EPA-600/2-76-196
August 1976

Environmental Protection Technology Series

DEMONSTRATION OF COAL MINE HAUL ROAD SEDIMENT CONTROL TECHNIQUES

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
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DEMONSTRATION OF COAL MINE HAUL ROAD SEDIMENT CONTROL TECHNIQUES

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FOREWORD

When energy and material resources are extracted, processed and used, changes are produced in the existing environment that in many instances are undesirable. These undesirable changes resulting from both substances and effects comprise what we define as pollution. Pollution of air, land and water may adversely affect our aesthetic and physical well being. Protection of our environment requires that we recognize and understand the complex interaction between our industrial society and our environment.

The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies aimed at minimizing, abating and preventing pollution from industrial and energy-related activities.

This report examines the feasibility of demonstrating the most effective methods of controlling erosion which results when land is disturbed by the construction of coal mine access roads. The techniques presented are those that can reasonably and economically be constructed by conventional equipment that is normally used or is available to coal operators. This study will augment the sedimentation studies already being performed by the Extraction Technology Branch, and broaden the base of knowledge for pollution control for contour coal surface mines. The information will be of most benefit to the operators who are charged with protection of the environment and increased production of coal.

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ABSTRACT

This Report was prepared to examine the feasibility of demonstrating the most effective methods of controlling erosion which results when land is disturbed and altered by the construction of access roads to coal mining operations in the steeply sloping areas of Appalachia. The methods of controlling erosion on haul roads as examined herein are techniques that can reasonably and economically be constructed by conventional equipment that is normally used or is available to coal operators.

A method to collect quantitative data, by remote instrumentation, for evaluation of the effectiveness of the erosion control methods is also examined herein.

The project will be located in Martin County on the Pevler operations site, which is part of the Island Creek Coal Company operation. The exact road will be determined from several which have been offered by Island Creek that best fits the need of this project and will be built in the time frame of this project.

This report was submitted in fulfillment of EPA Project Number S-802682 by Mayes, Sudderth and Etheredge, Inc. through the Commonwealth of Kentucky under the sponsorship of the Environmental Protection Agency. Work was completed as of June, 1975.

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ACKNOWLEDGMENTS

The assistance and guidance of Robert E. Nickel and William S. Kelly of the Office of Planning and Research, Kentucky Department for Natural Resources and Environmental Protection, are sincerely appreciated.

The USEPA grant S-802682-01-3 was with the Kentucky Department for Natural Resources and Environmental Protection of Kentucky. Environmental Systems Corporation, Knoxville, Tennessee was responsible for the on-line instrumentation elements of this project.

SECTION I

CONCLUSIONS

After an extensive literature search and field investigations relative to coal mine haul roads, the following conclusions have been reached:

(1) Visual observations have indicated that the contribution of eroding haul roads to stream pollution relative to the overall mining operation is significant and should be studied, but quantification data is not available.

(2) Erosion, and the subsequent material movement during heavy rains, from coal haul roads originates at points common to any road, namely, the roadside ditch, roadway surface, and exposed areas of the cut and fill slopes. Methods used to prevent erosion from normal public roads would also work with coal mine haul roads; however, most are considered too expensive to be integrated into the coal mining operation. Since most coal haul roads are of a temporary nature, much more economical erosion control techniques must be used.

Compounding the problem is the fact that haul roads in southern Appalachia are mostly located in steeply sloping areas. The cut and fill slopes are not only steep, the road grades are usually steeper than the erosion resistance of most soils. Highly erosive velocities are attained in the roadside ditches and on the road surfaces. The problem, therefore, is the control of a highly susceptible erosion condition complicated by severe economic restraints which necessitate using native materials and relatively unskilled labor.

(3) There have been extensive studies on erosion and sedimentation control, especially as it applies to construction sites such as land development, highway construction, urban development, etc. Guidelines for erosion and sediment control practices have been published; however, these techniques generally do not have practical applicability to the steep roads encountered in the coal mining area of Appalachia.

(4) Most states have some type of guidelines governing the construction of haul roads, some of which are more stringent than others. The relative quality of haul road construction as examined for this study exist at opposite extremes: the large operators often build a good road, while most others build short-term dirt roads which turn to muddy channels during heavy rains.

(5) The steep terrain of the Appalachian area presents a special problem of economically controlling erosion under the most adverse conditions of steep slopes and highly erodible soils.

(6) Road gradient is the single most important factor in the erosion control difficulty of haul roads. Maximum sustained grades of 10 percent are generally permitted, and most haul roads are constructed at that limiting gradient or greater for most of their length. The roadside ditches are usually constructed on the same gradient as the roadway surface. Water flowing in unlined earth channels with slopes of 10 percent produces velocities which are beyond the erosive resistance of most soils. Water flowing on roadway surfaces with these steep slopes will attain velocities and depths which not only move material under sheet flow conditions but will begin to cut small channels in the surface, in which the flow becomes concentrated, thus increasing its erosive energy. Other measures must be devised if the erosion from these roads is to be reduced, if nonerodible surfaces such as pavement are to be considered outside the economic practicality of the small coal operator and his temporary road. An ideal sustained grade would be in the range of 4 percent to 8 percent. This would not only facilitate the control of drainage but would have economic benefits in that more haul trips per day could be made over gentler grades.

(7) Many of the erosion control techniques which are effective on steep, remote mountain roads used only occasionally by light vehicles or even on permanent, frequently traveled, U.S. Forest Service roads are not applicable to coal haul roads due to the incessant battering of high traffic volumes and extremely heavy loads to which the coal haul roads are subjected. It is imperative that the economic framework of the coal mining operation be considered in specifying measures for reducing erosion from haul roads. There is such a wide range of magnitude of coal mining operations that it is difficult to generalize on the economic feasibility regarding the sophistication of the haulageway. Such factors as length of time the road will be used and the amount of coal to be hauled over it are extremely pertinent to how much the operator is willing to invest in the haul road. It is conceivable that such cost factors could be included in the evaluation of mining permit applications. The haul road erosion control methods proposed in this project are ones which could reasonably be expected to be utilized by the mining industry.

(8) Under the most favorable conditions and with the best of erosion control plans, some erosion will occur. Therefore, a plan to minimize sedimentation must include a means by which the sediment from unpreventable erosion is intercepted before reaching the receiving stream. The control of erosion, economically, on roads with grades in the range of 10 percent is limited. Therefore, to minimize sediment movement into the stream network, a good sedimentation plan is necessary, utilizing filter berms, filter strips, sediment traps, etc. This project, however, proposed to demonstrate erosion control measures and their effectiveness, realizing that this is only half of a sedimentation control effort.

(10) The berm on the fill side of the road, required by the Federal safety law, is usually constructed of loose soil and rocks which readily are washed down the fill slope during rains. Failure to inslope the haul road surface, as is sometimes the case, results in water flowing to the toe of the safety berm, where it is diverted down the road surface, usually creating a rut or channel.

(11) Cut slopes in soils are generally at a maximum of 1:1. Low cuts have been observed that were steeper. It is difficult to start vegetation on slopes greater than 1:1, although heavy stands of vegetation were noted on very steep slopes in West Virginia. If the soil could be stabilized on these slopes until vegetation is established, erosion would be reduced. The slopes are usually too steep for normal mulching procedures. Some kind of chemical binder could be used to bind the soil into a coherent mass until the vegetation can become established. Some research has been done relative to chemical soil stabilizers; however, their use on steep slopes has not been demonstrated adequately and should be explored more extensively.

(12) Some type of roadway surfacing should be required on all haul roads. Material used for sub-base and surfacing should have adequate compressive strength to withstand the heavy loadings.

(13) The most practical method of demonstrating the effectiveness of different erosion abatement procedures is to isolate the drainage from specific sections of road, on which certain erosion control techniques have been incorporated, and monitor the material movement from each section and compare it with a base section which has been constructed according to prevailing haul road construction practices.

(14) It will not be necessary to measure every rainfall-runoff event in order to determine the effectiveness of the project. If a few significant events can be thoroughly recorded, adequate information will be available for evaluation of the parameters demonstrated.

(15) Channeling runoff from the roadway surface, roadside ditch, and cut slope presents no problem; however, monitoring the total runoff from the haul road will require a special provision in order to measure the diverted water through the ditch relief culverts.

(16) The most important element in the instrument package is the automatic sampler, which extracts moving water, at specific intervals, and stores the samples in bottles for later laboratory analysis. This is the most accurate method of determining quantities of suspended solids, since it is direct and does not depend on indirect techniques such as light scatter.

(17) A bituminous fiber ditch liner can be very effective for use in haul road drainage design. This material is strong, cheap, easy to install, can be cut to shape with normal hand tools, and will decay in time. The fact that it will decay in several years is important as it will permit vegetation to develop and form a permanent ditch liner.

SECTION II

RECOMMENDATIONS

Based on the foregoing conclusions, we recommend the following:

(1) A demonstration of erosion control techniques on coal haul roads is a necessary step in determining the most effective ways to reduce sediment movement and should be funded.

(2) A site opened by the Island Creek Coal Company in the Pevler operations area of Martin County should be used.

(3) A new haul road should be built to demonstrate erosion control techniques, which would be incorporated into the new road at the design stage and constructed according to strictly controlled specifications.

(4) The erosion control techniques to be demonstrated would include grade reduction, surfacing, roadside ditch lining, ditch relief culverts, check dams, chemical soil stabilizers, and methods for channeling drainage to the toe of the fill slope. All of the aforementioned techniques and the manner in which they would be used are described in Section VI. A new road should be divided into at least four sections, as follows:

Section 1: "control" section built according to present regulations and practices; sustained road gradient of 8-10 percent.

Section 2: sustained grade of 6 percent; check dams 0.3 m (1 foot) high, spaced at 15 m (50 feet), to reduce the hydraulic gradient in the roadside ditch to 4 percent; ditch relief culverts, spaced at 61 m (200 feet); surface to be the same as Section 1; culvert outfall to toe of fill slope by bituminized fiber sectional downdrains, pipe buried in the fill, and flexible downdrains; inslope roadway surface 0.06 m/m (3/4 inch per foot).

