain adequately.

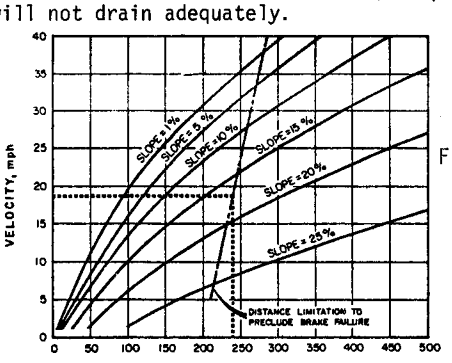


Figure 1. Stopping distance characteristics of vehicles of less than 100,000 pounds GVW.

TABLE 1

MAXIMUM GRADES FOR HAUL ROADS

Road Class	Overall Grade %	Pitch Grade %	Permissable Length of Pitch Grade
Class 1	10	15	300 (Maximum length within 100 feet)
Class 2	10	15	300 (length)
Class 3	10	20	1,000 (consecutively)

Source: Regulations

III. TRANSVERSE GEOMETRY

The transverse geometry, the cross section of the road are of great importance especially in ensuring good drainage of the road and stable construction.

The Regulations specify the width of haul roads required. Skelly and Loy's report gives the following design guide for vehicles up to 100,000 pounds gvw. The width for 1-lane (23 ft.) and 2-lane (40 ft.) haul roads on curves are shown in Table 2.

TABLE 2

RECOMMENDED WIDTHS FOR HAUL ROADS

Curve Radius (Ft.*)	One-Lane Haul Way	Two-Lane Haul Way
25	27	48
50	25	44
100	24	42
200	23	41
tangent	23	40

Source: (9)

*On the inner edge of the pavement.

If the area upstream of the haul road is also disturbed, all runoff from the road must be passed through a sediment basin [816.42]. Therefore it is clearly best to try to concentrate road drainage at a few selected points. This will mean the use of roadside ditches, usually located on the upslope side of the road, with a reverse fall on the whole roadbed so that all drainage flows to the ditch (Fig. 2). This will mean a culvert under the road at each sag in the vertical profile.

In steep terrain where most haul roads will be on cut and fill, a downslope ditch would have to be located on fill (Fig. 3) and would be liable to washout unless lined. The reverse fall also prevents overland flow from upslope areas flowing onto the road. Cross-slope to give rapid drainage of surface water should be ¼-½"/ft (10). However in flatter terrain such an arrangement or a cambered road with a ditch on both sides is possible when road is in total cut

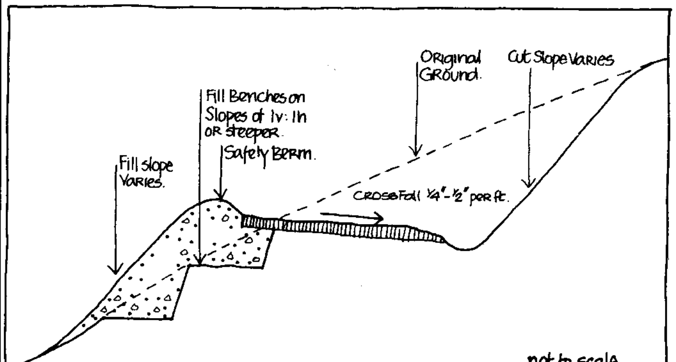


Figure 2

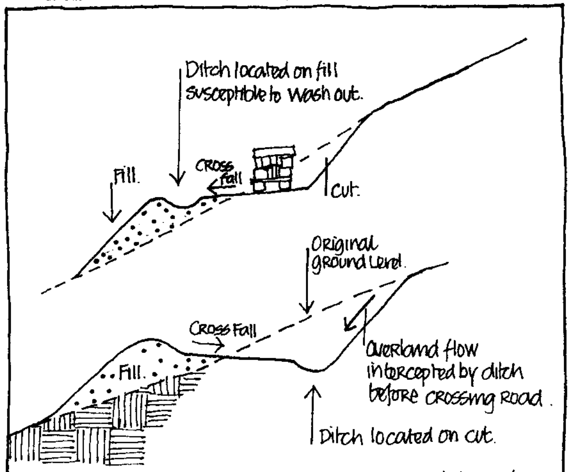


Figure 3

Curves on haul roads should normally be superelevated (banked) for greater safe-operating speeds. Superelevations will normally be banked into the slope of the land at crests and away at sags which allows most drainage to be handled in upslope ditches as suggested above. The Regulations do not specify superelevations, but Skelly and Loy's report gives criteria for calculating superelevations necessary on high-speed haul roads.

The Regulations specify maximum slopes for cuttings and embankments on haul roads for Class I and II roads. These are shown in Tables 3 and 4.

TABLE 3

MAXIMUM CUT SLOPES FOR HAUL ROADS

Road Class	Unconsolidated Material	Rock
Class I	1v:1.5h	1v:0.25h
Class II	1v:1.5h	1v:0.25h
Class III	no standards specified	

TABLE 4

MAXIMUM SLOPES FOR EMBANKMENTS IN HAUL ROADS

Road Class	Unconsolidated Fill	Rock
Class I	1v:2h	1v:1.35h
Class II	1v:1.5h	1v:1.35h
Class III	no standards specified	

Topsoiling and temporary erosion control measures are required for Class I and II roads in the performance standards for slopes of 1v:1.5h or flatter (i.e. those slopes not in rock or constructed of rock fill).

IV. DRAINAGE [816.153, 816.163 AND 816.173]

On Class I roads the drainage system must be designed for a 10-yr, 24-hr precipitation event. Sedimentation control for all classes of roads must comply with Sections 816.42 and 816.45 requiring that all runoff from "disturbed areas" be passed through sedimentation ponds; however, Section 816.42(a)(4) notes that "disturbed areas" do not include those areas in which only roads are installed if the area upstream of the road is not "otherwise disturbed." Natural drainage channels may not be altered without the approval of the RA and may not be altered at all in the case of Class III roads. Drainage structures are required for all stream crossings.

4:1 Ditches are required for Class I road (on both sides of a throughcut and on the inside shoulder of a cut-and-fill section). Ditches are not necessarily required for Class II roads where ditches, surface dips and natural drainageways may be used. Where ditches are provided a cross fall of ½" per foot will be adequate to drain the surface of all roads. Ditches themselves may be 'V' shaped or trapezoidal but 'V' shaped ditches are easier to construct without specialized equipment. Erosion is likely in ditches with a grade of over 4%, in which case they may require protection with riprap or other lining (Table 5). Avoid constructing ditches on fill.

TABLE 5

ROADSIDE DITCH LINING

Grade	Lining
0-3%	None required.
3-5%	Seed with erosion resistant grass and protect with jute matting or similar.
Over 5%	Riprap to at least 6" above max depth of flow.

Source: (9)

As an alternative to lining ditches, where the grade is too steep it can be reduced by constructing checkdams along the length of the ditch. These checkdams may be constructed of logs, riprap, or gabions, although logs are probably the cheapest on most forested sites. An example of a log checkdam is shown in Figure 4 (7).

Smooth channel linings or conduits will speed up the flow of water in the ditch and an energy dissipator should be installed at the discharge point. Fig. 5 shows a dumped rock energy dissipator to check erosion (9).

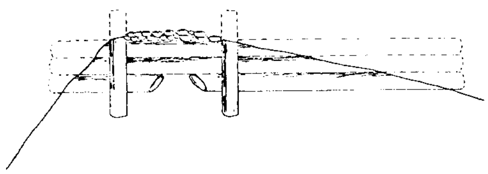


Figure 4

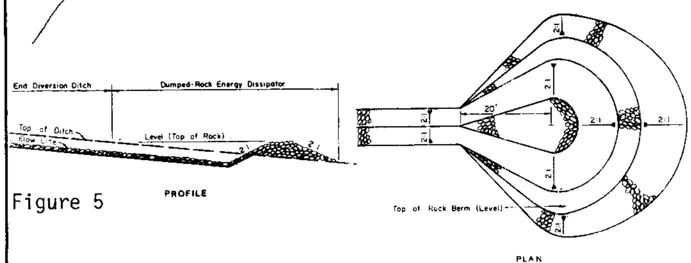


Figure 5

4:2 Culverts. The maximum spacings for culverts on haul roads required in the performance controls [816.153.(c)(v)] are shown in Table 6.

TABLE 6

MAXIMUM SPACING FOR CULVERTS ON HAUL ROADS

Grade %	Class I Road Maximum Spacing	Class II Road Maximum Spacing	Class III Road Maximum Spacing
0-3	1,000	1,000	unspecified
3-6	800	600	unspecified
6-10	500	400	unspecified
10 & greater	300	200	unspecified

Source: (Regulations)

Culverts should generally have a 2-4% grade to prevent clogging. The Regulations require protection of the culvert at both upstream and the discharge end to prevent erosion and scour. A riprap apron or energy disipator at the discharge end of the culvert will prevent the formation of a scour pool.

The Regulations require that a 10 yr/24 hr precipitation event be used for the design of all culverts on Class I and II roads where the end area of the culvert is 35 ft^2 or less. Where the end area is greater than 35 ft^2 a 20 yr/24 hr precipitation event should be used for the design. For both Class I and II roads the culverts should be covered in at least 1 ft of fill. Temporary culverts may be used on Class III roads. Temporary culverts for Class III roads should be designed for a 1 yr/6 hr precipitation event. These culverts can be constructed of timber. Details of timber culverts are shown in Figures 6 and 7 which are commonly referred to as open-top culverts. Figure 6 consisting of two logs held apart and parallel by 2" planks spiked at each end of the logs, and the second type (Figure 7) is made up of 3" timbers assembled in a trough shape with spacers of 1" pipe bolted across along the upper edge at about 4' intervals for rigidity (7). A photograph of an open-top log culvert is shown in Fig. 8.

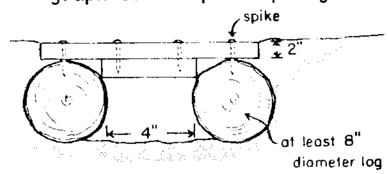


Figure 6

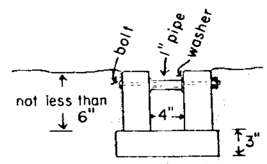


Figure 7

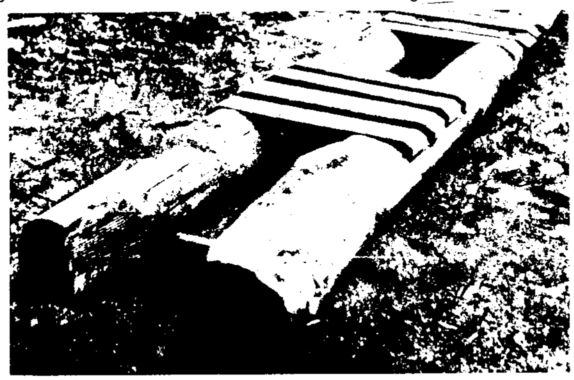


Figure 8

Weigle recommends the spacing for open-top culverts in Table 7 (spacing is not specified in the Regulations for culverts on Class III roads).

TABLE 7

SPACING OF OPEN-TOP CULVERTS

Road Grade (Percent)	Spacing (Feet)
2-5	300-800
6-10	200-300
11-15	100-200

Note: Spacing must be based on local conditions and the type of soil and the amount of watershed cover present in the area.

Source: (7)

4:3 Drainage Dips. Drainage dips are permitted in the Regulations for Class II roads. Broad-based drainage dips may be used to divert runoff across the roadbed without damage (but not in the case of permanent or ephemeral streams). These are normally 20' long with a 3% reverse grade in the roadbed. The spacing of these dips is recommended to be 400' divided by slope percent plus 100' giving the spacing in Table 8.

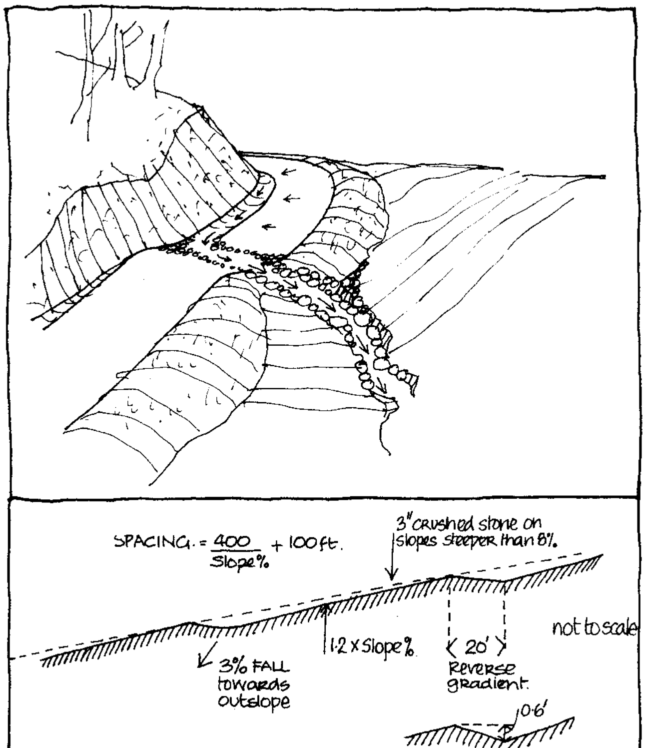
TABLE 8

RECOMMENDED SPACING FOR DRAINAGE DIPS

Road Grade (%)	Spacing (ft)
2-4	300-200
5-7	180-160
8-10	150-140

Source: (6)

Broad-based dips are cheaper to maintain and more permanent than wooden culverts but require a skilled bulldozer operator for construction. Fig. 9 shows the design factors for a drainage dip.



Source: Kochenderfer 1970 Figure 9

4:4 Berms. Berms have been used widely in haul roads as a safety feature, particularly, in hilly areas where there is a danger of vehicles running over the outslope. The configuration and the design of berms is discussed in Skelly and Loy's report (9). The height of the berm is the critical factor and this must be equal to or greater than the rolling radius of the vehicle's tire. The use of berms will also help in reducing the problem of runoff flowing over embankments.

V. CONSTRUCTION

5:1 Clearance. The Regulations require clearing vegetation from the roadbed and the removal of topsoil for all classes of haul roads before construction. It is sometimes suggested that any trees and vegetation should be wind-rowed at the base of fill slopes (7). The Regulations do not forbid this practice but it may cause instability if buried by the fill. It is preferable to chip the cleared slash and use it for erosion control on cut slopes and embankments as required in 816.152 (c)(3), 816.152(d)(15), 816.162(c)(2) and 816.162(d)(14).

5:2 Topsoil removal from the roadbed is required in the performance standards for all classes of road.

5:3 Sub-base. The maintenance of a good surface is dependent upon a properly designed and constructed sub-base. The Regulations do not actually specify sub-base standards. The required thickness of sub-base is usually based on the California bearing ratio and Skelly and Loy's report gives guidelines for calculating the required thickness.

Plastic filter cloths are frequently used below haul roads to prevent the pumping action of truck tires pushing stone aggregates into the roadbed, resulting in reduced traction and muddy conditions, which will also increase sediment generation from the road. There are a number of different makes of these plastic filter cloths, one is shown during installation in Figure 10 (8). Monsanto, who manufactures 'Bidim' fabric, emphasizes that roadbeds incorporating filter fabric dry out more rapidly after rainfall. Wheel loads are spread over a greater area when a filter fabric is used.

5:4 Surfacing. Surfacing is important not only in minimizing delays during adverse weather conditions and minimizing haulage time but is also an important factor in road safety. The surfacing will also affect erosion of the road surface and sediment problems which result.

Road surfacing of granite, crushed rock, asphalt, etc., is required for both Class I and Class II roads, but for Class III roads it is simply specified that the surface should be adequate for the use of the road.