Section 3: sustained grade of 8-10 percent; roadside ditch lined with bituminized fiber sectional downdrains; inslope roadway surface 0.06 m/m (3/4 inch per foot); ditches designed to carry entire flow to natural drainageway.

Section 4: sustained grade of 8-10 percent; inslope roadway surface 0.06 m/m (3/4 inch per foot); gravel surfacing 0.38 m (15 inches) compacted depth.

Section 5: second control section specifically to measure the material dislodged from the fill side.

Section 6: companion section to Section 5 in which the fill slope would be sprayed with a chemical soil stabilizer and compared to the untreated condition of Section 5.

(5) Each demonstration site should contain a primary monitor and the appropriate number of secondary monitors. The primary monitor will measure rainfall, water level, temperature, turbidity, conductivity, and pH. The secondary monitors will measure water level and turbidity. All monitoring stations will contain an automatic sediment sampler. Detailed descriptions of the monitoring stations, including instruments and equipment, are given in Section VI.

(6) All of the gathered data should be assimilated, analyzed, interpreted, and compiled into a final report.

(7) Grab samples should be taken at each site at periodic intervals upon which a complete chemical analysis would be done.

SECTION III

INTRODUCTION

In 1973, Kentucky was the nation's leading coal-producing state. Presently, there is an economic boom in eastern Kentucky and other coal producing areas of Appalachia like nothing ever before experienced. With the possibility of the nation's returning to coal as a primary energy source, the price of coal has tripled in less than a year. Coal which was formerly considered uneconomical to extract is now being heavily mined.

There is clearly a major national concern as to the environmental effects of surface mining of coal throughout the entire United States. Much of the public emphasis has been focused on strip mining in the precipitous terrain of southern Appalachia. While the strip mining activities *per se* have drawn most of the public attention, other related activities, such as the construction and operation of haul roads, are now being considered.

In the steep terrain of Appalachia, much damage to the forest streams is caused by the erosion of disturbed land resulting from natural resources removal. According to the U.S. Forest Service, muddy water in mountain streams can often be traced to eroding roads. For many years, stream sedimentation was thought to originate from timbered hillsides, but now it has been concluded that much of the sediment comes from the roads used to remove the harvested products from the forest.[17] It is possible that coal haul roads also contribute significantly to stream sedimentation.

The eastern Kentucky coal field is characterized by extreme relief steeply sloping terrain, creating rapid runoff of surface water, thus intensifying erosion and sediment movement in disturbed areas. The construction of access roads to the area's mining activities is one of the necessary coal mine-related land disturbances. General guidelines concerning haul roads are issued by various regulating authorities, but they have not been definitive; nor have innovative techniques in the design, construction, maintenance, and bedding down of haul roads been of primary interest.

Almost without exception, coal mine haul roads are not built like public roads: the choice of routes is limited and often extremely steep slopes must be traversed; they are intended for use only during the life of the mining activity. The control of erosion and sediment movement into the local stream network must begin with the basic design of the haul road and continue through the construction, operation, and bedding-down period.

A study location in the eastern Kentucky coal field was selected for the demonstration project proposed herein because of the acute stream pollution problems in that area, caused partly by the difficulty associated with the economical control of erosion in steeply sloped, disturbed areas. The problems encountered in this area are not similar to those in areas where the slopes are less severe or where the soil types are substantially different. This project is limited, therefore, to haul roads in areas where side hill cuts are made for the road and where the terrain has slopes in excess of 20 degrees. Roads in this type of terrain appear to cause the greatest problems in regard to sedimentation.

STATEMENT OF OBJECTIVES

The objective of this project is to identify specific techniques for controlling the erosion which naturally results when land is disturbed and altered during the construction of access roads to coal mining operations in the steeply sloping areas of Appalachia and to obtain quantitative data for evaluation of the effectiveness of the erosion control methods. A restriction imposed by the practicality of the project is that the economic framework of the coal mining operation must be considered and the specific erosion control techniques must be economically feasible for incorporation into the design and construction of haul roads with normally available staff and funds.

STATEMENT OF WORK

The scope of the project is:

(1) To compile and examine various erosion control techniques that are applicable to coal mine haul roads;

(2) To select specific erosion control techniques for demonstration and to measure the relative effectiveness of each by installing the selected techniques in the field on a haul road and measuring their relative effectiveness using on-line monitoring instruments and equipment;

(3) To assimilate, evaluate, and interpret the collected data and prepare a report describing the results of the demonstration and to make specific recommendations about these techniques for future incorporation in guidelines concerning haul roads.

GENERAL DESCRIPTION

Background

During the preliminary phase of this project, an extensive literature search was conducted to determine the state-of-the-art relative to erosion and sedimentation control. Particular attention was centered on those methods technically and economically applicable to steep-slope coal mining operations. Specific erosion control methods were selected as ones which would be the most practical for use on steep coal mine haul roads.

New Haul Road Site

A site for a new haul road is located in the Pevler area of Martin County, Kentucky. A new haul road will be designed and field surveyed by the consultant. The road will be divided into six sections. The drainage in those sections will be separated so that water from each specific section can be individually monitored. The sections will be divided as follows:

Section 1: "control section built according to present regulations and practices; sustained road gradient of 8 percent to 10 percent.

Section 2: sustained grade of 6 percent; check dams 0.3 m (1 foot) high, spaced at 15 m (50 feet), to reduce the hydraulic gradient in the roadside ditch to 4 percent; ditch relief culverts, spaced at 61 m (200 feet); surface to be the same as Section 1; culvert outfall conveyed to toe of fill slope by bituminized fiber sectional downdrains, pipe buried in the fill, and flexible downdrains; inslope roadway surface .06 m/m (3/4 inch per foot).

Section 3: sustained grade of 8 percent to 10 percent; roadside ditch lined with bituminized fiber sectional downdrains; inslope roadway surface .06 m/m (3/4 inch per foot); roadway ditches designed to carry entire flow to natural drainageway.

Section 4: sustained grade of 8 percent to 10 percent; inslope roadway surface .06 m/m (3/4 inch per foot); gravel surfacing 38.10 cm (15 inches) compacted depth.

Section 5: second control established to specifically measure the amount of material that is transported from the fill side of a road which is not monitored in any of the other stations. section of bituminous pipe placed below the toe of the fill to catch the runoff from the fill and convey it to the monitoring station.

Section 6: fill slope of this section treated with a chemical soil stabilizer. section monitored as Section 5 and the results of these sections compared for effectiveness.

It can be seen from the description of the various demonstration sections that the entire road drainage is taken to a natural drainageway in some cases. This is being demonstrated as an alternative to spilling culverts discharge on the fill slope as is commonly done now. The ditches in this case will be adequately sized to carry the increased flow. The drainage at the toe of the fill slopes will be intercepted and channeled to the monitoring station, which is only a means of assuring the measurement of all of the flow and is not intended to be a demonstration parameter. In actual practice the drainage from the fill slope would pass through a filter strip to filter the sediment from the water before it reaches the stream.

On-Line Instrumentation

A monitoring station will be located in the natural drainageway of each section. Each monitoring station will contain a flume constructed in the drainage channel of each section to form a measuring device and wet pool for the on-line instrument electrodes and grab sample withdrawal. Each station will contain an automatic sediment sampler. The instruments will be housed in a commercial steel shed. A six-channel magnetic tape recorder will be used which will record, at predetermined intervals, the following: pH, conductivity, temperature, water level, rainfall, and turbidity. The station will be activated by an automatic rain gauge, as water will be in the ditches only during periods of rainfall. This system will be backed up by strip chart recorders for the information which is transmitted on the magnetic tape. The data will be assimilated, analyzed, and interpreted, and a final report will be prepared.

A detailed description of the erosion control techniques, monitoring station, instruments, and sediment sampler and sample analysis is contained in Section VI.

EFFECTIVENESS OF THE PROJECT

In much of the Appalachian area, accelerated erosion and the resulting sedimentation, caused in the quest of natural resources are threatening the useful lives of reservoirs and the integrity of mountain streams. The project described herein will yield data which will be highly valuable in the determination of the origin of sediment movement into streams draining coal mining haul roads. When the origin of such sediment is determined, pertinent techniques can be introduced into the design, construction, maintenance, and bedding down of haul roads to eliminate or substantially reduce such sediment movement.

The basic value of the project will be its impact on water resources in the coal mining regions of the Appalachian area. Sedimentation from mining operations has seriously degraded regional water quality, has caused increased flooding due to deposition of sediment in stream channels, and has adversely affected Federal reservoir projects. As stated previously, the pollutants entering the streams as a result of haul roads may be as great as those from areas of mining activity itself. Therefore, if pollution from haul roads can be reduced or eliminated, a major step will be taken toward alleviating these problems.

A secondary benefit is the documentation of the effectiveness and cost of haul road erosion control methods. It is difficult to convince coal operators of the need for proper design of haul roads without quantified evidence. It is not uncommon for mine operators to be unable to truck coal off the mines due to the poor condition of the haul roads. This may place the operator in a poor cash flow position. The haul road erosion control methods to be demonstrated will not only reduce sediment loads in receiving streams, but should also increase the number of days per year that coal can be hauled off the mines.

The need for remote sediment sampling is becoming more apparent as stream pollution studies continue. Problems relative to automatic sampling have not been solved satisfactorily, and more research is needed in this area. The operation and effectiveness of the monitoring equipment in this project will be closely documented. A benefit such as this is not only beneficial to this project but extends to similar projects in the future.

SECTION IV

JURISDICTIONAL FRAMEWORK

AUTHORITY

This study has been conducted under the auspices of the Environmental Protection Agency. The agency is subject to the provisions of the Water Quality Improvement Act of 1970, P.L. 91-224. The act includes a subsection titled "Area Acid and Other Mine Water Pollution Control Demonstrations" which became Section 107 of the Federal Water Pollution Control Act, as amended. This section provides for the demonstration of techniques for mine drainage pollution control and directs that the Environmental Protection Agency shall conduct such feasibility studies as necessary in selecting watersheds for the purpose of the demonstration projects. Such feasibility studies are to aid the EPA in selecting not only the mine drainage pollution control method(s) but also the watershed or drainage area for such application. The act requires that EPA give preference to areas which will have the greatest public value and uses.

The Department for Natural Resources and Environmental Protection, Division of Reclamation, is permitted to accept Federal and other funds in accordance with KRS 350.150 and 350.163, which are included in Appendix D to this report.

All sums received through the payment of fees, forfeiture of bonds, and Federal grants are placed in the State Treasury. The Department for Natural Resources and Environmental Protection, Division of Reclamation, receives a general fund appropriation on a bi-annual basis as approved by the Kentucky General Assembly. Funds are expanded for the administration and enforcement of KRS 350 and for the reclamation of improperly reclaimed strip-mined lands. Expenditure of funds is administered by the director of the Division of Reclamation.

Federal funding for this project was provided by way of a grant to the Commonwealth of Kentucky by the Environmental Protection Agency under authority of Section 107 of the Federal Water Pollution Control Act, as amended. The grant offer was made to the Commonwealth of Kentucky's Department for Natural Resources and Environmental Protection, Division of Reclamation. Administration of the study has been the responsibility of the Department for Natural Resources and Environmental Protection, Office of Planning and Research.

The Department for Natural Resources and Environmental Protection was established by KRS 224 enacted by the General Assembly in 1974. The Department has the responsibility of administering functions relating to conservation, maintenance, and preservation of land and water resources and the prevention, abatement, and control of all water, land, and air pollution. The Department is headed by a Secretary who is responsible for the overall direction of the following ten major divisions of the Department:

(1) Solid Waste (KRS 224);

(2) Forestry (KRS 149);

(3) Reclamation (KRS 350);

(4) Conservation (KRS 146);

(5) Water Quality (KRS 224);

(6) Water Resources (KRS 151)

(7) Air Pollution (KRS 224);

(8) Special Programs

(9) Sanitary Engineering (KRS 211)

(10) Plumbing (KRS 211)

The Kentucky General Assembly, under KRS 350, has vested in the Department for Natural Resources and Environmental Protection, Division of Reclamation, the authority to regulate and control mining of coal to minimize or prevent its injurious effects on the people and resources of the Commonwealth. The Division of Reclamation, under the supervision of the Secretary and the Commissioner of Land Resources, has the following authority and powers relative to this project.

(1) To exercise general supervision and administration and enforcement of KRS 350 and all rules, regulations, and orders promulgated thereunder;

(2) To encourage and conduct investigations, research, experiments, and demonstrations and to collect and disseminate information related to strip mining;

(3) To adopt, without hearing, rules and regulations with respect to the filing of reports, the issuance of permits, and other matters of procedure and administration;

(4) To examine and pass upon all plans and specifications submitted by the operator for the method of operation, backfilling, and grading and for the reclamation of the area of land affected by his operation.

EXISTING STANDARDS

No operator in the Commonwealth of Kentucky is allowed to engage in strip mining without having first obtained from the Division of Reclamation a permit designating the area of land affected by the operation. Permit requirements are described under KRS 350.060.

An operator is required by KRS 350.060(4) to submit with his permit application a drainage plan. This plan must indicate the directional flow of water, constructed drainways, natural waterways used for drainage, and the streams or tributaries receiving the discharge. In addition, the operator is required by KRS 350.090 to prepare and carry out a reclamation plan for the area of land affected by his operation. The reclamation plan must provide for the following:

(1) Cover the face of the coal with compacted non-acid-bearing and nontoxic materials to a distance of at least four feet above the seam being strip mined or by a permanent water impoundment;

(2) Bury under adequate fill all toxic materials, roof coal, pyritic coal, or shale determined by the division to be acid-producing, toxic, or creating a fire hazard;

(3) Seal off, as directed by regulations, any breakthrough of acid water creating a hazard;

(4) Impound, drain, or treat all runoff water so as to reduce soil erosion, damage to agricultural lands, and pollution of streams and other waters;

(5) Remove or bury all metal, lumber, or other refuse resulting from the operation;

(6) Revegetate with suitable seed or plant mixtures after approved regrading and soil preparation.

Requirements for the water quality of runoff from surface mining operations are spelled out in two of the Division of Reclamation's regulations, 402 KAR 1:055, "Water Quality," adopted September 29, 1971, and 402 KAR 1:060, "Water Impoundments," adopted November 28, 1972. (See Appendix D for 402 KAR 1:055 and 402 KAR 1:060). 402 KAR 1:055 requires that treatment facilities be constructed by the operator prior to the stripping operation. 402 KAR 1:055 further requires that the treated discharge have: (1) pH of between 6.0 and 9.0, (2) iron concentration not in excess of 7 mg/l, (3) total alkalinity in excess of total acidity, (4) no settleable matter, and (5) suspended matter not in excess of 150 JTU's except during a precipitation event, in which case 1,000 JTU's may not be exceeded.

402 KAR 1:060 requires that a drainage, erosion, and silt control plan for the area to be permitted by prepared by a registered professional engineer and submitted with the permit application. After approval of the drainage plan by the Division of Reclamation, silt dams are to be constructed in the drainage areas to be immediately affected by the operation.

The streams involved in this demonstration are considered public waters of the Commonwealth and are, therefore, subject to the Federally approved Kentucky water quality standards for interstate waters. The water quality of the public streams, within the confines of the Commonwealth, is maintained through the authority vested in the Department for Natural Resources and Environmental Protection, Division of Water Quality, under KRS 224.033. The applicable standards by which said authority is administered are covered by regulation 401 KAR 5:025 adopted March 13, 1975 and by regulation 401 KAR 5:035 adopted March 13, 1975. Since the streams involved in this demonstration are not shown on the map "Streams of Kentucky" prepared in 1973 by the Kentucky Department of Commerce, they must meet the water quality standards set forth in 401 KAR 5:025 only at the point where they join the streams shown on the map.

It has been the policy of the department that in the case of surface coal mining operations, compliance with the provisions of KRS 350, 402 KAR 1:055, and 402 KAR 1:060 would be necessary and sufficient to constitute compliance with 401 KAR 5:025 and 401 KAR 5:035. Surface mine operators are not required to obtain permits from the Division of Water Quality.

In addition to the KRS laws pertaining to water quality in the Commonwealth, 402 KAR 1:025, "Access Road" (regulations) is particularly applicable to this project. This regulation concerns the construction and maintenance requirements of haulageways and bedding-down procedures after abandonment.

Copies of the above referenced standards and regulations are contained in Appendix D to this report.

SITE ACQUISITION

The sites chosen for the demonstration project are located within the Commonwealth of Kentucky. The authority to acquire, restore, and reclaim land, as required for the project, is vested in the Commonwealth of Kentucky in accordance with KRS 350.152, 350,154, and 350.156, relating to surface mining and reclamation.

The Island Creek Coal Company has agreed to make a site for the project available. The project will be conducted under the rights they have to the land and their right to build a haul road to the mining site.

In the normal progress of the demonstration project presented, it is not anticipated that transfer of the property will be required, especially since a formal working agreement for conducting the project has been made among the parties concerned. Acquisition of the property by purchase or under the power of eminent domain would become necessary only if severe health or safety hazards were encountered under the present ownership arrangements or if the operators defaulted on their responsibility to restore all strip-mined land.

WATER AND MINERAL RIGHTS

Property ownership and the associated holding of water and/or mineral rights for areas designated as sites for the demonstration project presented herein are not of major concern. A working agreement, by mutual affirmation, is in effect between the Commonwealth of Kentucky (grantee) and the operators of the active surface mines selected as a site for the demonstration.

No transfer of property and/or rights is anticipated with the performance of the demonstration project. The working agreement entered into with the coal operator provides that the grantee will conduct the project so as not to interfere with the mining operation, and likewise the operator will not interfere with the performance of the project. All streams running through the properties are considered public waters of the Commonwealth and are subject to all applicable Federal and Kentucky water quality standards. The operators of the mines are subject to all existing standards concerning water quality and regulations for reclamation which apply to the workings and adjacent property covered by the boundaries stipulated in the property title, lease, permit, etc.

No water rights are required for performance of the project, since the water courses would be maintained during the project. This is in keeping with Commonwealth of Kentucky water rights laws, since surface water flowing in a stream of definite channel is not subject to ownership, in accordance with 1954 legislation (KRS 262.670 and 262.690), which states in part (KRS 262.690-2):

> The owner of land contiguous to public water shall have the right to such reasonable use of this water for other than domestic purposes as will not deny the use of such water to other owners for domestic purposes, or impair existing uses of other owners heretofore established, or unreasonably interfere with a beneficial use by other owners."

PREVENTION OF FUTURE POLLUTION

The Department for Natural Resources and Environmental Protection, Division of Reclamation, has the authority to regulate and control the quality of drainage water emanating from strip mining operations in the Commonwealth.

The existing standards and regulations which have been established to protect the people and resources of the Commonwealth from the injurious effects of untreated and uncontrolled strip mine operations are vested in this agency under KRS 350.

In addition to this regulation, the Department for Natural Resources and Environmental Protection, Division of Water Quality, is charged with safeguarding the uncontaminated waters of the Commonwealth, preventing the creation of new pollution in the waters of the Commonwealth, and abating existing pollution.

The laws and regulations of the Commonwealth, in conjunction with the authority to assure compliance of these laws and regulations, as described above, assure the Federal government that the area will not be affected adversely by the influx of acid or other mine water pollution from nearby sources.

SECTION V

INVENTORY AND CHARACTERIZATION

PHYSICAL CONDITIONS

Climate

The humid continental warm summer climate of eastern Kentucky is characterized by abundant precipitation, moderately high summer temperatures, and moderately cold winter temperatures. The average annual precipitation is 114 cm (45 inches) (average since 1965). There is no definite dry season. The summer months of June, July, and August have the highest amount of precipitation generally in the form of intense rainfalls of relatively short duration.

The rainfall intensities for 5-, 10-, and 25-year frequencies are 6.96 cm (2.74 inches), 8.10 cm (3.19 inches), and 9.53 cm (3.75 inches), respectively, for a storm of 6-hour duration.

The average summer temperatures for eastern Kentucky are 70°F to 76°F, with the winter temperatures averaging from 33°F to 35°F. These temperatures allow for a frost-free period or growing season of 150 to 180 days.