Figure 10

Asphalt surfacing is expensive, a 4" surface costing about $5/yd^2 for labor, equipment and material at 1978 prices (11). Asphalt surfaces may also become extremely slick when wet, especially if there is mud on the road. Crushed stone is far more commonly used on haul roads. Stone aggregate should not contain more than 10% fines to prevent muddy conditions after freezing and thawing. Sometimes operators supplying power plants with coal may arrange to haul back cinders as a road surfacing material.

VI. BEDDING DOWN AND RESTORATION
[816.156, 816.166 AND 816.176]

The regulations require as part of the restoration performance standards that all bridges and culverts be removed from haul roads. Ditch relief culverts should generally be replaced by water bars. These should also angle downgrade at 30 degrees at the spacing shown in Table 9. They may be a ditch or a berm (of earth or crushed stone). Earth berms are useless once they are

DISCUSSION & DESIGN GUIDELINES (CONTINUED)

rutted so traffic must be kept off closed roads by erecting a barricade across them. For Class 1 roads, the rounding of cut and fill slopes to blend with the surrounding topography (but not regrading to the approximate original contour) is required. The standards for the restoration of Class II and Class III roads are similar, and in all cases, roadbeds are to be topsoiled and revegetated in accordance with 816.111-816.116.

TABLE 9

WATER BAR SPACING RECOMMENDATIONS

Road Grade (%)	Spacing (ft)
2	250
5	135
10	80
15	60
20	45

Source: (7)

REFERENCE

(1) Grim, E.C. and Hill, R.D., Oct 1974, "Environmental Protection in Surface Mining of Coal," EPA-607/2-74-093.
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PROBLEM & PURPOSE

Runoff water from surface mine sites often carries a heavy sediment load which can cause severe damage in receiving streams. If the water is impounded in small ponds, much of the sediment will settle out. The amount of sediment which will settle depends upon the period during which the water is detained in the pond and also upon the size of the particle. Large heavy particles settle rapidly but small particles may take days to settle. In some cases settlement can be speeded by adding 'flocculants' to the water, but usually careful location, design and management of ponds is sufficient to meet the effluent limitations in Section 816.42.

APPLICABILITY

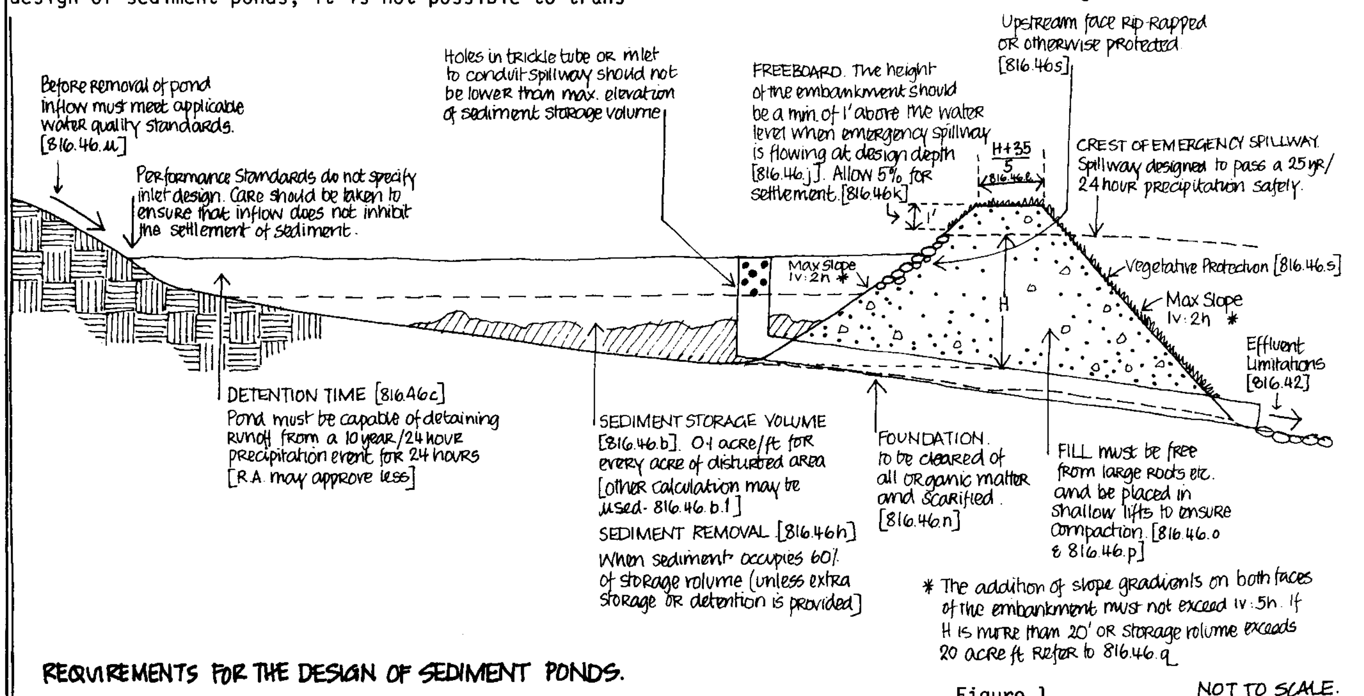
All surface mine sites must meet the effluent limitations in Section 816.42 and "appropriate sediment control measures must be designed, constructed and maintained" [816.45(a)]. It will generally be easier for operations in flat or rolling terrain to meet sediment limitations because, in these areas, runoff is more controllable and 'internalized' within the permit area. Operators in steep terrain will have more difficulty in meeting limitations on suspended solids.

REVELANT SECTIONS OF THE REGULATIONS

Section 780.25 of the Regulations requires that "each application shall include a general plan for each proposed sediment pond." Section 816.42 requires that all surface drainage from disturbed areas including disturbed areas that have been graded, seeded or planted, shall be passed through a sedimentation pond or series of sedimentation ponds before leaving the permit area. The sedimentation ponds must remain in place until the disturbed area has been restored and the vegetation requirements of Sections 816.111-816.117 are met, and the quality of the untreated drainage from the disturbed area meets applicable State and Federal water quality standards.
Discharges from the area must not exceed certain effluent limitations [816.42(a)(7)]. Maximum allowable total suspended solids is 70 mg per liter, but the average daily value for 30 consecutive days must not exceed 35 mg/l. These limitations do not apply if the discharge results from a 10 yr/24 hr precipitation event or larger. Note that the effluent standards for suspended solids are the same as those recommended by EPA in 1976 "Effluent Guidelines and Standards."
The design standards for sedimentation ponds (see Figure 1) are quite specific. Other types of sediment control impoundment can be constructed upstream of the required sedimentation pond but this does not relieve the operator of responsibility for meeting the requirement for a sediment pond of the standard design. The RA does have the discretion however of reducing the required storage volume of the sediment pond if it can be demonstrated that sediment removed by other measures is equal to the reduction in sediment storage volume [816.46(b)].

DISCUSSION & DESIGN GUIDELINES

"Each pond shall be designed and inspected during construction by a registered professional engineer." [816.˚6(f)]. It should be noted that even when sedimentation ponds are constructed according to the specifications in this Part, that the operator is still subject to the effluent limitations as contained in Section 816.42[816.46(f)].
The design of the sediment ponds is not based on a precise method and includes considerable safety factors built into the design. While it is possible to determine the settlement velocity and other factors important in the design of sediment ponds, it is not possible to translate these factors into precise design criteria because of the many variables which affect the performance of a sedimentation pond.
The main requirements for the design of a sedimentation pond included in the Regulations are shown on Figure 1 which shows a schematic section through a pond and the embankment. When a sedimentation pond has an embankment which is more than 20' in height or a storage volume greater than 20 acre-ft., additional design requirements are specified in Section 816.46(q). These larger ponds must be designed to pass a 100 yr/24 hr precipitation event without damage.



REQUIREMENTS FOR THE DESIGN OF SEDIMENT PONDS.

Figure 1

I. LOCATION

The main economic criterion for the construction of a sedimentation pond will be to minimize earthmoving. This demands careful location which is made considerably easier by the availability of a good topographic map during the pre-mining planning process. Sediment ponds can be used individually or in series [816.46(a)]. They must be constructed before any disturbance takes place, and they may not be constructed in the course of perennial streams unless approved by the RA.

II. DETENTION TIME

The total volume of the pond will depend partly on the sediment storage volume and also upon the detention time. The detention time is calculated using a 10 yr/24 hr precipitation event and is the average time that the design flow is detained in the pond. Sedimentation ponds must provide a theoretical detention time of not less than 24 hours. In certain circumstances [816.46 (c)(1)], the RA may approve a detention time of less than 24 hours but not less than 10 hours. Approval of a shorter detention time depends upon the designer being able to demonstrate an improved sediment removal efficiency due to the pond design, and that the pond is capable of achieving and maintaining effluent limitations. The RA may also approve detention times of less than 10 hours in cases where a chemical treatment process is to be used, if it can be demonstrated that this will be harmless to fish and wildlife and will achieve and maintain effluent limitations.

The design of sediment ponds should in theory be based on the size of the particles which are to be trapped, their settling velocity and hence the detention time required. The settling velocity is a function of the density, size and shape of the particle and also the viscosity of the fluid. Table 1 shows how long it will take particles, with a specific gravity of 2.65, to settle in still water at 10°C.

TABLE 1

SETTLING TIME FOR PARTICLES IN FLUID
(S.G. 2.65, at 10°C)

Diameter (mm)		Time Required to Settle 1'
1.0	coarse sand	3 seconds
0.1	fine sand	38 seconds
0.01	silt	33 minutes
0.001	bacteria	35 hours
0.0001	clay	230 days

Source: (3)

From Table 1, it will be appreciated that very fine colloidal particles may take considerably longer to settle than the 1 day detention time required in the performance standards. However, irrespective of the requirements of the performance standards, effluent limitations apply, and if these are exceeded, the operator may be required to take additional measures to reduce the concentration of suspended solids. In these cases, when drainage water contains a high percentage of very fine colloidal particles it may be necessary to add a flocculating agent to speed the rate of settlement. There are a number of these available and the operator should consult a qualified engineer.

III. SEDIMENT STORAGE VOLUME

There are two methods by which sediment storage volume may be calculated. The first, which is rather complicated, involves the use of the "Universal Soil Loss Equation (see Sheet 6:1), Gully Erosion Rates and the Sediment Delivery Ratio converted to sediment volume." The second method, which is much simpler, requires a sediment storage volume of 0.1 acre-ft. for each acre of disturbed area within the upstream drainage area. The RA may approve a storage volume of less than 0.1 acre-ft. under certain conditions [816.46(b)(2)]. These conditions require the operator to demonstrate that sediment is removed by other sediment control measures equal to the reduction in sediment storage volume. There are a number of measures which the mine operator may take upstream of the sedimentation pond including other detention ponding devices employing less elaborate dams and spillways than those required for the main sedimentation pond. An effective sediment control impoundment, for instance, to remove larger sediments can be constructed without a trickle tube using a permeable rock dam with a plastic filter cloth. There are a number of these plastic filter cloths available. Figure 2 shows a hypothetical section through a rock sediment control dam across a small drainage channel.

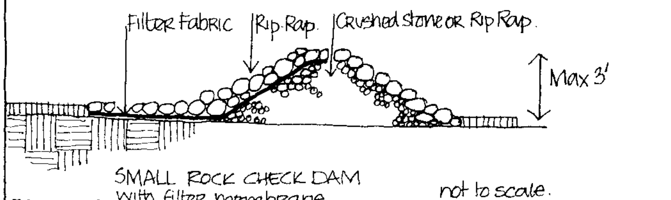


Figure 2

Other small sediment control impounding devices using gabions, log dams, etc., may be used above the main sedimentation pond. Gabions have been used fairly widely in the surface mining industry and in some cases have been used for fairly large dams. The photograph (Figure 3) shows a gabion type structure also used for silt control in Fayette County, WV (Source: 1).

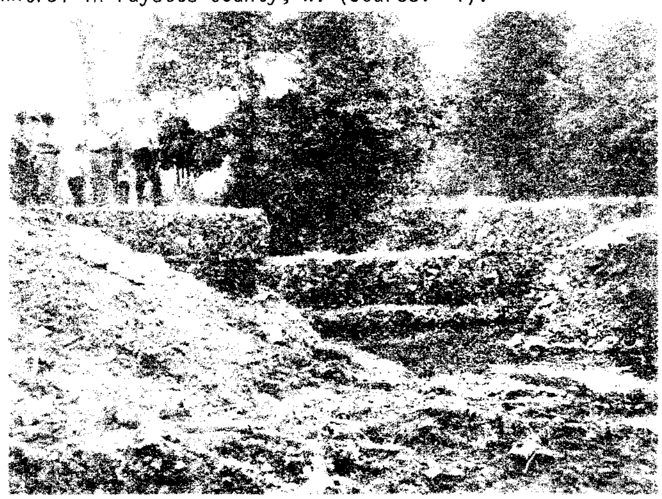


Figure 3

The Northeast Forest Experimental Station at Berea, Kentucky, conducted experiments early in the 1970's to estimate the sediment generation by land disturbed by surface mining. In the experimental watershed, which contained 63 acres of land affected by surface mining, the sediment pond trapped 0.82 acre-ft. of sediment which was equivalent to 0.54" over the whole disturbed areas. Partly on the basis of these experiments, the Forest Service and the Soil Conservation Service predicted a 0.20 acre-ft. sediment yield per acre of disturbed acreage. This production included a safety factor and this was subsequently used in Kentucky's surface mine regulations. (6)

IV. DEWATERING

"A non-clogging dewatering device" (e.g. a trickle tube with a trash rack or conduit spillway) shall be located so that its lower elevation is below the maximum elevation of the sediment of the sediment storage volume. [816.46(d)] Figure 4 shows a simple trickle tube arrangement with a trash rack.

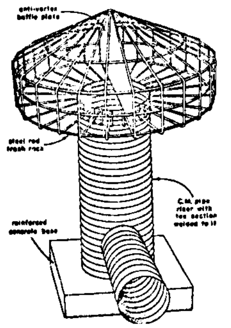


Figure 4

V. SEDIMENT REMOVAL

Sediment must be removed when the volume of sediment accumulates to 60% of the design sediment storage volume [816.46(h)]. This applies unless the sedimentation pond has been designed and constructed with additional sediment or water storage capacity and approved by the RA. Sediment removal is most easily accomplished using a dragline or a clam-shell. Many small operators will have access to neither of these pieces of equipment although a long-arm backhoe may be available in these cases. It may be more economic to construct the sediment basin with a larger storage volume as is permissible in Section 816.46(h) in order to reduce the need for sediment removal.

VI. DAM, EMBANKMENT

[816.46(i)-(p)] The minimum elevation of the top of the settled embankment must be 1 ft. above the water surface in the pond when the emergency spillway is flowing at the design depth. A minimum of 5% allowance for settlement in the height of the dam must be allowed during construction. The minimum top width of the embankment shall not be less than the quotient of (H + 35) divided by 5 where H is the height in feet of the embankment as measured from the upstream toe of the embankment. The maximum slopes of the upstream or downstream sides of the embankment should not exceed 1v:2h but the addition of the gradients for both embankments should not exceed 1v:5h. During construction, the foundation of the embankment should be cleared of all organic matter and the entire foundation area scarified. The fill material should be free of large roots and other vegetative material and built up in horizontal lifts so as to achieve good compaction. The entire embankment should be stabilized after construction with a vegetative cover, and the active upstream face of the embankment rip-rapped or otherwise stabilized [816.46(s)].

VII. INLET DESIGN

Inlet design is an important factor in the design of sediment ponds. The performance controls do not specify the design of inlets for sedimentation ponds. However in section 816.46(c)(1) it is stated that the RA may approve a detention time of less than 24 hours (but not less than 10 hours) if an improvement in "sediment removal efficiency" can be demonstrated by "inflow and outflow facility locations, baffles to decrease inflow velocity and short circuiting...." If water enters at one point at a high velocity, sediments already settled in the pond are likely to be disturbed and settlement is poor. Multiple inlets, baffles, or spreading devices to reduce inlet velocity are recommended. Small modifications to the inlet design and consequently the pattern of flow of polluted water through the pond may significantly alter the percentage of suspended solids removed.