Geology

Most of eastern Kentucky is underlain by the Breathitt formation of the Pennsylvanian period. This formation consists of medium- to fine-grained sandstones, siltstones, clay shales, and beds of coal. The sandstones are massive and cliff forming and will generally be found as the ridge formers in the area. The highest hills in the region show the Breathitt formation to have a thickness of at least 167 m (550 feet).

Natural Resources

Natural resources being extracted in eastern Kentucky are coal, oil natural gas, clay, and, to a lesser extent, sand, gravel, shale sandstone, and limestone.

In eastern Kentucky, coal is the most valuable natural resource. The exploitation of the resource is the greatest factor in the economic development of the area.

The eastern Kentucky coal field is part of the Appalachian coal field and encompasses all or parts of 37 counties, totaling about 10,400 square miles. Within the six reserve districts, as defined by the U.S. Geological Survey, there is an average of 19 coal beds each for which reserves have been calculated. The major seams are the Lower Elkhorn, Upper Elkhorn 1-2-3, Fire Clay, Hazard 5a(6)-7, Hignite, Hindman, Lily, Princess 5-7, and Sterns 2. The coals have been ranked as high volatile B to high volatile A bituminous. These are high in volatile matter, low in sulphur (less than 3 percent) and ash (less than 10 percent), and relatively high in heating volume. These coals are excellent industrial coals, but their ranking also classes them for the manufacture of metallurgical coke. [11]

The major industry of eastern Kentucky is the coal mining industry, which employs over 22,000 men. There are four types of coal mines active in the area. These are underground mines, strip mines, auger mines, and auger-strip mines. The last three are considered surface mines. Of the 1,371 active mines in 1970, 68 percent were underground mines, 7 percent were strip mines, 3 percent were auger mines, and 21 percent were a combination of strip and auger mines. Over 72 million tons of coal were extracted from eastern Kentucky in 1970, of which 60 percent was from underground mines and the remainder extracted by the surface mines. [11]

In 1970, 243 oil and natural gas drilling permits were issued for areas within eastern Kentucky. [11] This is 24 percent of the total for the state. Oil production amounted to 3,250,000 barrels, or 28 percent of the total production for Kentucky. Much of this oil came from Lee County.

Clay mining is found primarily on the western boundary of the eastern coal fields. The 28 active mines in 1970 produced 45 percent of the Kentucky total, or 256,000 tons. [11]

Topography And Drainage

The eastern Kentucky region is maturely dissected; thus a minimum of flat upland and bottom land is present. Hilltop elevations over the proposed project site range from 1,000 feet to 3,800 feet. Local relief varies from about 500 feet to over 2,000 feet.

The region is drained by the Big Sandy, Licking, Kentucky, and Cumberland Rivers. The Big Sandy River in its lower part is the only navigable river within the area. The stream valleys themselves are of major importance, since they supply access for railroads into the coal fields.

Soils

Soils on the uplands are predominantly steep, sandy, and stony. Soils on higher elevations in the valleys usually have better drainage and are more suitable for development. Soils in the valleys consist of alluvium developed from the sandstones, siltstones, and shales as well as colluvium and landslide debris along sides of stream valleys. Low areas in bottoms or low terraces have severe flood hazards. The lower areas on stream terraces often have wetness hazards from seasonal high water tables or slow internal drainage. All of the soils are naturally acid. Particle size ranges from sand to clay, with a considerable amount of coarse fragments in the alluvial deposits. This difference in particle size distribution accounts largely for the difference in physical properties and has a direct bearing on engineering uses.

Soils that have developed from sandstones are sandy and often have stones or boulders on the surface. Sandy soils have a low shrink-swell potential and high bearing values and are more stable in embankments. Shale-originated soils sometimes have a high clay content, are plastic and sticky when wet, and have a moderate to high shrink-swell potential.

The soils that have developed from sandstone and siltstone are loams and silt loams and have a low to moderate shrink-swell potential. Silty soils have fair to poor stability and low bearing values. The alluvium-derived soils are variable, consisting of sandy, silty, and clayey contents, and have a low to moderate shrink-swell potential.

Vegetation

In 1963, 80 percent of the total area of eastern Kentucky was in forest land. The climax (original) vegetation of this region is mixed deciduous forests. The major types of trees are mixed oak (chestnut, red, black, scarred), mixed hickory, and yellow and tulip poplar. These trees are generally tolerant but do grow better in moist, well drained soils.

Of the total forested area, one-half consists of stands of saw timber, while the remaining one-half is equally divided into stands of pole timber and stands consisting predominantly of saplings and seedlings. [6]

WATER RESOURCES

The three main drainage basins in eastern Kentucky are the Big Sandy River Basin, the Cumberland River Basin, and the Kentucky River Basin.

Within the Big Sandy River Basin, approximately 800 km (500 miles) of streams are polluted by coal mine drainage and activities related to coal mining. There are more than 2,800 active mines within the basin. Levisa Fork is mainly affected in its headwater area, with intermittent mine drainage pollution in the Beaver, Middle, Toms, and Greasy tributaries to Levisa Fork. The streams in the Big Sandy River Basin that are polluted by mine drainage have high mineral contents but low acid concentrations.

At least 510 miles of streams within the Cumberland River Basin are polluted by mine drainage. The basin has approximately 29,000 acres of unreclaimed surface-mined land. These streams are acidic, with a minimum of 18,000 kg (200 tons) per day of sulfate originating in mine drainage being carried by the Cumberland River. Three tributaries of the Cumberland which are severely polluted are Cranks Creek, Left Fork Straight Creek, and Raccoon Creek in Harlan, Bell, and Laurel Counties, respectively.

Four portions of the Kentucky River Basin have mine drainage pollution which coincides with the mining activity in the areas. These four areas are the headwaters of the North Fork of the Kentucky River in Letcher County, the Carrs Fork-Lotts Creek and Troublesome Creek areas in Leslie County, and the South Fork Kentucky River area in Clay County. In many areas, refuse piles are located on the stream banks which allow drainage and silt to enter directly into the streams. The most severe pollution in the basin occurs during periods of high runoff, when large slugs of pollution enter into the streams. The severity of the mine drainage pollution in the Kentucky River Basin lessens rapidly with the entrance into the main stream of slightly polluted or unpolluted tributaries further downstream.

SOCIAL AND ECONOMIC ENVIRONMENT

The demonstration is located in Martin County in the easternmost portion of Kentucky. Martin County adjoins Pike, Floyd, Johnson, and Lawrence Counties, Kentucky, and Wayne and Mingo Counties, West Virginia. These counties are located in the central Appalachian region.

Countless books, magazine articles, newspaper articles, and government reports have documented the social and economic conditions existing in this region. Only a few relevant statistics need to be listed here:

		Martin County (19)	Kentucky (19)
(1)	Population		
	1970	9,377	3,219,000
	1960	10,201	3,038,000
	Percentage change	-8.1%	+6.0%
(2)	1968 birth rate per 1,000	17.7	17.7
(3)	Net migration, 1960-1970	-2,327	
(4)	1970 estimated rate of unemployment	10%	4.6%
(5)	1970 per capita income	$1,128	$2,425
(6)	1970, families below poverty level	53.4%	19.3%
(7)	1970 adult population with less than 12 years of school	86.2%	61.4%
(8)	1970, median years of school completed by adult population	7.9	9.9

As can be seen from the data above, Martin County has experienced a relatively high rate of unemployment and low per capita income, accompanied by steady declining population due to net migration. Education levels in Martin County does not indicate the presence of a skilled work force necessary for the attraction of new industry.

In 1970, mining accounted 17.7 percent of employment in Martin County. During the period from 1970 to 1973, it is estimated that the population of Martin County grew 11.2 percent. It has been suggested that this turnaround in the general population trend for this county was caused by the "coal boom" which started at the close of 1969 and is continuing. These two statistics are indicative of the impact of the coal industry on this county.

SECTION VI

PRELIMINARY ENGINEERING

ABATEMENT METHOD DESCRIPTION

Erosion Origin

Erosion can be defined as the process by which the land surface is worn away. An understanding of the processes of erosion is necessary in order to develop mechanical and vegetative measures of control. The agents of erosion are water, wind, ice, and gravity. Sediment is the by-product of erosion and is usually referred to as the eroded material which is transported and deposited by one of the abovementioned erosive agents. Natural erosion and sediment deposition have been occurring through geologic time and account partly for the topographic features of the land.

Water erosion occurs in two general forms: sheet erosion and channel erosion. In either case, the amount of sediment that water can carry is a function of its velocity. Water with a high velocity is capable of detaching and tranporting more material, hence has a higher erodibility factor than water moving at a slower velocity. Most of the theory of sediment movement control is directly related to methods of reducing the velocity of water, be it in small riverlets or major channels. Sheet erosion is the result of detachment of soil particles, by raindrop impact, and the subsequent removal by runoff. Channel erosion is the removal and transport of material by the concentrated flow in stream channels.

Since this project is located in southern Appalachia, wind and ice erosion are insignificant.

Gravity erosion occurs when the weight of the material exceeds the internal resistive forces of friction and the shearing strength of the material. The presence of water sometimes reduces the shearing strength of soil and is the primary contributing factor to certain forms of gravity erosion, such as landslides and mudslides. These natural resources are necessary for environmental balance, but this balance is upset when the natural features of the land are altered and the normal rate of erosion is accelerated.

From the standpoint of stream pollution, water is the most severe agent of erosion.

The types of accelerated erosion which are encountered in this project are stream channel and sheet or overland erosion. Stream channel erosion is not considered in the normal context in that the channel is a constructed roadside ditch rather than an altered natural channel; nevertheless, the effect and control measures are the same.

Accelerated sheet or overland erosion is the result of denuding the land surface, removing the natural protection from raindrop impact, allowing the soil particles to break down more readily, making them more susceptible to movement by the ensuing runoff. Also, the retardance to sheet flow is reduced, thereby allowing the flowing water's erosive energy to increase.