VIII. EMERGENCY SPILLWAY

The combination of principal and emergency spillways must be capable of passing a 25 yr/24 hr precipitation event without damage to the pond. The elevation of the crest of the emergency spillway must be 1 ft above the crest of the principal spillway, and the emergency spillway must be capable of passing the design flow without damage.

IX. REMOVAL OF PONDS

Sedimentation ponds may not be removed until the disturbed area has been restored and revegetated. The drainage entering the pond must meet applicable State and Federal water quality requirements for the receiving stream. In certain cases, the RA may approve retention of a sedimentation pond in which case it must meet the requirements for permanent impoundments of Sections 816.49 and 816.56. Where the RA has approved permanent retention of sedimentation pond, 816.56 requires that operators renovate the pond to meet the criteria specified for permanent impoundments [816.49(a)].

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(9) U.S. Environmental Protection Agency, October 1976, "Erosion and Sediment Control - Surface Mining in the Eastern U.S. - Design," EPA Technology Transfer Seminar Publication, EPA 625/3-76-006.

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PROBLEM & PURPOSE

It is usually in the interest of the mine operator to divert clean runoff and streamflow from areas upslope or upstream of the mine site before it becomes contaminated with sediment and polluted water on the mine site itself. These diversions intercept runoff and streamflow and convey it around the mine working area to a receiving watercourse, downstream. This can result in considerable savings for the operator because all surface drainage from disturbed areas must be passed through a sedimentation pond [816.42]. The size of this sedimentation pond has to be sufficient to hold the flow from upstream for a 24 hour period [816.46(c)]. If much of this upstream flow can be diverted, then the size requirement for the pond will be that much less. The diversion itself is not part of the "disturbed area" and therefore flow through it need not be passed through a sedimentation pond [816.42(a)(4)]. Diverting overland flow before it enters the mine area will also help the operator in keeping the working area and the pit dry and the operations running smoothly. In cases where the overburden contains acid-forming materials, diversions around the workings are especially important to reduce the possibility of AMD and the possible need to treat the discharge water.

APPLICABILITY

These measures apply to all surface mining sites. They are especially important where there is a large area upslope of the mine site from which overland flow or streamflow, which then passes over the mine site, originates. In these cases the required size of sedimentation ponds would be very large unless the flow is diverted. The measures are also especially important in steep terrain where erosion problems are most serious, where it is difficult to keep polluted water within the mine site, and where confined pit conditons make a dry working area important for smooth operations.

REVELANT SECTIONS OF THE REGULATIONS

The Regulations distinguish between 3 types of stream. [Definitions, 701.5]

(i) Ephemeral streams. These carry water only immediately after rain or during snowmelt, otherwise they are almost dry.

(ii) Intermittent streams do not carry water the whole year but they drain at least one square mile, receive some flow from groundwater as well as runoff and are also below the local water table for part of their length for some of the year.

(iii) Perennial streams, flow the whole year round, receiving flow from both runoff and groundwater.

The requirements of the performance standards for ephemeral stream diversions [816.43] are less stringent than those for perennial and intermittent streams [816.44]. Temporary or permanent diversion channels may be used to divert overland flow, or flow in ephemeral streams, away from disturbed areas in order "to minimize erosion, to reduce the volume to be treated and to prevent or remove water from contact with acid-forming or toxic-forming materials" [816.43] but these diversions do need the approval of the RA. Plans of stream channel and other diversions to be constructed within the proposed permit areas are required under Section 780.29.

Section 816.43 contains the various performance standards for design and construction of diversions of overland flow and ephemeral streams, and they are also discussed below. It should be noted that in Section 816.42(a)(4) it states that "for the purposes of this Section only 'disturbed area' shall not include those areas in which only diversion ditches....are installed in accordance with this Part." This means that if the diversions are constructed to the standards in 816.43 and approved by the RA, the flow in the diversions need not be passed through a sedimentation pond, and the diversion will also reduce the size of sedimentation ponds which are required. However. Section 816.43(c) requires that all diversions be designed, constructed and maintained in a manner which prevents additional contributions of suspended solids to stream flow and to runoff outside the permit area.

DISCUSSION & DESIGN GUIDELINES

I. LOCATION

Locating a diversion for maximum effectiveness requires a good topographic map. No areas upslope of the diversion may be disturbed otherwise flow in the diversion would have to be passed through a sedimentation pond. The Regulations specify also that no diversion should be located so as to increase the potential for land slides [816.43(d)]. This is particularly important when locating diversion ditches around the upslope side of Head-of-Hollow or Valley fills, in which case these diversions should be constructed on solid ground.

II. DESIGN CAPACITY

Temporary diversions must be designed to pass safely a peak runoff from a precipitation event with a 2 yr recurrence interval. For permanent diversions the recurrence interval must be 10 years. Diversions must have channels which are capable of passing the design velocity without causing erosion.

The capacity of the channel is based on caluclation of the peak discharge. This is calculated in the normal way using the rational formula:

$$Q = CiA$$

Where:

Q = discharge in cfs;
C = runoff coefficient;
i = intensity of rainfall;
A = drainage area in acres.

The Soil Conservation Service's "Engineering Field Manual for Conservation Practices" gives several examples of methods of calculating the channel size for diversion channels.

III. CROSS SECTION

Waterways may be built in parabolic, trapezoidal or V-shaped cross sections. The parabolic cross sections have generally proved to be the most satisfactory. Waterways with a trapezoidal cross section, however, are easier to construct. Maintenance of grassed waterways by mowing is absolutely essential to insure the maximum erosion resistance of the grass. To enable frequent high-speed mowing to take place, side slopes of trapezoidal sections should not exceed 1v:3h.

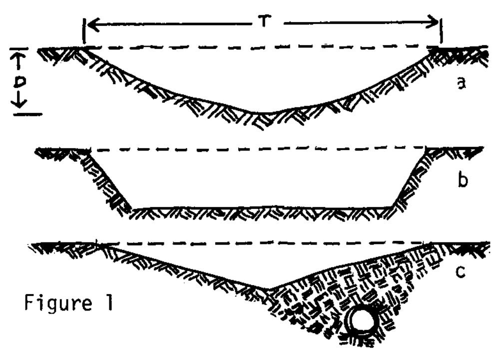

Figure 1

The performance standards require a freeboard of no less than 0.3 feet. [816.43(f)(2)].

IV. CHANNEL LINING: VEGETATIVE

The regulations require that "channel lining shall be designed using standard engineering practices to pass safely the design velocities." [816.43(f)(1)].

Grass-lined diversion channels are generally the most economical. There is also considerable expertise in the design of grass channels to minimize erosion. The USDA Soil Conservation Service's "Engineering Field Manual for Conservation Practices" gives an excellent guide for the design of grass diversion channels. This includes the method for estimating the "retardance" for various types of vegetation. Grass channels must be capable of withstanding the abrasive action of water without damage. Generally grass channels have slopes of between 1 and 10 percent. The permissible velocities for various types of grass and soil erodibility are shown on Table 1. Note that the range is between 2-6 fps with velocities of 7-8 fps used only where the sward is of the highest quality.

Table 1. PERMISSIBLE VELOCITIES FOR CHANNELS LINED WITH VEGETATION

Cover	Slope range 2/ (percent)	Permissible velocity 1/ Erosion resistant soils (fps)	Easily eroded soils (fps)
Bermuda grass	0-5 5-10 over 10	8 7 6	6 5 4
Bahia Buffalo grass Kentucky bluegrass Smooth brome Blue grama Tall fescue	0-5 5-10 over 10	7 6 5	5 4 3
Grass mixtures Reed canarygrass	2/ 0-5 5-10	5 4	4 3
Lespedeza sericea Weeping lovegrass Yellow bluestem Redtop Alfalfa Red fescue	3/ 0-5	3.5	2.5
Common lespedeza 4/ Sudangrass 4/	5/ 0-5	3.5	2.5

1/ Use velocities exceeding 5 fps only where good covers and proper maintenance can be obtained.

2/ Do not use on slopes steeper than 10% except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

3/ Do not use on slopes steeper than 5% except for vegetated side slopes in combination with a stone, concrete or highly resistant vegetative center section.

4/ Annuals--use on mild slopes or as temporary protection until permanent covers are established.

5/ Use on slopes steeper than 5% is not recommended.

Rapid stabilization of grass diversion channels following grading is obviously essential to minimize erosion. Hydroseeding and mulching will help considerably but in critical areas other forms of stabilization may be appropriate. A variety of jute, paper, and plastic nettings are on the market and can be used to stabilize grassed waterways at the time of seeding. In larger channels where several widths of netting are required these should overlap by 2 inches and the overlap be stapled 4 to 10 inches apart. The ends of the rolls should also be overlapped and the top ends buried in trenches 4 inches deep. After laying these nets, they should be rolled well to insure good contact with the soil.

V. REINFORCING VEGETATIVE LININGS

The erosion resistance of a grass waterway can be increased in difficult cases by reinforcing the sward with nylon netting or by introducing fiberglass erosion checks at regular intervals. Erosion checks are usually constructed of fiberglass matting which is installed across the waterway. They prevent the formation of gullies and aid in the establishment of vegetation. Preferably they should be installed at any changes in gradient and downstream from the confluence of two diversions. Installation involves excavating a 1 foot deep trench and installing a vertical membrane of fiberglass. It is secured with staples, backfilled, compacted and the excess fiberglass trimmed off flush with the surface (Figure 2).

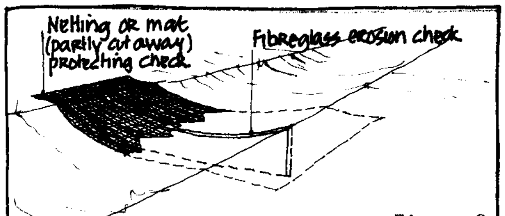

Figure 2

VI. STRAW BALE AND BRUSHWOOD EROSION CHECKS (ABOVE GROUND)

In cases where a grass channel is eroding or to help stabilize a grass channel various types of above-ground erosion checks can be used.

On channels over 9 feet wide, straw bale checks as shown in Figure 3 may be used. Bales are staked down with 2 x 2'6" wooden or metal stakes and tied down with nylon or wire. Riprap is placed to form an apron downstream of the check for a minimum distance of 4 feet and at the edge of the channel on both sides. On channels of less than 9 feet in width the small checks shown in Figure 4 may be used without an apron. They should be spaced about 40 feet apart. Checks must be removed prior to final restoration

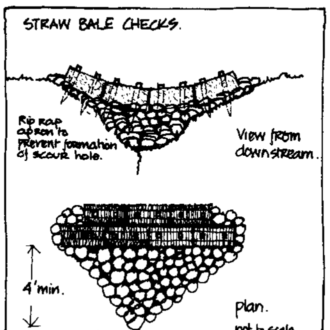

Figure 3

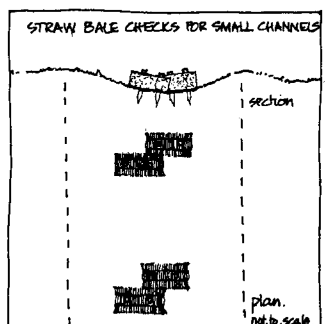

Figure 4

Where a longer life erosion check is required a three foot cyclone fence is nailed on the upstream side of 4" x 4" wooden stakes across the channel. Straw bales are placed on the upstream side as shown. These are wired together and to the fence. Riprap is placed as for straw bale checks and in some cases, the straw bales may be covered with crushed stone. This installation must also be removed prior to restoration. When straw is not available but when there are large quantities of brushwood on site, brushwood bundles approximately 18 inches in diameter can be made up on site with #9 wire and laid in staggered formation upstream of the fence and wired to the fence. Riprap is placed as before. Wooden stakes (usually 4 inch diameter poles) may also be used in various conformations to provide erosion checks alone or with straw or brushwood. These alternatives are shown in Fig. 5 and Fig. 6.

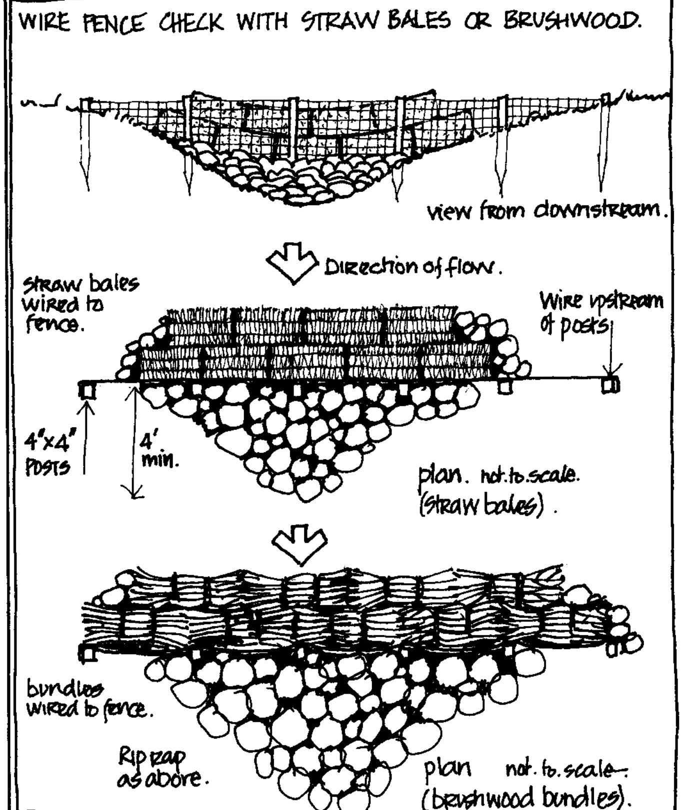

Figure 5

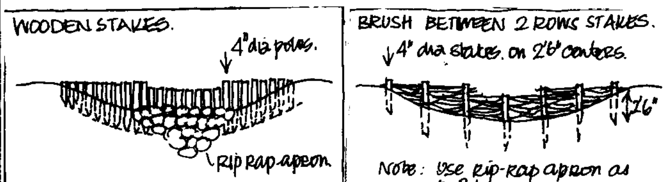

Figure 6

VII. CHANNEL LINING - NON-VEGETATIVE

Temporary diversion channels may be stabilized with asphalt concrete, riprap or other non-vegetative lining, but non-vegetative linings may be used for permanent diversions only with the approval of the RA. In the case of a diversion which has permanent wetness in the bottom, grass will not give good protection. In these cases it is questionable that it is an 'ephemeral' and not an intermittent stream. To prevent erosion a stone center drain or underdrain should be installed. Alternatives are shown in Figures 7 and 8.

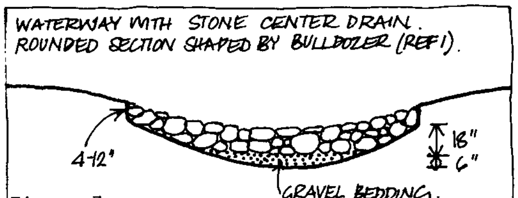

Figure 7

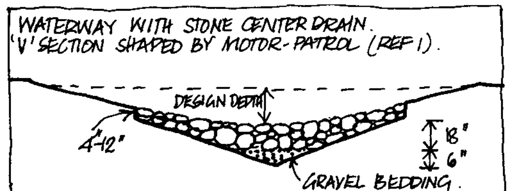

Figure 8

VIII. DROP STRUCTURES AND CHECK DAMS, ENERGY DISSIPATORS

These counteract gully erosion in waterways by reducing the effective gradient of the channel. They should be used when the flow velocity exceeds that for which vegetation can provide effective protection. These may be preferable to the use of a concrete, asphalt or riprap lining, particularly for permanent channels when such linings require the approval of the RA. Selection of the type of drop structure or check dam and the materials to be used will depend on flow velocity, cost, performance and aesthetic aspects. Materials may consist of timber, rock, gabions, concrete, brush or sod. To prevent undercutting the toe all structures should be keyed well into the existing ground surface. The approval of the RA should be obtained for the use of these structures on permanent diversions. Figures 9, 10, and 11 show alternative spillways for diversion channels. It should be noted that section 816.43(f)(3) requires that energy dissipators shall be installed where diversions meet a natural stream if the velocity in the diversion exceeds that in the stream. See Sheet 6:2 for details of a dumped rock energy dissipator.

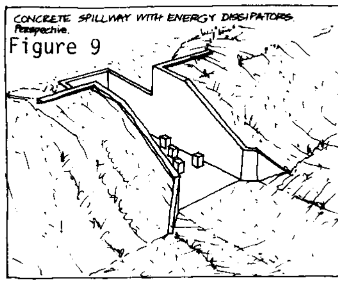

Figure 9

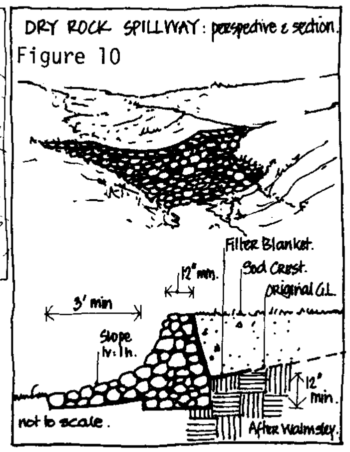

Figure 10

DISCUSSION & DESIGN GUIDELINES (CONTINUED)

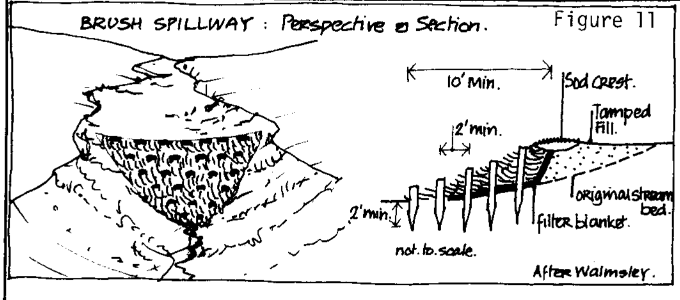

Figure 11

IX. REMOVAL

Section 816.43(e) of the Regulations requires that after operations are complete, temporary diversions must be removed and the affected land regraded, topsoiled and revegetated in the same way as other disturbed areas of the site.

REFERENCE

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(3) EPA, 1972, "Guidelines for Erosion and Sediment Control Planning and Implementation."

(4) Pennsylvania Department of Environmental Resources, Sep 1972, "Soil Erosion and Sediment Control Manual."

(5) Skelly and Loy, Engineers-Consultants, Oct 1973, "Processes, Procedures, and Methods to Control Pollution from Mining Activities," EPA 430/9-73-011.

PROBLEM & PURPOSE

It may be desirable to divert stream channels either temporarily or permanently for any of the following reasons:

1. To allow the existing channel to be mined through, enabling the extraction of coal beneath and rationalization of the mining operation.
2. To divert unpolluted stream flow around the mine working, so avoiding contamination with sediment or by contact with acid-forming materials while passing over the working area.
3. Diversion of flow from upstream areas reduces the required capacity of sedimentation ponds as only the drainage from the disturbed areas will flow through the pond.
4. Diversion of streams away from the working area reduces the problem of pit dewatering, and other problems of handling drainage water on a surface mine site.

APPLICABILITY

These measures apply to all surface mining sites. Diversion of streams which cross the proposed coal extraction area is particularly important for certain types of mining - e.g. area mining which relies on moving the cut steadily across the site without any obstructions. Where overburden is thick any obstructions on the surface (streams, roads, etc.) which are not diverted or relocated will result in the sterilization of a large area of coal because of the batter of the high wall when mining around obstructions.

Diversion of streams to reduce the amount of flow which must be passed through sedimentation ponds is very important on sites where there is a large area of undisturbed land above the mine site, and in hill terrain where it will be difficult to confine drainage water to the permit area. In the case of contour mining, diversions may have to cross the extraction area in temporary pipes or chutes.

The diversion of streams to reduce the problem of dewatering the working area and the pit will be most important in cases where the pit is confined and where much equipment is working in the bottom of the pit. It is also very important on sites where the overburden contains large amounts of acid-forming materials. It should be noted that diversions must be approved by the RA but that the RA may also require diversions to be installed.

REVELANT SECTIONS OF THE REGULATIONS

Sheet 6:4 described the performance control and design guidelines for the diversion of ephemeral streams and overland flow. This sheet considers the diversion of streams with perennial or intermittent flow. Both perennial and intermittent streams may be diverted [816.44] but the diversions must be approved by the RA. The application must contain plans of all proposed stream channel diversions within the proposed permit area under Section 780.29.

The performance standards make no distinction between the design requirements for permanent and intermittent stream diversions. But a distinction is made in the design of permanent versus temporary diversions. It should be noted here that Section 816.42 requires that all surface drainage from disturbed areas is passed through a sedimentation pond but Section 816.42(a)(4) specifically excludes diversion ditches. From this definition it is not clear whether "diversion ditches" include stream channel diversions. Sections of the Regulations which deal specifically with the design and construction of stream diversions are discussed below.

DISCUSSION & DESIGN GUIDELINES

I. CAPACITY

The combination of channel bank and floodplain configurations for temporary diversions must be adequate to pass safely the peak runoff from a 10-yr/24-hr precipitation event, while the combination of channel bank and floodplain configurations for a permanent diversion must be adequate to pass safely the peak runoff from a 100-yr/24-hr precipitation event. In both cases the capacity of the channel must be at least equal to the capacity of the unmodified stream channel immediately upstream and downstream of the diversion. The performance standards require that the longitudinal profile of the stream channel and the floodplain be designed and constructed to remain stable and to prevent additional contributions of suspended solids to stream flow or runoff outside the permit areas.

II. CROSS SECTION AND CHANNEL LINING

The required treatment of the channel differs between permanent and temporary diversions. Some of the principles described on sheet 6:4 of using grass and other vegetation to stabilize diversions also apply to that part of these diversions which is not permanently wet. Section 816.44(b)(1) requires that any erosion control structures, such as channel linings, retention basins, artificial channel roughness structures, should only be used with the approval of the RA and it is noted that these structures will be approved for permanent diversions only where they are stable and will only require infrequent maintenance. However 816.44(d) requires that the longitudinal profile and cross-section of a restored or permanent stream diversion should include aquatic habitats (usually a pattern of riffles, pools and drops rather than uniform depths) that approximate premining stream characteristics. It also requires that the stream be restored to its "natural meandering shape" with an environmentally acceptable gradient. The Section requires the operator to restore and enhance, where practicable, the natural riparian vegetation on the bank of the stream.

III. BANK CONFIGURATION AND STABILIZATION

A "natural meandering" stream is usually cutting the bank on the outside of bends (the bank here being steep) and depositing on the inside of the bend where the bank is shallow. When creating a meandering profile with variations in the depth of water, it is desirable to copy this natural situation. Steep banks can be constructed using various techniques and should usually rely on planting of natural riparian vegetation to provide permanent stabilization. The lower riparian zone in the Northeast and Middle Atlantic States has a natural growth of willow, alder, button bush, small maples, sweet gum and swamp rose. These vegetation types can be used to stabilize streambanks. The most commonly used of these is willow, because of its capability to develop roots from cuttings and it throws up suckers readily. Willows can be planted either as individual cuttings or bound together in various forms, e.g. willow mattresses or bundles or rolls (Figures 1 and 2).

Willow rolls (which may also contain reeds) are usually 1'-1'6" in diameter and are constructed of wire netting. A trench 1'6" wide and deep is dug along the bank with a row of stakes on the channel side. Wire netting is stretched across the trench and about 4" coarse gravel dumped onto it forcing it into the trench. On this should be placed layers of sod, willow shoots and reed clumps, until the upper edges of the wire will just meet. The upper edge of the roll should not be more than 2" above water level for a reed roll and 1' above water level for a willow roll.

Willow bundles or 'fascines' have a diameter of 3"-12" and contain willow shoots and sod and are tightly bound around with wire. On cut banks packed fascine crib-work

(Figure 3) can be employed or single fascines or willow rolls can be used (Figure 2). The packed fascine crib-work consists of layers of bundles, secured by stakes. The spaces between the bundles are filled with dirt and another layer is added on top. Another technique is the use of willow mattresses made from 4'-6' willow switches. These are held down by stakes and braided or wired together and covered lightly with dirt. These techniques can be adapted to the local conditions, vegetation and expertise available.

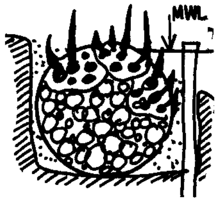


Figure 1. Willow roll formed of tightly bound bundle of willow shoots, sod and coarse gravel, in wire mesh roll.

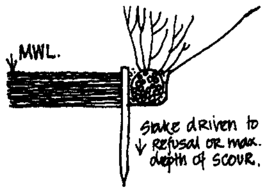


Figure 2. Willow roll staked against cut bank and throwing out new shoots.

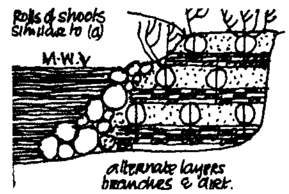


Figure 3. Crib-work of willow rolls or bundles backfilled with soil and coarse gravel.

IV. THE CREATION OF STILL SHALLOWS OR REED BEDS

Most natural stream channels contain still shallow areas and beds of reeds that are important to the biological community. These will gradually develop in a restored stream but the development can be hastened by artificial means. Reed or willow berms can be constructed by throwing up a riprap and earth embankment to just below the mean water level which is then planted with reed roots and/or willow cuttings as shown in Figure 4. These would be constructed in a wide section of the restored channel.

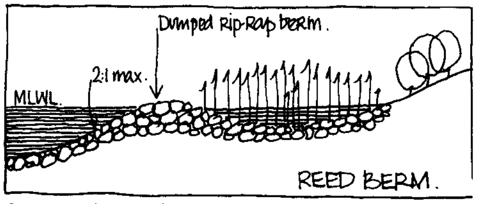


Figure 4. Reed or willow berms creating areas of still shallow water in a diversion channel.

V. THE CREATION OF RIFFLES AND POOLS

Most natural stream channels will include riffles and natural jetties which result in variation in the depth of water. The recreation of a natural stream habitat can be accelerated by the creation of certified jetties and riffles. These must be carefully stabilized with natural vegetation to insure their permanence. Various combinations of gabions, gabion mattresses, riprap, timber and natural materials can be used in the construction of jetties and riffles. Figure 6 shows a simple willow jetty constructed of riprap, crushed rock and soil.

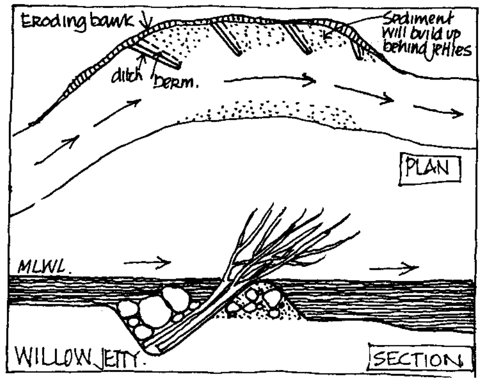


Figure 5. Willow jetties used here to stabilize an eroding stream bank will cause variation in water depth.

VI. REMOVAL

Temporary diversions must be removed and the affected area regraded and revegetated to the same standards as other disturbed areas of the site. If the removal of the diversion will cause downstream sedimentation ponds or other treatment facilities to be overtopped or fail, they must be modified or removed.

REFERENCE

(1) Tourbier, J. and Westmacott, R., 1974, "Water Resources Protection Measures in Land Development - A Handbook," University of Delaware, Water Resources Center, Newark, DE.

PROBLEM & PURPOSE

It has been shown that one of the most important factors in reestablishing vegetation on restored mine sites is replacing the topsoil. The removal, storage and replacement of topsoil are therefore emphasized in the performance controls of the new Regulations. Because much of the land planned for coal extraction, particularly in Appalachia is forested, the clearance of vegetation and grubbing of stumps is necessary before topsoil can be removed.

In some areas, including most of Appalachia, topsoil is thin. The Regulations do not specify the thickness of soil which must be restored but in areas where topsoil is thin, 6" of soil material, including whatever topsoil is present and the remainder unconsolidated material beneath has to be removed and treated as topsoil [816.22(c)].

In situations where existing topsoil is thin the overburden analysis, for which small operators can receive assistance under the Small Operators Assistance Program, may reveal suitable topsoil substitutes which may be approved by the RA. The operator will probably find that the selective handling required to place this material on top of regraded areas pays off in greatly improved establishment of vegetation.

APPLICABILITY

Applicable to all surface mining sites. There are special performance standards for topsoil removal and reconstruction on prime farmland (Part 823). On sites which have been forested, removal of topsoil with a scraper may not be possible. In these situations, especially on steep terrain, a tracked front-end loader may have to be used to grub stumps and remove topsoil. But this operation requires loading the topsoil for haulage to the distribution site, whereas a scraper can dig, load, haul and redistribute all in one operation, as well as maintain its own haul road. Therefore, these operations can be costly on heavily forested sites in steep terrain. The Regulations also contain a requirement that the minimum practicable area is disturbed at one time (disturbance includes removal of vegetation and topsoil) [816.45(b)(1)]. Requirements of the Regulations, that reclamation should be as contemporaneous as possible and that topsoil should only be stockpiled if immediate redistribution is not practical, make it imperative that vegetation removal and topsoil removal are planned and phased very carefully with other operations on all sites

REVELANT SECTIONS OF THE REGULATIONS

I. CLEARANCE OF VEGETATION

Few specific references are made to the clearance of vegetation in the Regulations. The clearance of vegetation is required specifically in the Regulations only to enable topsoil to be stripped [816.22]. This has the following implications:

1. The clearance of vegetation will have to include grubbing of tree roots to enable topsoil to be removed.
2. Section 816.45(b)(1) requires that the smallest practicable area is disturbed at any one time during the mining operation. Section 816.23(a) requires the topsoil to be stored only when it is impracticable to redistribute promptly and this is in the operator's interest to avoid double handling. Therefore, the topsoil should be removed in a phased sequence, and this should also apply to vegetation clearance and grubbing. The "disturbed area" as defined in 701.5 includes areas from which vegetation has been cleared. Section 816.42 which requires that runoff from disturbed areas must pass through a sedimentation pond also applies to areas cleared of vegetation. The clearance of vegetation should be phased with topsoil removal to disturb the smallest practicable area of the site at any one time.
3. The performance standards do not specify what the operator should do with the cleared vegetation. Many operators in the past found in satisfactory to windrow vegetation below areas of fill as a sediment control measure. However, these windrows tend to interfere with other requirements of the Regulations and the operator would be advised to chip all cleared slash (chips can be used for mulch) and to burn any unsaleable logs which cannot be used on-site for erosion control structures, etc.
4. Other specific references in the performance standards to the clearance of vegetation include restricting the clearance of vegetation for road construction to the width necessary for road and ditch construction only [816.153(a)(3)].

II. TOPSOIL REMOVAL

Section 779.21 (Soil Resources Information) requires that the applicant submits a soil survey which must include:

1. A map delineating different soils;
2. Soil identification;
3. Soil description; and
4. Present and potential productivity of existing soils.

Where the applicant wishes to use selected overburden material as a topsoil substitute he must also submit the results of certain analyses required under Section 816.22(e). The RA may approve the use of selected overburden as a substitute for topsoil if it is determined that the substitute material is equal to or more suitable for sustaining vegetation than the topsoil which is available. The determination will depend on the results of chemical and physical analyses of overburden and topsoil, which must be carried out by a certified laboratory approved by the RA. The details of the tests required are included in Section 816.22(e). They include determination of pH, alkalinity, phosphorus, potassium, texture and may also include other analyses. Under the Small Operator Assistance Program, the RA will pay for these overburden analyses by a certified lab.