Factors which influence the severity of overland erosion are rainfall intensity, the inherent erodibility of the soil, slope length and steepness, and ground cover. Although soil type is a major factor of erosion, vegetative cover (or lack of it) and slope are the factors which will need to be dealt with in this project. The coal haul roads are usually built along the contour of forested mountainsides. Erosion is rarely a problem in undisturbed forest lands. The forest provides a canopy, and the forest litter provides a shield against impact. Forest soil is usually permeable, allowing water to percolate rapidly. When a road is constructed along the mountainside, a large area is made vulnerable to the erosive force of rainfall and runoff. Continued use of the road maintains the disturbance of the all-important forest litter. It is toward the control of erosion on coal haul roads that the effort of this project will be directed.

Erosion Control

Methods of erosion control have been known and used successfully for many years. During the preliminary phase of this project, an exhaustive literature search was conducted relative to the state-of-the-art of erosion and sedimentation control. Individuals and organizations known to possess expertise, experience, and concern in the field of erosion control on secondary and mountain roads were consulted. Among the primary contacts was the U.S. Forest Service at Winchester, Kentucky, which provided information from their field design manual relative to forest roads, and the U.S. Forest Service Experiment Station in Berea, Kentucky, which provided the information in their files relative to forest and haul road design.

A tremendous amount of research has been accomplished relative to the prevention of pollution during all types of construction activities through erosion and sediment control techniques. Stream pollution from the specific activities of mining and mine drainage has also been studied extensively; however, the environmental affect of the coal haulageways has not been the focus of much concern. Past studies of erosion and sedimentation control have been directed primarily toward large long-term construction projects, such as transportation systems, urban housing, land development, etc. These types of projects are usually in and around built-up areas.

The U.S. Forest Service has been building forest roads for many years and in 1970 published a research paper entitled "Erosion Control on Logging Roads in the Appalachians" [12], which was prepared for the purpose of compiling the present state of knowledge on preventing and controlling erosion on logging roads in the Appalachians. In 1965, a booklet entitled "Designing Coal Haul Roads for Good Drainage" [17] was published by the U.S. Forest Service which presents drainage control techniques which are certainly not new but are seldom practiced by the average coal mine operator. In many cases, design factors applicable to forest roads and haul roads are the same. In other cases, they are different, due primarily to the fact that the traffic volume and weight of vehicles using coal haul roads is vastly greater than those using forest service roads.

While economics is certainly a consideration, sophisticated techniques of erosion control are usually within the economic framework of the overall project benefits. In fact, some drainage control techniques can provide esthetic benefits which can be integrated into the final landscaping. Information relative to the current state-of-the-art of erosion control techniques and products has been compiled in several publications [5, 13, 14]. Most of the physical means of erosion control are simply methods of controlling water depth and velocities which have been used for years. New products are continually being developed which can be used to implement specific methods. This is especially true in the case of controlling sheet erosion on denuded slopes. There are many varieties of nettings, blankets, and soil stabilizers available, some of which have been proven, while some still require additional field demonstration to prove their effectiveness over a range of conditions.

Limitations

Sedimentation can be defined as the deposition of the sediment produced by erosion. Sediment pollution is the result of eroded material transported in suspension and bedload in the stream network. A sedimentation abatement plan consists of two parts: erosion control and sediment control.

Regardless of the extent of the erosion control techniques used, the total prevention of erosion is not usually possible. Sediment control, then, is the control of unpreventable erosion. Relating to steep, unpaved mountain roads, the use of many erosion control methods is precluded by the steepness of slopes and road gradients. To maximize the sedimentation abatement plan, methods of sediment control must be used integrally with the erosion control plan; therefore, the initial control of erosion at its point sources is a primary factor in an effective sedimentation abatement plan. Much of the sediment which now moves from coal mine haul roads to nearby waterways can be prevented through the implementation of proper erosion control techniques. Recognizing that a certain amount of erosion can be expected with the best plan and that there are methods to retard sediment from reaching the stream, namely, filter berms, filter strips, filter inlets, sedimentation basins, etc., however, the primary purpose of this demonstration is to determine the most practical methods of minimizing the erosion, hence material movement from coal mine haul roads and to measure the effectiveness of the control techniques.

Erosion Control Concepts

There are four distinct areas on the haul roads from which the movement of material can occur. These are the roadway surface, the cut slope, the roadway ditch, and the fill slope. Erosion from the cut and fill slope surfaces results from water reaching those surfaces either through direct rainfall and runoff from above the surfaces or both. Water upon reaching the slope surfaces, attains a high velocity, quickly resulting in high erosive characteristics. All other things being constant, erosion potential can be expected to be directly proportional to the degree of slope.

Water that falls on the roadway surface flows laterally or obliquely from it under the influence of cross slope and road gradient. Erosion of an unpaved roadway occurs when the water reaches erosive depths and velocities. Many times ruts are formed, which concentrates the flow, increasing the velocity and hence the erosive energy.

The roadside ditch is used to collect runoff from the road and channel it into a natural drainageway. Like the roadway surface, erosion or scour in the ditch occurs when velocities exceed the erosion resistance of the soil.

There are guaranteed methods by which all sediment movement could be stopped from each of these points of origin. For example, if the surface of the roadway or the ditches were paved, then no sediment would originate from those points. Furthermore, if the cut slope or the fill slope had a heavy stand of grass cover, most or all of the erosion from them would be eliminated. These methods of erosion control are well known, and demonstration of them is not necessary. In addition, elaborate measures such as paving are very costly, and economic justification depends on such factors as length of time the road will be used and the amount of coal to be hauled over it; it is highly unlikely that such measures would be accepted as common practice by the average coal operator.

The primary function of this project is to demonstrate haul road construction techniques that are practical for the coal industry, can be built by the coal operator, and have a definite advantage over methods currently used in the coal industry with regard to erosion control.

The erosion control techniques proposed herein are, for the most part, straightforward and in keeping with general methods of road design practice. It is important to show, by on-line monitoring techniques, exactly what the effect of each technique is in order that its net value can be determined in relation to its cost. A haul road design manual can then be based on measured observations. Most present-day haul roads are seldom "designed." For the most part, they are hastily constructed dirt roads (muddy ruts during rainy periods) up the side of a mountain, with little or no consideration for the effects on the surrounding environment. If these roads were built in accordance with existing standards, the sediment movement from them would be much less than it is now. Erosion control is simply the result of effective water velocity control. Present regulations do not, however, cover all elements that are to be demonstrated herein.

The four sources of roadway erosion will now be examined and methods for the control of erosion evaluated.

PRELIMINARY DESIGN

The Roadway Surface

Control of erosion on the roadway surface is extremely difficult because of the punishment that must be sustained from the heavy vehicles. Any erosion control techniques must, therefore, take this factor into account.

Paving -
The only total prevention of runoff from the road surfacing is pavement. It is apparent, from observation of the damage to local roads in eastern Kentucky by coal trucks, that an ordinary pavement will not suffice. The costs of a pavement which will support loaded coal trucks over a reasonable period of time will be extremely high. The consideration of anything less would be a waste of time and money.

Gradient -
One of the primary and obvious factors affecting erosion control is road gradient. Present regulations in Kentucky allow sustained haul road grades of 10 percent and short intervals of higher grades. A minimum grade of about 3 percent is desirable to provide adequate drainage; however, it is difficult to adequately and economically control water velocities on roads with a sustained grade of 10 percent. According to U.S. Forest Service engineers, a sustained grade of 8 percent should be maximum. Grade reduction not only facilitates the control of water velocities; it provides economic benefits to the operation in that more haul trips per day can be made over gentler grades, with less wear on the vehicles.

Gravel Surface Of Road -
Dumped crushed rock or gravel is one of the most widely used techniques for maintaining the surface of nonpaved roads. A gravel road properly constructed and maintained would minimize erosion from the surface. The gravel must be adequate to withstand the loads of the trucks without being reduced to a fine powder. Such gravel is not always available near the mining site.

Inslope Of The Road Surface -
One of the best methods of draining the roadway surface is to crown the surface or slope it both ways from the center line. Due to the Federal mining safety law requiring a safety berm on the fill side of the road, crowning the road is not advisable, as a small channel develops at the junction of the road surface and the berm, which causes erosion in both places. These berms are generally loose soil and small rocks, about two feet high. Observation of these berms indicates that, for safety purposes, they are of limited value, as generally constructed, and that they contribute considerably to the sediment movement during heavy rains. Also, if the road is sloped toward the berm, a channel forms along the toe of the berm, concentrating the flow of water, which ultimately forms a rut. It is important, therefore, to keep water as far as possible from these berms and also to keep water from reaching the loose material on the fill side of the road. This can best be done by constructing the road with a constant slope to the ditch on the cut side (inslope), where the

water can be controlled. A slope toward the ditch of at least 0.06 m/m (3/4 inch per foot) of surface width along the length of the entire road should be maintained. This slope is sufficient to direct water to the ditch, but not generate damaging velocities. This does create, in some curves, a reverse superelevation, but at the speeds normally attained on coal mine haul roads, this is not considered a detrimental safety factor.

Open-top Culverts -
These culverts are constructed across the road surface at specific intervals in relation to the road gradient. The culverts intercept the water flowing over the road surface before erosive velocities are attained and channel it to a stabilized area.