The application must include: 1. a narrative explaining the topsoil handling and storage [780.11(b)(2)]; and 2. topsoil storage areas must be indicated on the operations plan [780.(b)(5)]. It is also required that this plan be prepared by or under the direction of a professional qualified engineer [780.14(c)].

The performance standards contain very specific requirements for removing, storing and distributing topsoil [816.21-816.25]. Some of these are discussed in the next section below. Topsoiling has been shown to be one of the most effective means of establishing vegetation on restored mined sites. However most of the potential mine land in Appalachia has shallow infertile soils and much of it is also steeply sloping. Topsoil in this area is often thin and it may be necessary for operators to carry out an overburden analysis to check whether there are suitable topsoil substitutes in the overburden. The performance standards for topsoil handling contain specific requirements for the use of topsoil substitutes [816.22(e)]. It should be noted that there are special provisions for the removal and handling of topsoil in the case of mining operations on prime farmland. These may be found in Part 823 (Special Permanent Program Performance Standards - Operations in Prime Farmland). One of the most stringent requirements of this Part is that the minimum depth of soil "to be reconstructed for

REVELANT SECTIONS OF THE REGULATIONS (CONTINUED)

prime farmland shall be 48 inches." For further details on application requirements and performance standards for mining on prime farmland, the operator should refer to Part 823.

DISCUSSION & DESIGN GUIDELINES

I. REMOVAL OF VEGETATION

It is in the interest of the operator to dispose of saleable timber but the actual clearance technique will depend on terrain, the equipment available and various other factors. The practice of windrowing slash and debris around the site is generally not advisable particularly where these may be buried in spoil heaps and cause instability. It is preferable that all slash be chipped, and the chips used for mulch on the restored area. Disposal of stumps, which are difficult to burn, should be in a designated disposal site in the permit area [816.89]. An example of efficient utilization of cleared vegetation is the Jones and Brague Mining Company who chip the vegetation on their sites and ship it to a Masonite plant at Towanda, PA. The company uses a chipper manufactured by Morbark Industries which accepts trunks up to 22" in diameter. (2)

II. TOPSOIL REMOVAL

Section 816.22 specifies that topsoil should be removed prior to any disturbance of the site other than clearance of vegetation. Disturbance includes drilling, blasting or any form of mining. Topsoil must be removed in a separate layer. When topsoil is less than 6" thick, a 6" layer of material including whatever topsoil is available should be removed and treated as topsoil. If the total unconsolidated material is less than 6", whatever is available should be removed and treated as topsoil [816.22(c)]. In some cases the RA may decide that to ensure soil productivity consistent with the approved post-mining land use, it is necessary to remove and redistribute the subsoil separately from the topsoil. But unless the RA determines this, it is not required. Where topsoil substitutes are to be used (this has already been discussed earlier on the sheet), the substitute material shall be removed and segregated (and stored, if immediate redistribution is not feasible, in the same way as topsoil).

The operator may have to limit either the size of the area in which topsoil is removed or the timing of redistribution if either operation results in serious erosion or if wet conditions are resulting in damage to topsoil, uneven distribution, or are causing erosion [816.22(f)].

The difficulty of using scrapers for topsoil removal have already been mentioned, particularly where a comparatively long haul is required and immediate redistribution is possible on a regraded area. (Figure 1)

III. TOPSOIL STORAGE

Topsoil, subsoil (if required), and any topsoil substitute should only be stockpiled where it is impractical to redistribute it promptly on regraded areas [816.23(a)]. Stockpiles must be placed on a stable area and protected from erosion either by water or

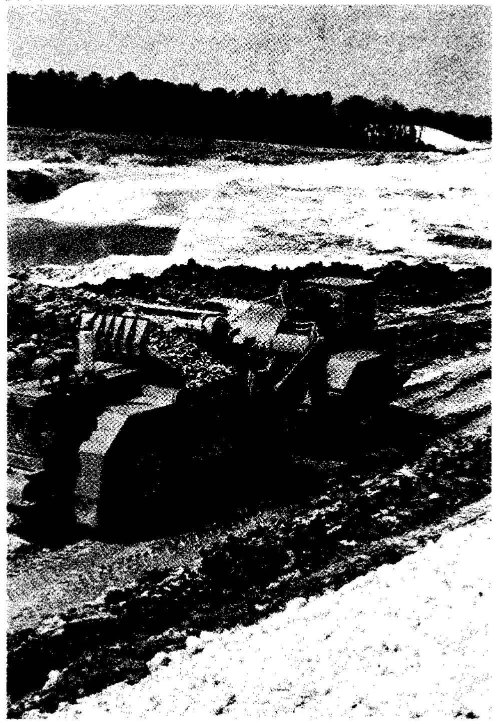


Figure 1

wind. This is best achieved in most cases with a quick-growing cover crop which should be seeded or planted during first "normal period" after placing the stockpile (see Sheet 7:11) [816.23(b)(1)]. The performance standards require that the stockpiles should not be removed until the topsoil is required for redistribution on a regraded area. Topsoil removal, segregation, storage and redistribution is also specifically required for certain operations by the performance standards, including the construction of stream diversions [816.43(f)(5)], the disposal of excess spoil [816.71(c)], and the construction of roads Classes I, II, and III [816.152(e), 816.162(e), 816.172(e)].

The regulations do not specify any design for topsoil stockpiles. Sometimes it is recommended that topsoil is not piled in excess of 8'-10' deep, and should preferably be placed in fairly narrow banks. This enables aerobic bacteria in the soil to survive. Some operators have found it useful to use topsoil stockpiles on the edge of the site to screen the operation from the public road or nearby residences. This is commonly practiced by contractors on N.C.B. sites in Great Britain.

REFERENCE

(1) Plass, W.T., Mar-Apr 1978, "Reclamation of Coal Mined Land in Appalachia," Journal of Soil & Water Conservation.
(2) Davis, H., Dec 1978, "Jones & Brague has been Recognized for Excellence of its Reclamation," Coal Age, pp. 94-97.
(3) Smith, R.M., Summer 1973, "Choosing Topsoil to Fit the Needs," Green Lands Quarterly, WV Surface Mining and Reclamation Association.

PROBLEM & PURPOSE

In surface mining operations, it is necessary to find somewhere to put the spoil from the initial cut to provide the working space in the pit. If the swell or bulking factor of the overburden exceeds the volume of coal to be taken out, more spoil may have to be removed from the pit as mining progresses to maintain working space in the pit. Therefore, at the end of the mining operation there will tend to be a final void and somewhere else on the site a dump or dumps of spoil. This spoil can, of course, be used to fill the final void but this requires double handling. Most operators therefore would prefer to place the box-cut spoils permanently and not have to transport it back to fill the pit. However, the requirements of the Regulations do require the elimination of all highwalls, spoil piles and depressions and that all disturbed areas be returned to their "approximate original contour" [816.101(b)]

APPLICABILITY

Applicable to all surface coal mine operations, but the problem of temporary spoil dumps is most serious in the following situations:

1. Open pit mines where overburden is thick. In order to provide sufficient working space in deep pits, the amount of spoil removed from the pit is very large and this must be stockpiled close to the pit for ease of backfilling. In these cases the problem is made worse if the bulking factor is large, making it necessary to take spoil out of the pit continuously to maintain its size.
2. Sites in steep terrain often have few suitable locations for temporary spoil dumps which will not cause serious instability, landslips and erosion. Often the only suitable locations involve the operator in long costly hauls.
3. Sites where the overburden contains large quantities of acid-forming materials. In these cases the performance controls require that material is buried within 30 days after it is first exposed. This means that careful selection of overburden materials from the box-cut spoils is necessary.

RELEVANT SECTIONS OF THE REGULATIONS

The Regulations are clear that sites must be returned to "approximate original contour," and that "spoil shall be transported, backfilled, compacted and graded to eliminate all highwalls, spoil piles and depressions" [816.101(b)(1)]. Although there may be a certain amount of freedom in interpreting the "approximate original contour" requirement, leaving the final cut open and restoring spoil dumps is clearly not sufficient to meet the requirements of the performance standards.

In the supplementary information to the Regulations it is stated that stockpiling and transportation of box-cut spoils to the final cut is encouraged. The use of the word "encouraged" appears to conflict with the specific requirements of the performance standards to eliminate all spoil dumps. It has been anticipated that if the post-mining graded slopes "approximate the general nature of the pre-mining topography" [816.102(a)] that a slight depression in the area of the final cut and a slight rise in the area of the temporary spoil dump would be allowed, provided that the other requirements of the performance standards are met.

Box-cut spoil requires expensive double handling. In some cases it may be appropriate, in the proposed post-mining use of the land, to have a water impoundment or other area of low terrain on the location of the final cut but this will require specific approval of the RA and may prolong the application process [816.49].

On sites with a high swell or bulking factor and thick overburden [816.105] the operator is not any worse off, as spoil in excess of that required to achieve approximate original contour at restoration may be disposed or permanently [816.71-816.74]. In fact, this may be an advantage in that the original box-cut spoil may be disposed of permanently and restored close to the cut and any temporary spoil piles which are needed, placed near the final cut so reducing handling costs.

Although there is not a Section of the performance standards dealing specifically with temporary spoil and the treatment of temporary spoil dumps, specific reference is made in the permit application requirements in Part 780 (Permit application - Minimum requirements for reclamation and operations plan). This must include [780.11(b)] "a narrative explaining the construction... and removal of overburden storage areas and structures." This must be accompanied by maps and plans [780.14(b)(5)] of each spoil storage area and it is specified [780.14(c)] that these maps or plans be prepared by or under the direction of a qualified registered professional engineer. It should also be noted that this refers to "storage areas", which implies the temporary nature of the piles. Permanent disposal of excess spoil is dealt with separately in this Section [780.14(b)(11) and 780.14(c)(2)] and specifically in the performance standards in Sections 816.71 - 816.74.

The amount of latitude that the RA will permit in interpreting the "approximate original contour" requirements of the performance standards will become clearer as time goes on. It appears, however, that temporary stockpiling of spoil is one of the operations for which premining planning is required as part of the application procedure, but to which only general performance standards apply, leaving it up to the discretion of the RA to determine to what extent it is necessary to the operator to "transport box-cut spoil to the final cut" to achieve the "approximate original contour." Nevertheless it is quite clear in the performance standards that grading must "eliminate all highwalls, spoil piles and depressions" [816.101(b)(1)].

DISCUSSION & DESIGN GUIDELINES

I. PLACEMENT OF TEMPORARY SPOIL PILES

Temporary spoil piles should be placed to avoid problems of instability. The operator will wish to place temporary spoil dumps so as to minimize handling costs. For instance this might involve placement close to the final pit so that the spoil can be pushed into the pit rather than a load/haul operation. With these considerations in mind, the operator should avoid steep areas (if the slope is in excess of 1v:2.8h special measures may be required to stabilize the spoil mass) and also wet areas containing seeps or springs which may result in instability.

Topsoil must be removed from areas on which temporary spoil piles are to be placed, in the same manner as for all other areas of the site to be disturbed [816.22(b)].

II. THE PROTECTION OF TEMPORARY SPOIL PILES FROM EROSION

It is emphasized that temporary spoil piles, as part of the permit area, are subject to the various requirements of the performance standards which require removal of topsoil from the disposal area and the control of sediment. All surface drainage from the disturbed area (which includes temporary spoil piles)...shall be passed through a sedimentation pond. As temporary spoil heaps may remain in position for the whole life of a surface mine site. It is important that they should be placed on a stable site, graded to a stable slope and be protected from erosion by a vegetative cover crop. (see Sheet 7:11) In order to achieve this some topsoil may be required. Large temporary spoil piles with long slopes are especially vulnerable to erosion and should be terraced (see Sheet 7:2).

Generally, the design and configuration of these terraces should be similar to those for excess spoil disposal facilities (Sheet 6:8). However, as all temporary spoil heaps must be designed by or under the supervision of a registered professional engineer, guidelines for large spoil heaps are not included on this sheet.

III. STABILITY OF TEMPORARY SPOIL PILES IN STEEP TERRAIN

The requirement that temporary spoil piles be designed by a professional engineer will reduce problems of instability [780.14(b)]. However, some general notes are included here on the principal causes of slides. They are based largely on a report by the State of Kentucky, Department of Natural Resources and Environmental Protection (1). Slides will tend to occur when there is a high shear stress and a low shear strength and will be a result of 4 main practices.

1. The removal of lateral support may be caused by the action of streams, weathering (wetting, drying, swelling, shrinking), frost action or subsidence.
2. The removal of underlying support may be caused by the undercutting of streams, frost action or underground mining.
3. Surcharge may result from excess fill on the pile or be due to heavy rain or snow resulting in saturation.
4. Lateral pressure due to water or ice may also cause instability.

Kimball (1) suggests that the sequence of events for the initiation of slides in stacked spoil is:

a. stacking too much spoil on an unstable site in a loose and generally wet condition;
b. initial slumping of the spoil caused by overloading or failure in spoil material;
c. a sudden downpour of rain, resulting in small slides and then:
   i. piling additional spoil on the slip plain of smaller slides;
   ii. development of tension cracks;
   iii. percolation of surface water into tension cracks, leading to the vertical displacement along cracks;
   iv. slumping due to decrease in shear strength along the slip plain results in major slides.

From the above, it is apparent that the principles in ensuring the stability of temporary spoil piles include the following:

1. Selection of a stable, gently sloping site;
2. Removal of topsoil and any organic matter from the disposal site and if necessary a key cut;
3. Spoil material should not be placed when too wet;
4. Placement should be carried out in such a way to ensure good compaction;
5. Attention should be paid to drainage of the pile particularly the diversion of surface water around the base of the pile.

IV. ACID AND TOXIC-FORMING SPOIL IN TEMPORARY SPOIL PILES

If spoil is acid or toxic-forming, as identified and analyzed in the geology description [779.14], it should not be stockpiled but should be buried within 30 days after it is first exposed on the mine site as required in Section 816.48(c).

Temporary storage of acid-forming or toxic-forming spoil may be approved by the RA if it is not feasible to bury or treat within 30 days and if it will not result in any water pollution risks; however, this too must be buried at the earliest possible opportunity.

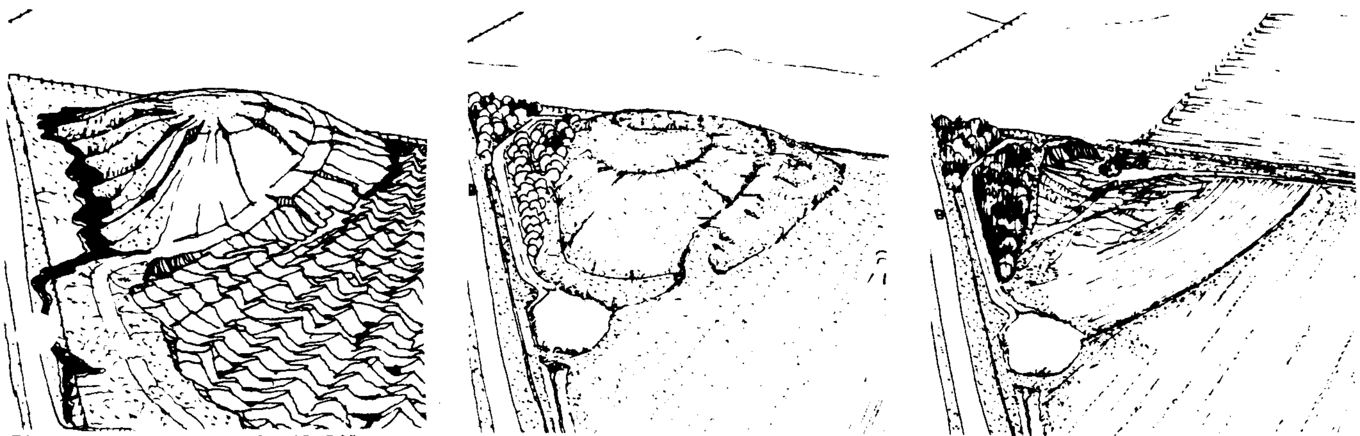


Figure 3. Temporary Spoil Piles
a. Uncontrolled   b. Controlled   c. Being Removed

REFERENCE

(1) Kimball, L.R., 1975, "Slope Stability, Volume 1, Report and Field Book," Department of Natural Resources and Environmental Protection, KY.

GROUP	MOBILIZATION AND MINING OPERATIONS	HANDBOOK FOR SMALL MINE OPERATORS	6
MEASURES	DISPOSAL OF EXCESS SPOIL - HEAD OF HOLLOW AND VALLEY FILLS		8

PROBLEM & PURPOSE

1. Disposal of excess spoil in surface mine operations may be necessary for various reasons. This sheet deals with this operation on sites in steep terrain as often found in Appalachia. Here the need for disposal of excess spoil is often created by mountain top removal operations.
2. This sheet does not cover the temporary stockpiling of box-cut spoil (see Sheet 6:7). The techniques described on this sheet are for permanent placement of excess spoil. Spoil may be in excess due to thick overburden and a high bulking factor or because the RA has allowed a variance from the "approximate original contour" requirement of the performance standards for regrading.
3. The methods covered on this sheet do not apply to "durable rock fills" which are covered separately in the performance standards [816.74].

APPLICABILITY

This sheet applies only to sites in mountainous or steeply rolling terrain. The Regulations require that all disturbed areas shall be returned to their "approximate original contour" [816.101]. However there are provisions for obtaining variances from this requirement in cases of mountaintop removal [Section 785.14] and in some other situations involving steep slope mining [Section 785.16]. If these variances are granted, there will be a need to dispose of large quantities of excess spoil.

On sites with thick overburden and a high bulking factor [Section 816.105] it will not be possible to regrade to the approximate original contour. In these cases, Head-of-Hollow or Valley fills may be used. The operator will probably wish to dispose of this box-cut spoil permanently in a Head-of-Hollow or Valley fill and create temporary spoil dumps as the need arises to maintain working space in the pit. In this way the haul distance for transporting spoil to fill the final pit is minimized.

REVELANT SECTIONS OF THE REGULATIONS

Because this sheet concentrates on the design requirements of the Regulations for constructing Head-of-Hollow or Valley fills, the Sections of the Regulations containing design specifications are covered under "Guidelines" below.

It is emphasized that the design of "Valley and Head-of-Hollow fills" must be certified by a professional engineer. It is stated in the Regulations [780.14(c)(2)] that spoil disposal facilities, maps, plans, and cross sections may only be prepared by a registered professional engineer. Section 780.35 specifies the application requirements for the disposal of excess spoil. It should be noted that the Regulations are generally more stringent for spoils larger than 1,000,000 cubic yards but on this sheet we concentrate on fills of less than 1,000,000 cubic yards [816.72(b)(3)].

The Regulations contain general requirements [816.71] covering the disposal of excess spoil. These include the placement of spoil in a manner to prevent degradation of surface and ground water and to insure the stability of the fill.

The Regulations distinguish between "Valley fills and "Head-of-Hollow fills". The Valley fills do not completely fill the valley between the ridge lines which is a requirement of Head-of-Hollow fills. The Regulations covering Valley fills [816.72] also apply to Head-of-Hollow but there are additional performance standards for Head-of-Hollow fill [816.73].

DISCUSSION & DESIGN GUIDELINES

In March 1978, EPA published an assessment by Skelly and Loy comparing the methods of Head-of-Hollow fill in West Virginia and Kentucky. The report included the consultants recommendations. The Regulations are very similar to these recommendations and much of the information and data for the drawings on this sheet are derived from that report (1).

I. SITE SELECTION

Applications must include a geotechnical investigation and a stability analysis [780.35]. Section 816.71(e) requires that disposal areas be located on the most moderate slopes available, and that sites with few seeps or drainage channels will reduce the amount of under-drainage required. When the average slope of the disposal site exceeds 1v:2.8h (36%), keyway cuts or rock-toe buttresses are required [816.71(i)]. It is noted that Skelly and Loy's recommendation is that stabilizing structures should be utilized when "the slope of the hollow at the proposed toe of the fill exceeds 10°," 1v:5.7h (1). Section 816.71(h)(1) does not specify the size of keyway cuts or rock toe buttresses and only requires that the size be based on a stability analysis. In cases where the toe of the spoil rests on a downslope, the details shown in Figures 1 and 2 should be taken only as guidelines, and site specific designs must be carried out by the professional engineer.

II. PREPARATION

Section 816.71(c) requires that vegetative and organic matter be removed from the disposal area and that the topsoil be removed, stored and replaced [816.21-816.25]. The RA may allow organic material to be used as a mulch to control soil erosion but the practice of windrowing cleared vegetation at the toe of the slope is not specifically mentioned and probably would not be allowed by the RA. Skelly and Loy's assessment of Head-of-Hollow fill practices points out that carelessly placed windrows may be buried by fill material and result in instability of the fill mass. (Special performance standards for steep slopes [Part 826] forbid burying woody materials in the backfilled areas.)

Specific regulations for the construction of sediment basins with Valley or Head-of-Hollow fills are included in Sections 816.71-816.73 but it is specified that leachate or the runoff must not exceed the effluent limitations in Section 816.42. That Section requires that "any surface drainage from the disturbed area . . . shall be passed through a sedimentation pond before leaving the permit area" [816.42(a)(1)]. Skelly and Loy recommend that "sediment control ponds must be constructed near the proposed toe of the fill" (1).

III. DESIGN

Section 816.71(d) requires that diversion ditches conform to the requirements of Section 816.43. In addition to the main underdrain, lateral drains must be built to any springs, water courses or seeps. The main underdrain and these laterals must be protected with a filter system. The Regulations do not specify the minimum size of lateral drains. The main underdrain may be made of durable non-acid rock (no more than 10% may be less than 12 inches in size and none larger than 25% of the drain width). The width and height of underdrains for fills of less than 1,000,000 cubic yards are shown in Table 1.

Table 1
Minimum Dimensions of Underdrain

Type of Fill	Minimum Size of Drain (feet) Width	Height
Sand Stone	10	4
Shale	16	8

Note - these dimensions are the same in the case of shale as Skelly and Loy's recommendations (1).

Section 816.71(g) permits no depressions or impoundments on the fill mass. However, an exception is made for Head-of-Hollow fills. A "drainage pocket" [816.73(e)(3)] is allowed at the head of the fill to intercept runoff and discharge it through or over the rock chimney drain. Skelly and Loy's report notes that surge ponds located at the head of the rock core in West Virginia's fills, though not intended to retain the water, did so with resultant instability problems when water saturated the fill.

The design criteria for the fill mass as shown in Figure 1 apply both to Valley and Head-of-Hollow fills. But in the case of Head-of-Hollow fills, which must completely fill the disposal site to the elevation of the ridge line, the surface drainage of the fill may be directed inwards to a rock chimney drain as shown in Figure 2 [816.73(a)].

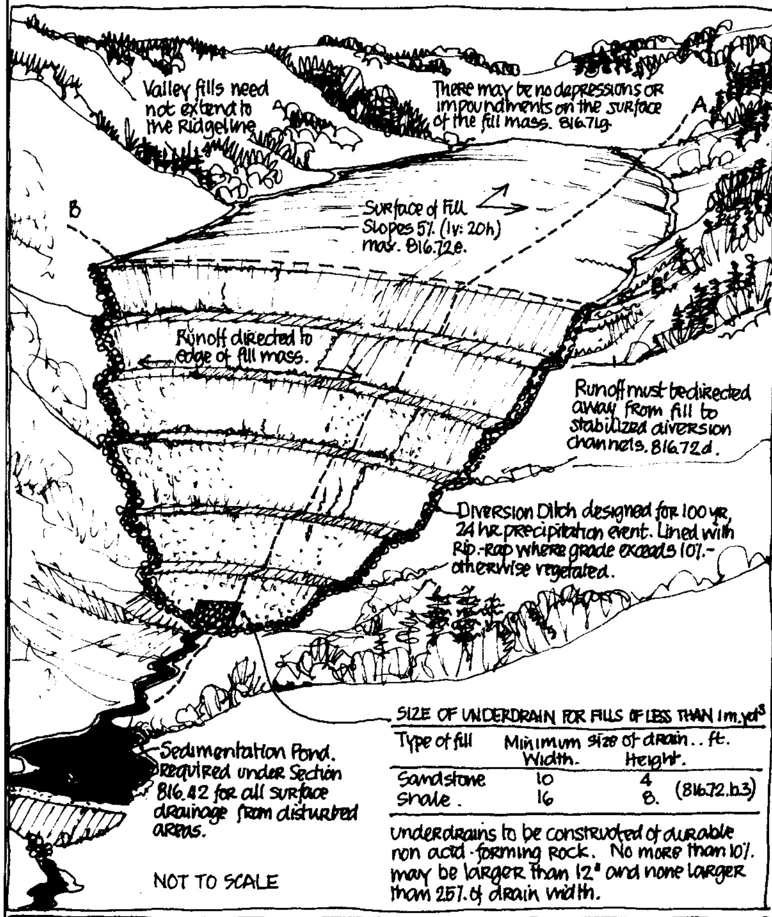
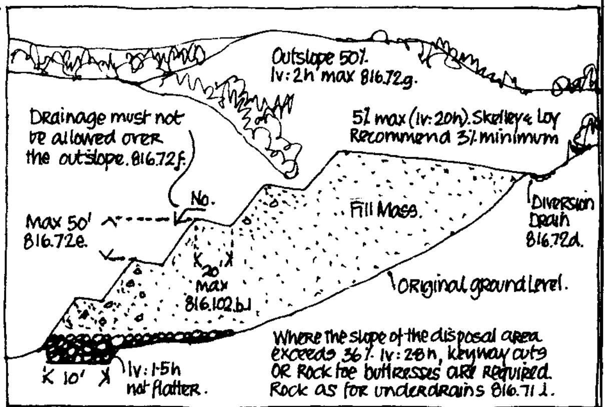
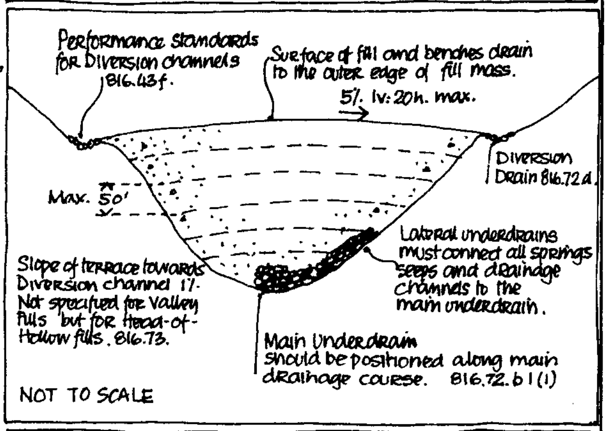


Figure 1 DESIGN REQUIREMENTS FOR VALLEY FILLS. Section 816.72.

The surface of the fill must be sloped towards the edges where runoff is collected in protected diversion channels. Terraces must also direct water off the fill to these channels.



DESIGN REQUIREMENTS FOR VALLEY FILLS Section AA' NOT TO SCALE



DESIGN REQUIREMENTS FOR VALLEY FILLS. Section BB'

Skelley and Loy Recommend that diversion ditches are located on undisturbed ground & Rip-Rapped.

IV. PLACEMENT

The Regulations require that placement is carried out in such a way as to ensure a long-term static safety factor of 1.5. The requirement that spoil be placed in horizontal lifts of 4 feet or less [816.72(c)] and concurrently compacted makes the placement procedure as used previously in Kentucky unacceptable. Dumping spoil over the outslope of a fill tends to result in the segregation of fill, the large coarse materials at the bottom forming a "natural" French drain system. The requirement that spoil be placed in horizontal lifts of 4 feet or less and concurrently compacted prevents formation of a natural under-drainage system but the increased stability which results from controlled placement and compaction usually outweighs this disadvantage. Placement of spoil in 4-feet lifts was already required by West Virginia law. During the placement process the fill must be inspected at quarterly intervals at least and at certain stages, by a registered engineer or a professional who must submit a certified report. Operators are not permitted to dispose of coal processing waste in Head-of-Hollow or Valley fills.

V. REVEGETATION

Each lift of both Valley and Head-of-Hollow fills should be vegetated immediately upon completion. This was not feasible with the method previously used in Kentucky, and it is an advantage of placing spoil in horizontal lifts that revegetation can be carried out

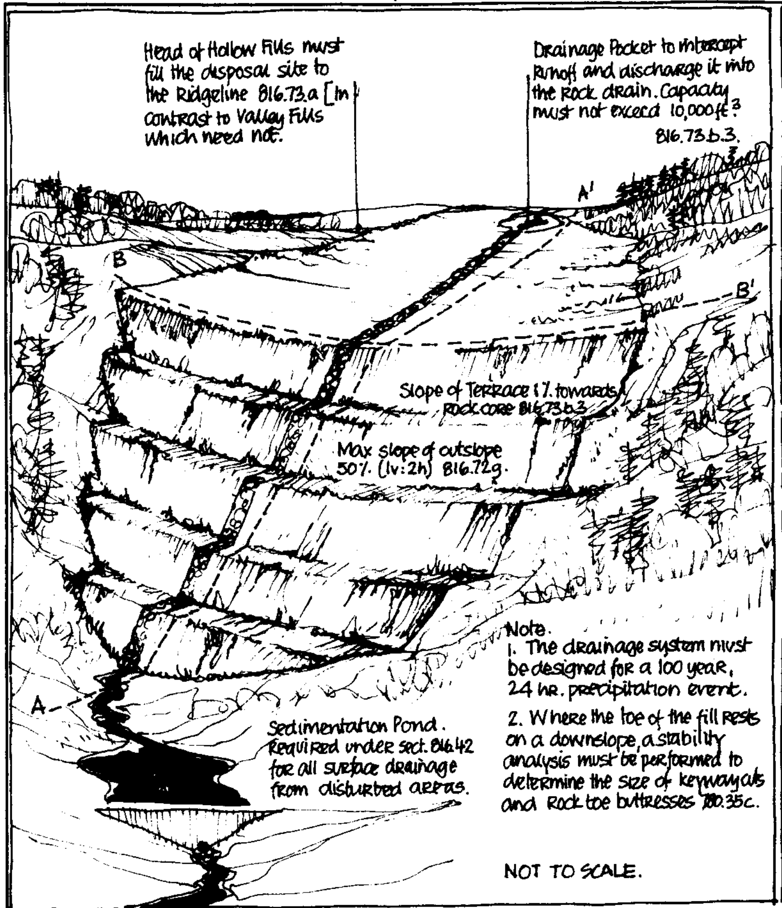
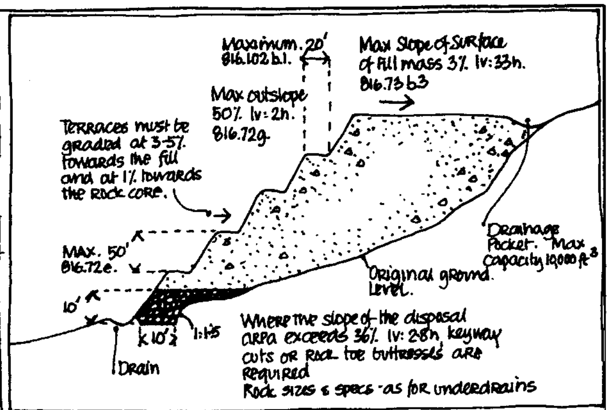
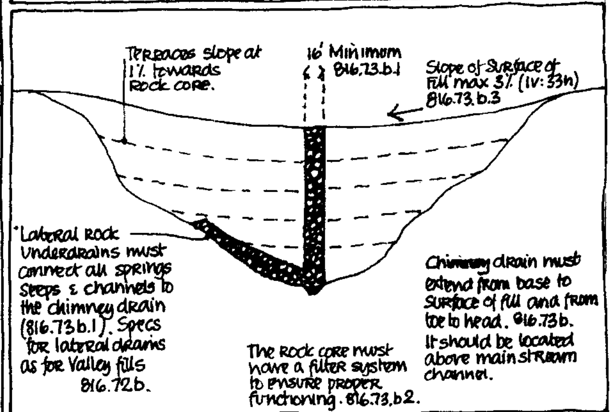


Figure 2 DESIGN REQUIREMENTS FOR HEAD-OF-HOLLOW FILLS Section 816.73 The surface of the fill and terraces should slope inwards to a central chimney drain. The fill must entirely fill the disposal area to the elevation of the low point of the ridge. 816.73.a.