The Roadside Ditch

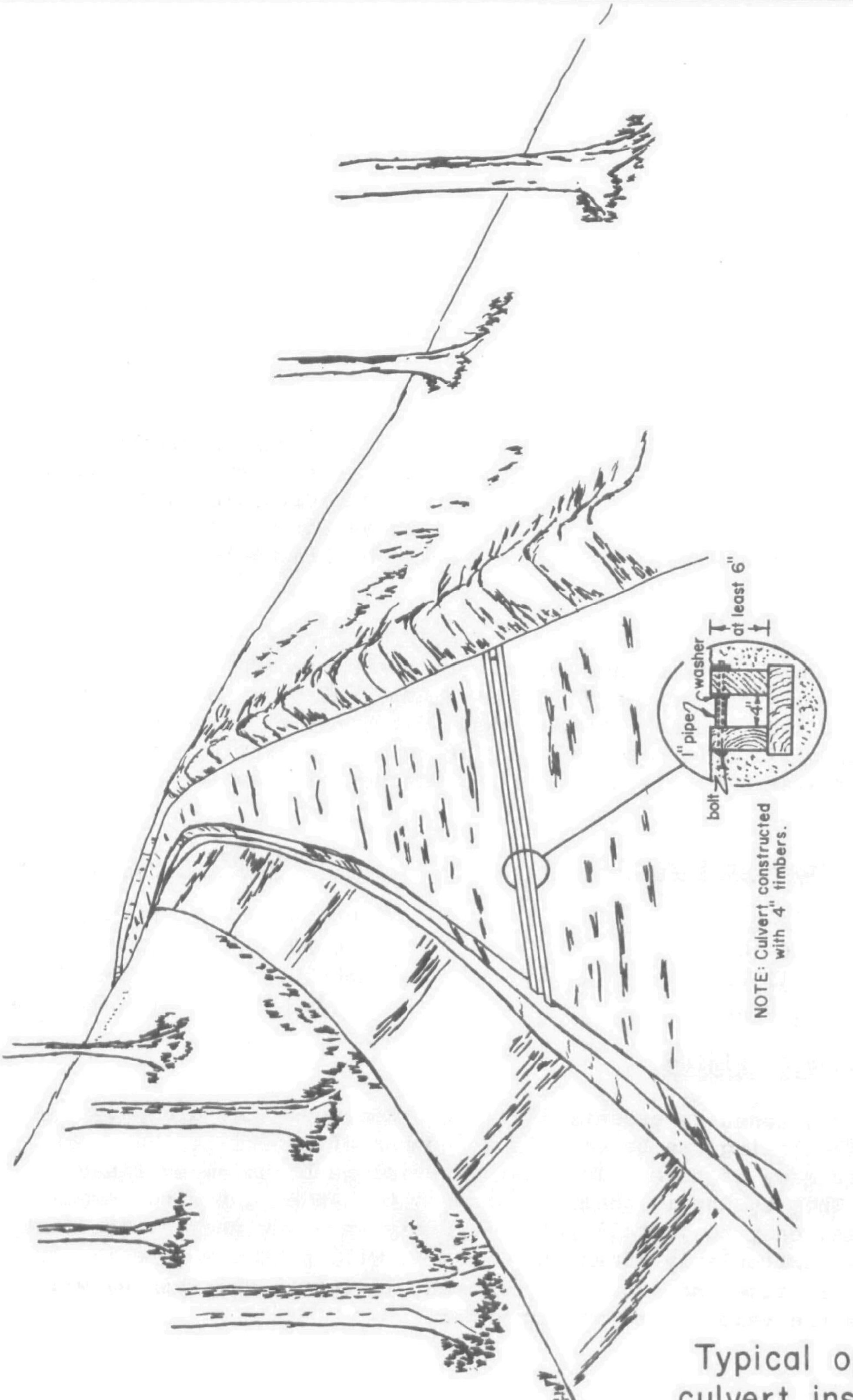
A general "rule of thumb" is that erosion will occur in ditches where slope exceeds 4 percent. On steeper slopes, the water velocities must be physically controlled or some type of vegetative lining applied where possible. When vegetation cannot be sustained or slopes are 10 percent or greater, some type of paving or lining is necessary.

Ditch Relief Culverts -
The state regulations require ditch relief culverts at specified intervals, which are intended to divert the water from under the road before the flow can gain sufficient volume, velocity, or depth to erode the ditch. In many cases, these ditch relief culverts, when installed, spill onto the road fill rather than carrying the flow to a stabilized area. The regulations for Kentucky are as follows: (402 KAR 1:025)

Road Grade In Percent	Spacing Of Culverts In Meters	
2-5	90-150	(300-500 feet)
6-10	60-90	(200-300 feet)
11-15	30-60	(100-200 feet)
16-20	30	(100 feet)

Ditch Paving Or Lining

Erosion of ditches is essentially eliminated when they are paved or lined. The lining can be of a large number of materials, but cost eliminates many of them. The best material is bituminized fiber tubing. This tubing is cheap, lightweight, can be cut with normal hand tools, easy to install and will decay in a few years. The decay factor is particularly advantageous as it will permit vegetation to take over in time and create a permanent lining to the channel which will slow the velocity of moving water.

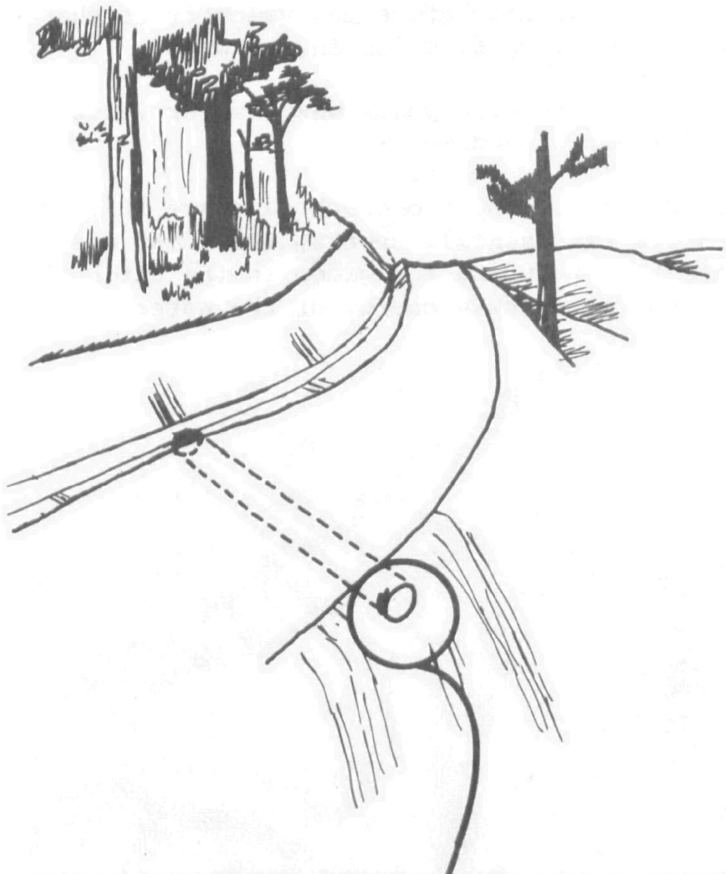


Typical open top
culvert installation
Figure 1

Check Dams -
When channel scour is indicated, means for reducing water velocities to a safe level are necessary. It is possible to reduce the hydraulic gradient in the ditch, hence the velocity in the ditch, by introducing baffles, checks, or drops in the channel. Since velocity varies as one-half the power of the slope in Manning's channel flow equation, a large slope change is required before the velocity is changed appreciably. Check dams in the ditch function in two ways:

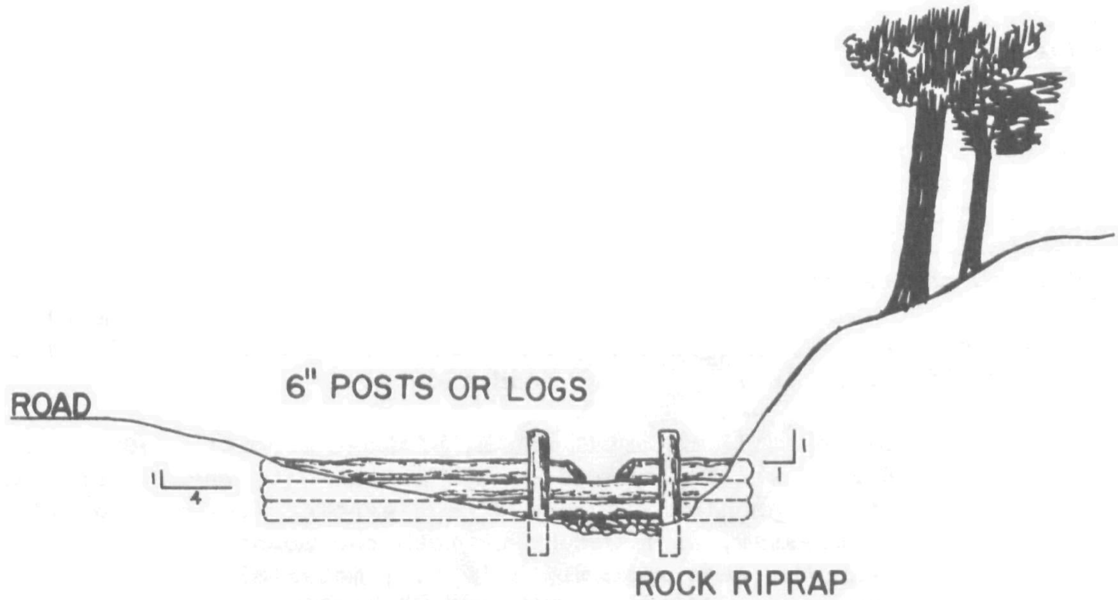
(1) They create small retention ponds where water velocities are reduced, hence a fallout of sediment;

(2) When the ponds created by the check dams are full of sediment, which may take only a few rainfall events, they form a series of steps, which has the effect of reducing the grade in the ditch, hence the water velocities and the erosive energy of the water.



NOTE: CULVERT OUTFLOW CONDUIT TO
TOE OF SLOPE NOT SHOWN

Typical ditch relief
culvert installation
Figure 2



NOTE: SIDES AND BOTTOM OF DAM EXTEND SIX INCHES INTO DITCH LINE

Typical check dam installation
Figure 3

Grade Reduction -
Since the roadside ditch is usually on the same grade as the roadway, a significant reduction in road gradient would facilitate drainage control in the ditch.