DESIGN REQUIREMENTS FOR HEAD-OF-HOLLOW FILLS. NOT TO SCALE
SECTION AA' Note: This section does not cut the Chimney Drain



DESIGN REQUIREMENTS FOR HEAD-OF-HOLLOW FILLS. NOT TO SCALE
SECTION BB'

concurrently.

Section 816.71(c) requires replacement of topsoil. This will be difficult on outslopes of 1v:2h but can be achieved by dumping soil from the terrace and then spreading using a dozer up and down the slope. The dozer's cleat depressions help to minimize erosion and to trap seed. Hydroseeders are the most effective method of applying seed and mulch (Sheet 7:9 and Sheet 7:14).

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PROBLEM & PURPOSE

From the operator's point of view, keeping the pit free of water is important to minimize delays and to improve working condition. Water which accumulates in the pit is likely to be heavily polluted with sediment or dissolved salts or both. Therefore, pit dewatering is likely to result in heavy pollution loads in the receiving waters. In addition, if the coal lies below the groundwater, pumping to keep the pit dry may lower the water table which may reduce the yield of wells, springs and seeps. There are provisions in the Regulations for diverting surface water around disturbed areas so that it will not contribute to the problem of dewatering the pit. Water may enter the pit from various sources:

1. Groundwater: if coal is below the water table the flow of groundwater into the pit may be more or less continuous and consequently the pit may require continuous dewatering.
2. Abandoned deep mine workings: frequently, abandoned deep mine workings are encourntered during surface mining and may result in sudden flow of large volumes of water into the pit. This water may be seriously polluted.
3. Rainfall and runoff: heavy rainfall and runoff will result in the accumulation of quantities of water in the pit and inevitably this will carry heavy sediment loads.

Whatever the source, the water in the pit bottom will come into contact with coal and other materials which frequently are high in pyrite and other toxic-forming or acid-forming materials. Therefore pit water is usually a serious pollution hazard and, in order to minimize the need for the treatment of drainage water, the operator should make every effort possible to divert water before it flows into the pit as it is likely that water pumped from the pit will need some form of treatment before it is discharged from the permit area.

When water comes into contact with pyrite, which is iron sulfide ($Fe\ S_2$) in the presence of oxygen, ferric sulfate ($FeSO_4$) and sulfuric acid are formed. The reaction and the speed of the reaction depends partly on the presence of certain bacteria. Unfortunately pyrite occurs naturally and in close proximity to coal seams in many coal mining areas particularly in the Northern Appalachians. Mining exposes quantities of pyritic materials to this oxidation process. Preventing oxygen and water coming into contact with pyritic materials therefore is usually the approach taken to controlling acid mine drainage (AMD) and only if this is ineffective, is treatment of acid water considered. The problem in the past has been that, due to the method of removal of overburden, acid-forming materials tended to end up on top of spoil heaps where they were exposed both to oxygen and to the leaching action and runoff of water. Instability of these spoil heaps also tended to expose fresh acid-forming materials continuously to weathering. AMD problems are serious in regions where there is a high content of pyrite in coal seams and in overburden strata. The states of West Virginia and Pennsylvania identified acid mine drainage as their worst water pollution problem. In fact AMD is considerably worse in the northern 1/3 of the Appalachian coal field than in the southern 2/3. This is partly due to the fact that there is more coal mined in the northern Appalachia than in the south but the amount of sulfuritic material exposed for each ton of coal mined in the north may be greater than in the south (21). See Figure 1 in section on Applicability.

It is estimated that in the Appalachian region 6,000 tons of sulfuric acid is being produced daily through the oxidation of pyrite and that the acid drainage from strip mines accounts for about 15% of the total acid production. Note that this was in 1971 (4).

Another study found that acid produced in Appalachian area coal mines (1969) was the greatest from abandoned deep mines (53%). Active underground mines produced 19% and abandoned surface mines only 11% (7). The pattern of acid discharge is erratic. Stream damage may be caused by continuous acid discharges caused usually at low and moderate levels but also by extremely high discharges caused by dewatering of mines during periods of high precipitation which often causes dramatic stream damage (21). The low pH resulting from acid mine drainage may not be a problem in itself. Low pH does make certain heavy metals excessively available to plants and cause toxicity. Manganese and aluminum are two cases. Other heavy metals in toxic amounts may also be found in acid mine water and certain metals are found associated with a high suspended solid concentration often associated with acid mine drainage. Fe, Zn and Ni were generally found to be more abundant in fine sediment in mine runoff (19). There is considerable work in progress to try to assess the mobilization of heavy metals by acid mine water and also their availability to plants (19).

However, extensive neutralization of acid drainage often occurs within the coal regions. In fact Biesecker and George report that acid drainage is most serious in head water streams near active or abandoned mines but that the mixture of alkaline streams with mine drainage waters eventually neutralize all acid streams in Appalachia. Neutralization is usually due to the presence of certain soluble rock minerals, including calcium bicarbonate ($CaCo_3$), which are in sufficient quantities to neutralize drainage water. A problem is that this process increases the total hardness of the water through the addition of calcium and magnesium.

When the acid stream contacts an unpolluted or alkaline stream, it is partly neutralized and the iron begins to precipitate out as ferric hydroxide froming a yellow coating on the streambed, locally known as "yellow boy." As iron, aluminum and manganese are acid soluble, merely neutralizing the water (increasing the pH) will also precipitate these ions but as, is noted by Walmer, this is not as easy as it sounds, as several factors complicate the precipitation. But the approach to solving acid drainage problems is to prevent oxygen and water coming into contact with pyritic materials and treating only as a last resort. Treatment has the advantage of resulting not only in a water with a higher pH, but it also tends to precipitate out some of the heavy metals such as iron, aluminum and manganese.

Even if acid drainage from new surface mining operations can be controlled effectively, the problem of acid drainage from abandoned underground mines and from abandoned surface mines will remain for many years. There is a opportunity for new surface mine operations to reduce some of these problems as part of ongoing surface mining activities: in the case of abandoned underground mines by daylighting and sealing the old working; and in the case of abandoned surface mines by shifting and burying abandoned spoil piles in the working pit.

APPLICABILITY

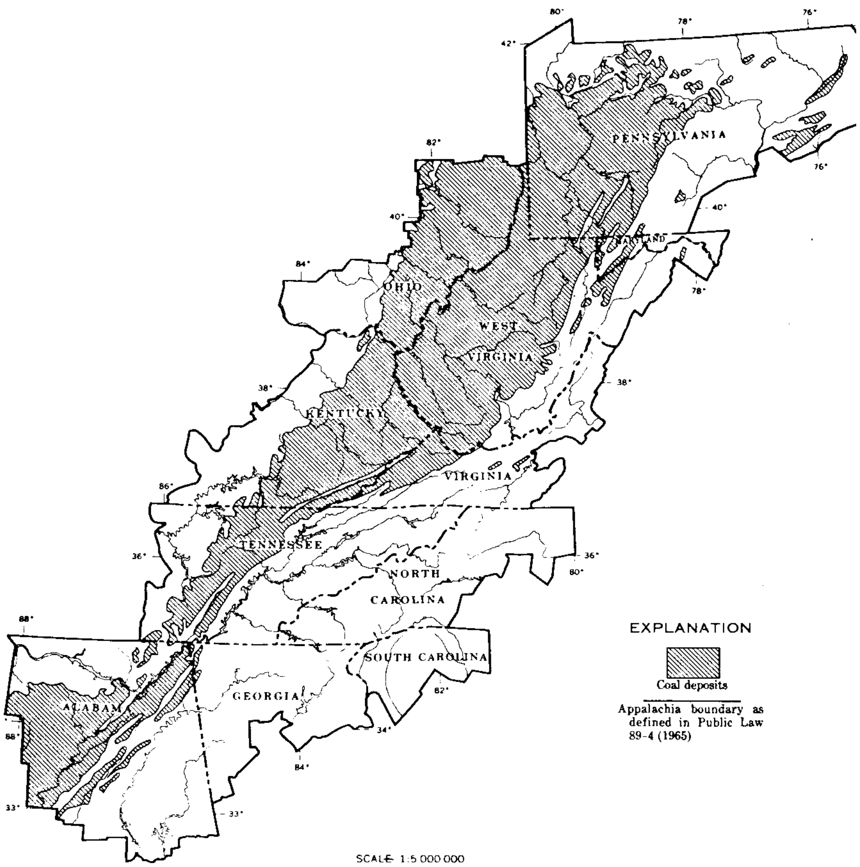

Figure 1

The problem of pit dewatering will apply to all sites. But the impact of dewatering on water pollution and the groundwater hydrology will vary greatly. The groundwater information required as part of the information in the application procedure [Section 779.15] will indicate whether any coal lies below the water table and consequently whether pit dewatering is likely to affect groundwater yield. The "Geology description," also required as part of the application procedure to identify potential acid forming materials in the overburden or pit water in order to control AMD. Therefore, the applicability of these measures depends largely on the hydrologic and geologic characteristics of the area. Measures to control pollution from pit water and AMD apply to all sizes of operation but small mine operators should note that the RA will pay for a laboratory to analyze test borings and to assess the likely impact of operations on the hydrology and water quality of the area.

REVELANT SECTIONS OF THE REGULATIONS

The requirements for a "Geology description" which identifies (amongst other things) potential acid-forming materials in the overburden [Section 779.14] and for groundwater information which identifies the depth of the pit below the surface and the horizontal extent of the water table and aquifers [Section 779.15] have already been mentioned. There are provisions in the Small Operators Assistance Program for results of test borings to be analyzed and assessment of possible hydrologic impact to be made by a certified lab and paid for by the RA.

Section 816.48 specifically addresses the problem of handling acid-forming and toxic-forming materials. This problem is covered in more detail in this Handbook on Sheet 6:10.

Section 816.52 requires surface and groundwater monitoring when surface mining activities may affect groundwater or surface water systems. This would be the case where continuous pumping is required to keep the pit free of groundwater inflow. All discharges from the permit area must meet effluent limitations [816.42] and all drainage from disturbed areas must be passed through a sedimentation pond. If this is not sufficient for drainage water to meet effluent standards "adequate facilities shall be installed, operated and maintained to treat any water discharged from the disturbed area so that it complies with all federal and state regulations." If the pH of the water is below 6.0 an automatic lime feeder is required unless the flow is infrequent in which case the RA may authorize the use of a manual lime feeder [816.42(c)].

DISCUSSION & DESIGN GUIDELINES

The approach to control of acid drainage in the Regulations is based largely upon the selective handling, burying and sealing of acid-forming spoils (see Sheet 6:10), exposed coal seams and old deep mine workings, and generally preventing drainage water from coming into contact with acid-forming spoils. Measures on Sheet 6:5 to divert water around disturbed areas will help considerably, but it will not be feasible to prevent entirely water coming into contact with acid-forming materials. Runoff from all disturbed areas must be passed through a sedimentation pond before leaving the permit area [816.42(a)] which will remove suspended solids. But if the drainage water fails to meet the effluent standards set out in 816.42(a)(7) particularly in respect to pH, which must be within the range of 6.0 to 9.0, some form of treatment will be necessary. An automatic lime feeder or other automatic neutralization process is required by the RA unless the flow of acid water is infrequent and "presents small and infrequent treatment requirements to meet applicable standards." The drainage water from surface mine sites is unlikely to be highly acidic and therefore some of the processes which have been developed for acid mine drainage originating from underground mines are inappropriate to the mildly acidic water from surface mines. These include reverse osmosis and other elaborate treatment techniques. Although it may be necessary to provide some settling pond in which insoluble salts can settle after neutralization, the disposal of acid brines or brine sludge which results from the neutralization process of strongly acid mine waters, will generally be unnecessary.

In the cases where the RA permits manual treatment and the water can be easily impounded, it may be possible to spread lime manually from bags onto the surface of the impounded water. However lime is not readily soluble in water and some form of mixing must be applied to obtain satisfactory utilization of the lime. This is most easily accomplished by installing a pump at one end of the pond but there may be a problem on some mining sites where no electrical outlets are available at the pond site. After treatment the treated water should be transferred to a settling basin to remove the suspended solids and sludge prior to discharge.

Automatic feeders to dose acid drainage with lime slurry have automatic pH controls and generally use hydrated lime. If limestone can be used in treatment plants instead of lime significant savings can occur, but there is a drawback in that limestone has a slow reaction rate and often a coating of iron hydroxide forms on the surface of the limestone. The problem of coating can be solved by some sort of abrasive or tumbling action which also breaks off fines and exposes a reactive limestone surface. Tumbling drums are an effective means of treating acid mine drainage in cases where there is enough hydraulic head to power the drum. Limestone is contained in the drum which is driven by a waterwheel. The outside diameter of the waterwheel should be 1.5 times the diameter of the tumbling drum (Figure 2) (15). Tumbling drums are generally most suitable for complete neutralization of mildly acidic mine water in contrast to limestone barriers which are more suitable for partial neutralization of highly acidic waters.

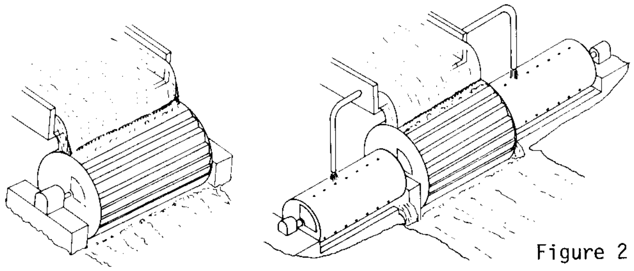

Figure 2

Limestone barriers are probably the most commonly used method of AMD treatment. Experiments carried out by Pearson and McDonald tested the effectiveness of four types of barrier and led to a suggested design procedure for limestone barriers which can be found in reference 11. See also Figure 3.

Some experiments have been done to try to inhibit the activities of bacteria which are responsible for the formation of acid in mine water. Iron oxidizing bacteria (Thiobacillus ferro-oxidans and Thiobacillus thiooxidans) are active in the production of sulfuric acid from iron pyrite, and it has been found that certain detergents and organic acids can inhibit the activity of these bacteria. However, generally the use of these techniques is still in experimental stages and is not sufficiently reliable to justify general use.

Other bacteria are responsible for the breakdown of wastewater constituents and a device called "the rotating biological contactor" utilizes these microorganisms for treatment of acid drainage. This device

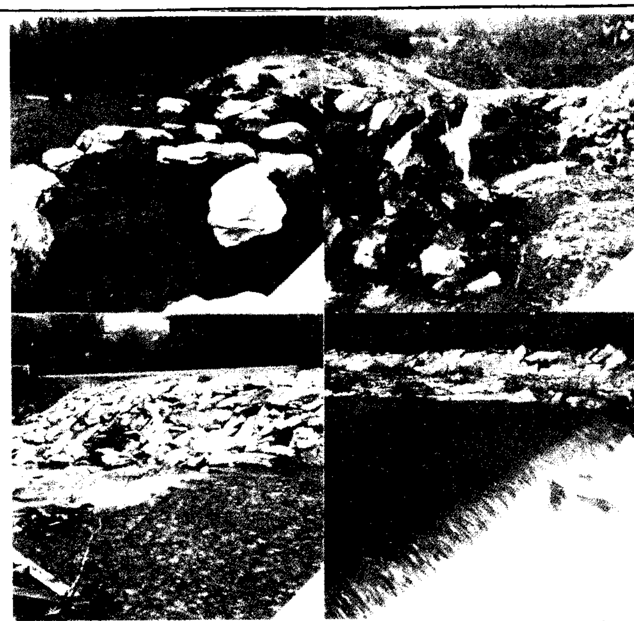

Figure 3. Limestone Barriers Source: (11)

provides a large surface area for the attachment and colonization of the bacteria which oxidize ferrous iron in acid water to an insoluble form which precipitates out. However, this device has a high capital cost and at present is inappropriate for use for small surface mining operations.

It was noted previously that the most effective method of sealing acid-forming spoil from oxidation is to bury it in spoil material and consolidate it. Shumate and Brant (1971) states that "It is unlikely that material buried several feet or more beneath the surface can undergo significant oxidation because of the restriction of oxygen diffusion to these depths" (4). The use of other surface sealants has not been particularly successful. Lime, gypsum, sodium silicate and various rubber latex seals have sometimes been effective. They require repeated application and maintenance and are not recommended for general use. Water barriers can provide an effective seal against oxidation of pyrite, but a safety factor to allow for evaporation is necessary. Also, if things go wrong, sealing acid-forming materials with water may in itself result in serious pollution of surface or groundwater.

Some experiments have been done using irrigation of treated acid mine water to further improve its quality. It was found in one study that acid mine drainage filtering through 40 inches of calcareous soil resulted in a percolate that had a slightly alkaline reaction and was completely devoid of Fe, Al, Mg, Zn & Cu. Even acid soils were effective in improving water although not as effective as calcareous soils (1). The use of acid mine water for irrigation on particularly dry reclamation sites may result in improved quality of vegetation and protection against erosion.

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GROUP	MOBILIZATION AND MINING OPERATIONS
MEASURES	ACID FORMING MATERIAL, ROUGH BACKFILLING AND GRADING

PROBLEM & PURPOSE

The requirement of 816.100 "that all reclamation, occur as contemporaneously as practicable with mining operations," and the need to minimize double handling, makes it necessary to plan the backfilling operation to occur as part of the task of overburden removal. The way in which backfilling and rough grading are carried out may have a major effect on both groundwater recharge and streamflow. Not only must the spoil be regraded so that it can remain stable but it should be regraded so as to maintain infiltration and percolation of rainfall so as to recharge groundwater sources on which both dry weather streamflow, water supply to springs and seep areas, and the safe yield of springs and wells depend. It may also affect the establishment of an effective vegetation cover, particularly of tree species, as the amount of infiltration will affect the availability of water for plants.

The amount of compaction of the spoil which occurs during regrading will affect the amount of runoff and consequently will affect erosion. Therefore, prior to final grading it may be necessary to pass a ripper over the site to reduce consolidation of rough-graded spoil which may occur during final grading operations, cultivation, etc. (see Sheet 7:3) This process should be carried out along the contour to achieve an optimum level of infiltration and to minimize erosion.

The type of machinery used to shift overburden and to carry out rough grading has an important impact on the infiltration of surface water into the ground. "Where scrapers have dumped spoil and the heavy tires compacted the spoil, the infiltration may be one or two orders of magnitude less than in cases where a dragline dumps the spoils" (13). Therefore, it may be in cases where rough grading is carried out on spoils cast by a dragline using a bulldozer or even a dragline bucket, subsoiling using a ripper may not be necessary to reduce the amount of compaction.

Generally, the Regulations require regrading to "approximate original contour". The degree of approximation which will be permitted by the RA will depend upon a number of factors including the approved post-mining land use, the impact of any change on the natural drainage pattern, hydrology and landscape of the area, etc.

The sequence in which backfilling of spoil materials is carried out and the methods used are of vital importance in minimizing AMD.

Acid-forming materials are frequently found in association with coal, usually within the coal itself and in strata close to the coal. Careful handling is the key to preventing acid drainage in order to prevent oxidation and the forming of acid solution by excluding air and water.

APPLICABILITY

Backfilling and rough grading are of course applicable to all sites, but the requirements of the Regulations vary according to the mining method as to the period or distance allowed before contemporaneous reclamation must begin.

The specific requirements of the Regulations affecting the handling of acid-forming materials will only apply to areas where the analysis of core samples [779.14] shows significant amounts of acid-forming materials. In the case of small mine operations, this analysis will be paid for by the RA under the provisions of the Small Operator Assistance Program.

REVELANT SECTIONS OF THE REGULATIONS

I. BACKFILLING AND ROUGH GRADING.

A detailed timetable for the completion of each major step in reclamation, including a plan for backfilling and grading, is required as part of the reclamation plan [780.18]. The plan for backfilling and grading should consist of contour maps and/or cross sections that show the anticipated final surface configuration of the proposed permit area.

"Reclamation efforts, including...backfilling and grading...shall occur as contemporaneously as practicable with mining operations" [816.100]. Section 816.101 actually specifies time limits for rough backfilling and grading of surface mine sites. In the case of contour mining, backfilling and grading must follow coal removal by not more than 60 days or 1,500 feet. In the case of area strip-mining 180 days is allowed following coal removal, but rough grading may be more than 4 spoil ridges behind the pit which is being worked. In the case of open pit mining the timing of backfilling and grading must be in accordance with the time schedule approved by the RA. Section 816.101(b) contains the requirement that all disturbed areas shall be returned to their "approximate original contour." It also requires that all spoil shall be transported, backfilled, compacted and graded to eliminate all highwalls, spoil piles and depressions; the term "approximate" implies a certain latitude in interpreting this requirement and Section 816.102 states that "post-mining final graded slopes need not be uniform but shall approximate to the general nature of the pre-mining topography." It also requires that final graded slopes shall not exceed the grade of the pre-mining slopes but that backfilling and grading should be carried out to the most moderate slope possible. Cut and fill terraces are only permissible in situations expressively identified in Section 816.102 and require approval from the RA. To obtain this approval, terraces must be compatible with the approved post-mining land use and they must be "appropriate substitutes for construction of lower grades on the reclaimed land." Further discussion on the use of terraces for water conservation and erosion control can be found on Sheet 7:2.

II. BACKFILLING AND GRADING (THIN OVERBURDEN - SECTION 916.104).

The performance standards contain different requirements for backfilling and grading in situations of "thin overburden and thick overburden." Thin overburden applies to situations where the final thickness (Tf) is less than 0.8 of the initial thickness (Ti). Where Ti = the sum of the pre-mining thickness of the overburden (Tb) + the thickness of the in-situ coal (Tc). The final thickness (Ti) = the product of the pre-mining thickness of the overburden (Tb) x the bulking factor (K).

Thus: $Ti = Tb + Tc$.

$Tf = Tb \times K$.

Section 816.104 applies when Tf is less than 0.8 x Ti. In these situations there is unlikely to be sufficient spoil available to achieve the grades which approximate original contours. If this is the case, the grading must achieve adequate drainage and all acid-forming and toxic-forming material must be covered as required in Section 816.103, i.e., with a minimum of 4' of non-toxic spoil or non-toxic material.

All highwalls must be eliminated by grading or backfilling to stable slopes which may not exceed 1v:2h (50%) unless steeper slopes are approved by the RA [816.104(b)(2)]. In situations where spoil is insufficient to achieve the approximate original contour, a common technique for grading the site is to leave an impoundment in the area of the final cut. An impoundment which is planned must be approved by the RA and this approval is conditional upon the impoundment being suitable for the approved post-mining land use. Approval of an impoundment in the area of the final cut does not relieve the operator of the requirement to eliminate the highwall. Where the RA approved a permanent impoundment as part of the restoration plan, it must meet the requirements of Section 816.49.

III. BACKFILLING AND GRADING (THICK OVERBURDEN - SECTION 816.105)

Section 816.105 of the performance standards applies where the final thickness of overburden is greater than 1.2 of the initial thickness using the same method of calculation as in the previous paragraph. That is, it applies when Tf is more than 1.2 x Ti.

This Section [816.105] applies in those situations where the volume of spoil is demonstrated to be "more than sufficient" to achieve the approximate original contour. In these cases, the mine area should be graded to the approximate original contour and any excess spoil should be hauled and disposed of in excess spoil disposal areas in accordance with the relevant sections of the performance standards [816.71-816.74]. As is the case for all other surface mines, highwalls and depressions must be eliminated.

IV. SELECTIVE HANDLING OF ACID-FORMING MATERIALS.

Identification and analysis of potential acid-forming, toxic-forming or alkalinity-producing materials are required as part of the Geology Description [779.14(b)(1)]. These will provide the operator with a good basis for planning the selective handling of these materials, as is required in the performance standards, and of the potential buffering or neutralizing capacity of other strata in the overburden. Section 780.18(b)(7) requires as part of the reclamation plan "a description of measures to be employed to insure that...all acid-forming and toxic-forming materials are disposed of in accordance with Section 816.103." There are two sections in the performance controls which specifically cover the handling of toxic-forming or acid-forming materials. These are Section 816.48 (Hydrologic Balance: Acid-forming and toxic-forming spoils) and 816.103 (Backfilling and Grading: Covering coal and acid-forming and toxic-forming materials).

Section 816.48 specifies that acid-forming or toxic-forming spoils must be buried within 30 days of exposure on the mine site. In some cases temporary storage of acid-forming spoils may be approved by the RA if burial is unfeasible within 30 days, but only if this will not result in water pollution problems.

Section 816.103 requires that acid-forming and toxic-forming materials and all exposed coal seams after mining are covered with a minimum of 4' of "the best available non-toxic...material." If necessary these materials must be treated to neutralize toxicity and in some cases the RA may specify thicker cover and special compaction and isolation measures to prevent contact with groundwater.

The requirements of Section 816.52(a) and (b), that groundwater and surface water be monitored, means that if selective handling of acid-forming or toxic-forming materials is not effective and groundwater or surface water pollution results the RA will be able to trace the source of the problem [816.104(b)(2)].

The performance controls covering the disposal of excess spoil in Sections 816.71 to 816.74 do not specifically prevent the disposal of acid-forming or toxic-forming material in Valley or Head-of-Hollow fills. But there is a general requirement in Section 816.71 that "the leachate and surface runoff from the fill will not degrade the surface groundwaters or exceed the effluent limitations. Also, acid-forming or toxic-forming materials are specifically outlawed for use in under-drainage systems in excess spoil disposal sites.

Coal processing wastes are a major source of water pollution in mining areas. This problem is not specifically covered in this Handbook. For performance standards covering the handling and disposal of coal processing wastes see Sections 816.81 to 816.93.

DISCUSSION & DESIGN GUIDELINES

I. BACKFILLING AND ROUGH GRADING.

Backfilling and rough grading, in order to meet the requirements of the Regulations for contemporaneous reclamation, have to be planned as part of the task of overburden removal. In order to minimize double handling, the techniques of achieving contemporaneous backfilling and regrading will vary with the type of mining operation. In contour mining, the practice of haulback was being used by many mining companies prior to 1977. The haulback method of surface mining, by backfilling simultaneously with excavation, cuts the area of disturbed lands by two-thirds (3). In doing so, this method also meets the requirement of SMCRA for contemporaneous reclamation, and reduces the disturbed area contributing to erosion. It was found that haulage distance for spoil in single seam haulback operations averaged 500'. (The Regulations allow 1,500'.) This operation involves 3 distinct operations: loading, haulage, and regrading. This, however, makes selective handling and replacement of overburden possible and also can achieve much more compaction of spoil than in cases of overburden cast with a dragline or shovel. Greater compaction of acid-forming materials can significantly reduce acid formation by excluding air.

Generally, smaller operators will not be involved in mountaintop removal operations. The large amounts of overburden to be removed in these cases makes very careful planning, programming and contemporaneous reclamation essential. Usually also there is a need for disposal of excess spoil (see Sheet 6:8); consequently, even prior to the 1977 Act, contemporaneous reclamation was practiced as part of mountaintop removal operations by most operators. An example is Vecellio & Grogan who were cited for excellence in reclamation by West Virginia's Dept. of Natural Resources for their 285-acre mountaintop removal operation near Beckley, WV, where reclamation goes on continuously as coal is mined. It is a loader/haul truck operation with scrapers used to remove and replace 2'-4' of soil on reclaimed areas (4).

In area mining being carried out with a dragline, the operation of backfilling is of course part of the overburden removal process. Rough grading is usually carried out with dozers. Spoil cast by a dragline is unconsolidated and therefore may be liable to settlement for several years after mining. This may cause problems when revegetating due to excessively rapid percolation of water and drying out. Unconsolidated spoil in areas affected by area or open pit mining has the potential for underground water storage, in effect by creating an aquifer.

The problem of handling and regrading of box-cut spoils was discussed on Sheet 6:7. In area mining, there may be more flexibility in planning the duration and sequence of working so as to minimize the distance between the temporary spoil dump and the final cut. Some double handling of box-cut spoils to eliminate the highwall and other requirements of Section 816.101 (Backfilling and Grading: General Requirements) is unavoidable.

Selective handling of overburden when it contains acid-forming materials is not easy with a dragline. Placement of the acid-forming material, consolidation and sealing with a relatively impermeable spoil material cannot be carried out with a dragline or a stripping shovel. The

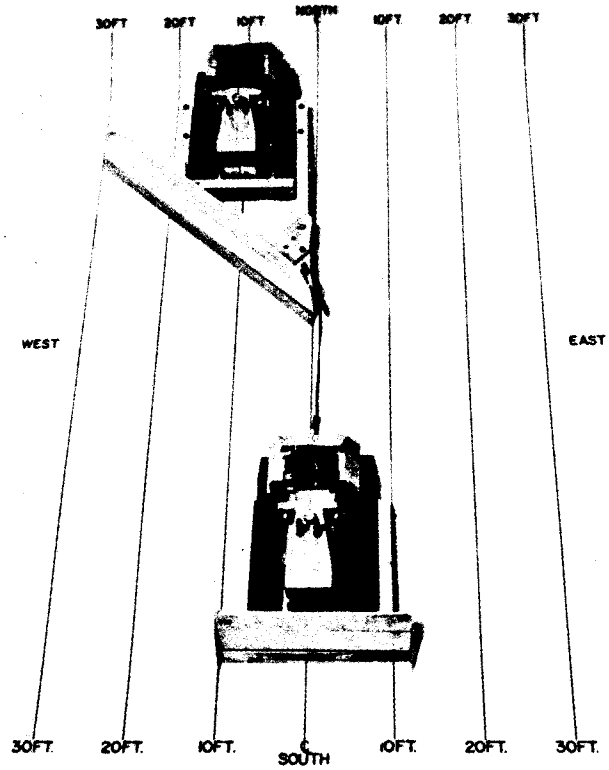
DISCUSSION & DESIGN GUIDELINES (CONTINUED)

presence of a large amount of acid-forming material in the overburden may justify a change in the method of operation and machinery chosen.

Rough grading of unconsolidated dragline spoils can be accomplished using dozers with very wide blades, and some interesting innovations have been tried out to increase the capabilities of bulldozers in this operation. The Push-Tow concept is described by Howland of the Pittsburgh and Midway Mining Co.

Under the Push-Tow concept, application of additional horsepower to the angle blade is made through a single point hitch to the leading edge of the blade. Through directional changes, the lead tractor helps counteract side thrust forces imposed upon the angle blade and "push" tractor. With a 40 degree angle of attack, the 40' blade has a maximum effective width of 30' for spoil relocation west of the centerline, as shown in the above illustration, and 30' east of the centerline on the return pass when tractors are moving north.

Generally, acid-forming spoil which is compacted and covered with relatively impermeable material and a minimum of 4' of non-toxic overburden requires no other sealant to prevent oxidation. In the past, various sealants have been tried to prevent the oxidation of pyrite in acid-forming spoils. It was found that generally compacted clay is the most cost-effective method of achieving this. More expensive materials, including concrete, bitumin and various latex sealers, have been tried but the results have generally been variable and their use is not recommended for covering surface mine spoils, although in some cases their use is recommended for sealing deep mine workings.



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