The Fill Slope

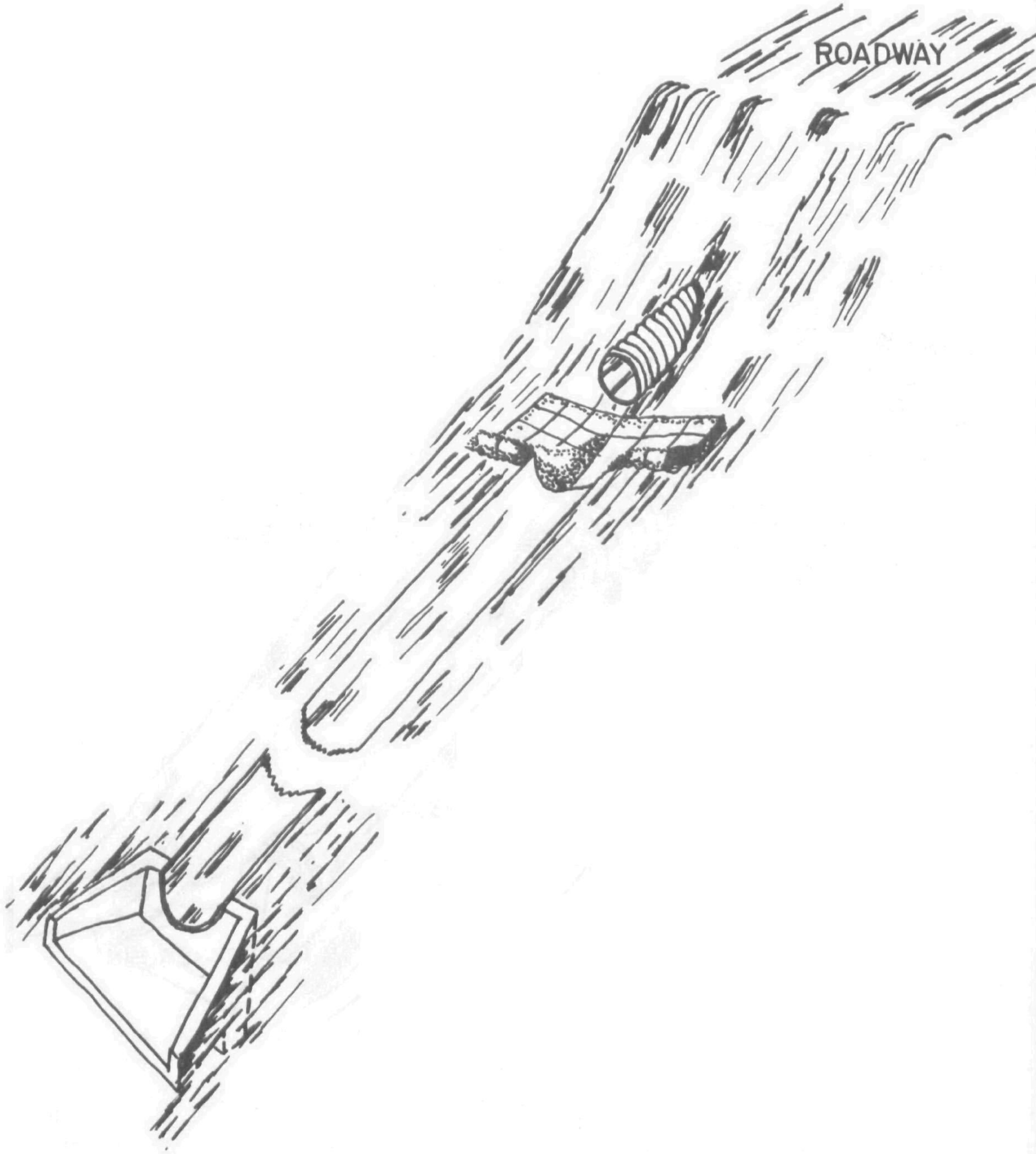
The method of construction presently practiced, for obvious reasons, is to spill material, cut from the hillside, down the slope, building up part of the roadway in fill and dumping the excess material over the side. This material is easily eroded and washed away during heavy rainfall. One of the most effective ways to control erosion is to disturb the natural surroundings as little as possible. If the entire road was cut from the hillside and the material hauled to some other location, i.e., in an area being reclaimed, the downslope side of the road would remain in its natural condition.

The removal of the fill material would, without a doubt, reduce the amount of sediment which ultimately reaches the waterways. There are drawbacks to this technique, however: the exposed face of the cut slope would be greater, as a wider cut into the mountainside must be made to maintain the same road width if fill material is not used as part of the road. In addition, the cost of hauling the material away would be very high, and a suitable place must be found to dispose of it. It is important that fill material be kept as far as possible from natural drainage channels. Any material that is pushed into a natural drainage channel will surely end up in a stream at the first heavy rain if the drainage is not properly controlled.

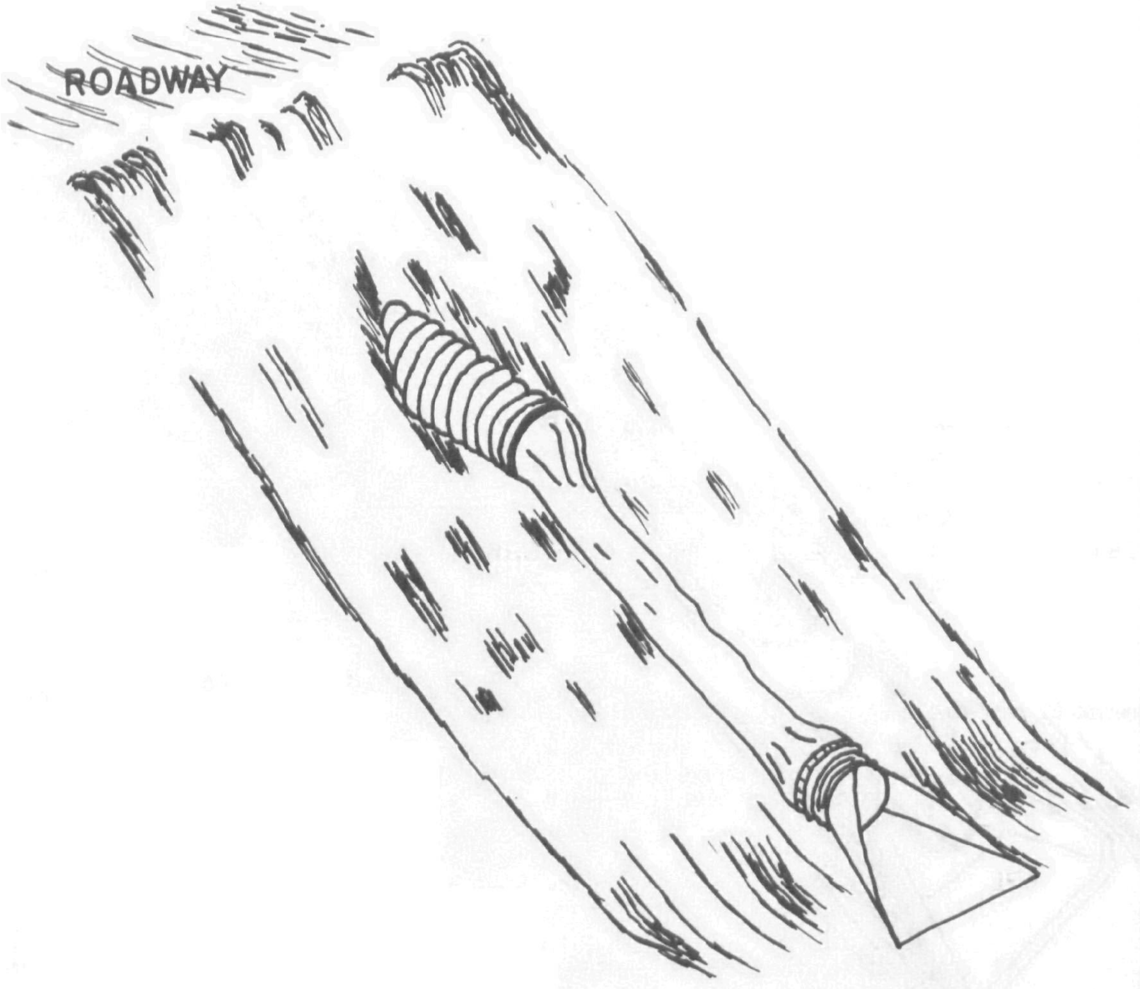
Transport Culvert Outflow To Toe Of Slope -
The use of section and flexible slope drains can be utilized to channel culvert outflows to stabilized areas at the toe of the fill slope; however, freezing weather presents some maintenance problems for flexible downdrains. Culvert pipe buried in the fill slope would probably require the least maintenance.

The Cut Slope

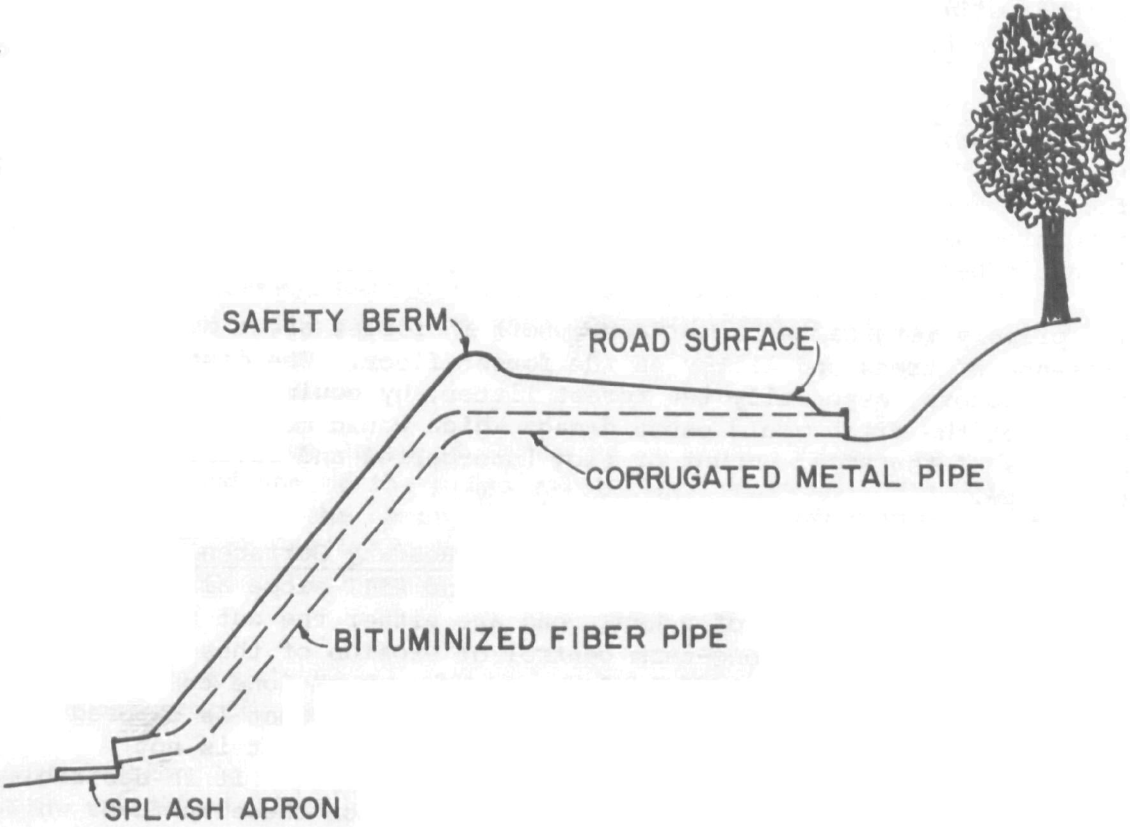
According to KRS 350.090-10, the maximum allowable cut slope in Kentucky is 1:1 in all soils. Vegetation supportability is greatly dependent on steepness of slope. A general rule for the maximum slope capable of supporting vegetation is 2:1. However, decreasing the cut slope substantially increases the slope length, which, all other factors being equal, will collect more runoff. Also, the longer slope will expose considerably more erodible surface.



Typical section slope
drain installation
Figure 4



Typical flexible slope
drain installation
Figure 5



Typical installation of pipe
buried in fill slope
Figure 6

The type of soil observed in most haul road cuts is a composition of weathered shale and sandstone. Shale can weather to extremely small particles as well as larger ones, and particles are continually breaking loose and falling into the roadside ditch. These particles readily find their way into the natural waterways during periods of intense rainfall. Water which reaches the side hill cut and fill face, either from the hill above or from water falling directly on it, attains a high velocity very quickly. This velocity, hence its erosion characteristics, can be reduced by reducing this slope. The slope of the cut face is generally limited by the slope of the mountain. The use of a slope of 2:1 or flatter will not be possible, because most of the hillside slopes in the Appalachian area are already steeper than 2:1.

Diversion Ditch Above Cut -
Field observation has shown that water flowing from a mountainside to the face of the road cut will, to some extent, cause erosion on the cut face. This could be largely prevented by the construction of a diversion ditch above the cut to divert this water to controlled channels before it reaches the exposed face of the cut.

The primary retardants of surface runoff in forest areas are the presence of trees and litter on the forest floor. The disturbance of these factors, especially the forest litter, by equipment necessary to construct the ditch would cause damage which would more than offset the benefits of the small amount of flow intercepted and diverted from the cut slope.

Treatment of Exposed Surfaces (Other Than Roadway Surfaces) -
The subsequent discussion applies to cut and fill slope alike. Most of the exposed surfaces of a haul road are either the cut face or the fill slope. The only long-term control of erosion of these surfaces is revegetation. A great deal of research has been done to find suitable methods of rapid revegetation of the soil that is exposed in the coal mining operations of the Appalachian area. It is not necessary to duplicate that research in this project. It is desirable, however, to find methods of controlling erosion of these surfaces while vegetation is being established.

Most of these fill slope surfaces contain a large portion of rocks and small stones; however, good vegetative growth has been observed on some fill slopes. Some of the methods available for controlling erosion while vegetation is being established are mulching, mulch blankets, jute nettings, plastic nettings, and chemical soil binders. The nettings and blankets are excessively expensive, and observation has shown that on steep slopes they do not readily remain in place. Most of these methods are used on wide-grassed drainageways and swales with gentle slopes. One of the most economical methods is the use of chemical soil stabilizers. This material can be sprayed on the cut and fill slopes together with a seed material and nutrient. The stabilizer will form a protective layer over the soil which should hold the soil until the vegetation can become established.

DEMONSTRATION PROPOSAL

General

From the sediment control concepts listed above, certain ones have been selected that are judged to have particular application to the coal mine haul roads of eastern Kentucky. Some of the ones so selected are part of the prevailing regulations of haul road construction in Kentucky and/or other states, but their value has never been specifically demonstrated by actual field measurements, as proposed in this project. Other concepts which are proposed herein are not part of any current regulations but are judged to be of sufficient validity for demonstration purposes. In setting up the demonstration techniques in the field, it is important to know what is being measured and how each erosion control method compares in effectiveness with other methods and with the practices currently employed by the coal operators.

New Haul Road Site

The new road will be designed according to good engineering practices, keeping in mind one of the principal factors of erosion control, namely, minimizing the area disturbed. The roadway surface on all sections will be insloped at the rate of 0.06 m/m (3/4 inch per foot). The demonstration parameters will be incorporated into the construction as follows:

(1) Section 1: "control section" built according to present regulations and practices; sustained road gradient of 8-10 percent.

(2) Section 2: sustained grade of 6 percent; check dams one foot high, spaced at 15.24 m (50 feet), to reduce the hydraulic gradient in the roadside ditch to 4 percent; ditch relief culverts, spaced at 6 m (200 feet); surface to be the same as Section 1; culvert outfall conveyed to toe or fill slope by bitumized fiber sectional downdrains, pipe buried in the fill, and flexible downdrains; inslope roadway surface 0.0. m/m (3/4 inch per foot).

(3) Section 3: sustained grade of 8-10 percent; roadside ditch lined with bituminized fiber sectional downdrains; inslope roadway surface 0.06 m/m (3/4 inch per foot); ditches designed to carry entire flow to natural drainageway.

(4) Section 4: sustained grade of 8-10 percent; inslope roadway surface 0.06 m/m (3/4 inch per foot); gravel surfacing 38 cm (15 inches) compacted depth.

(5) Section 5: second control section to measure material moved from an untreated fill.

(6) Section 6: fill slope treated with a chemical stabilizer and the results monitored.

According to the description of the various demonstration sections, it is obvious that in some cases the entire road drainage is taken to a natural drainageway. This is being demonstrated as an alternative to spilling culverts on the fill slope. The ditches in this case will have to be adequately sized to carry the increased flow. The drainage at the toe of the fill slopes will be intercepted and channeled to the monitoring station, which is only a means of assuring the measurement of all of the flow and is not intended to be a demonstration parameter. Actually, the drainage from the fill slope would be prevented from reaching the stream by a filter strip.

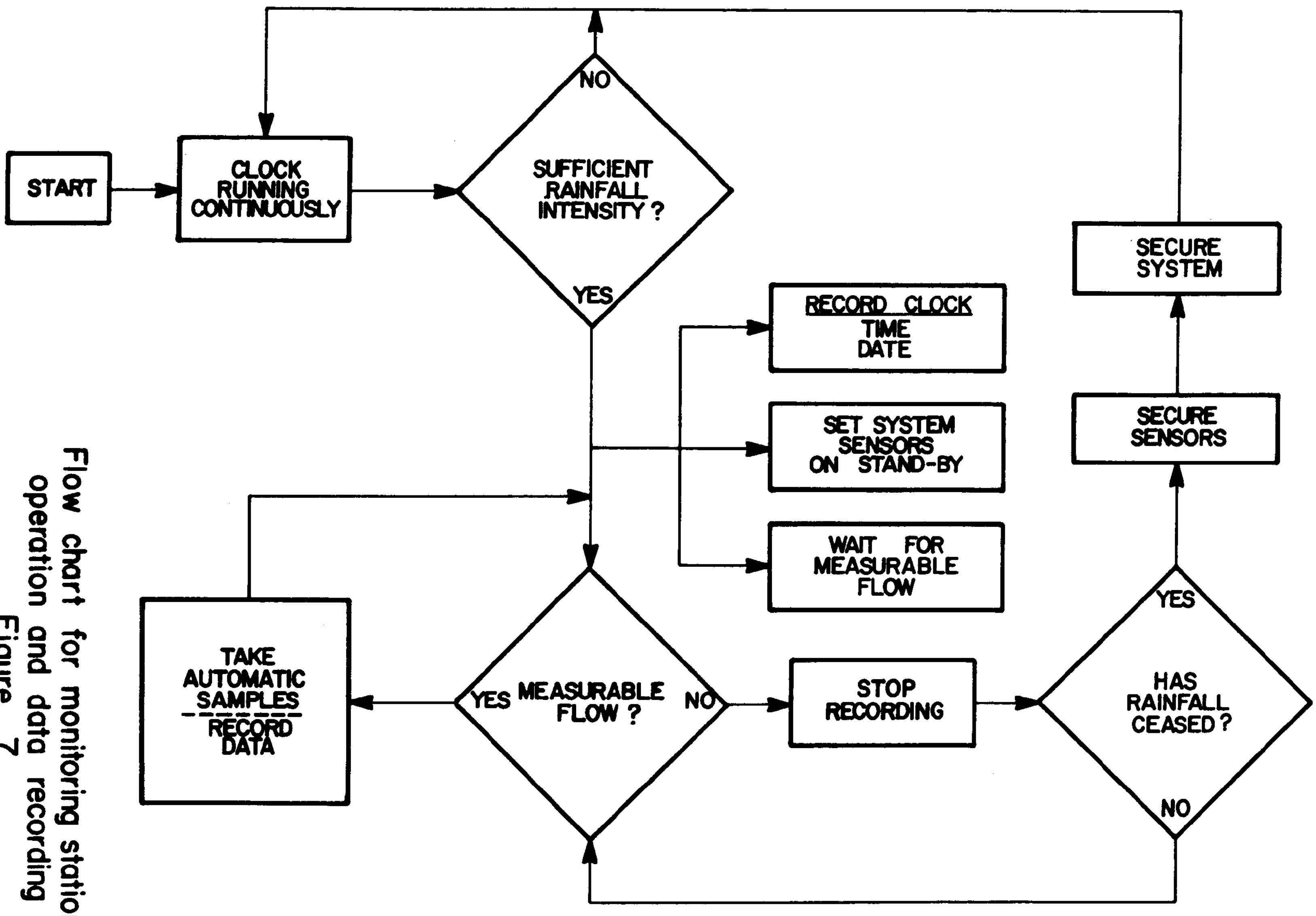
One problem that may be encountered concerning the site for the new haul road is that there will be mining activities above the haul road. It will be necessary to contain the drainage from the mining activities as it is passed through this demonstration project in order to monitor only the material movement relating to the haul road. This will be accomplished by intercepting the drainage and piping it past the monitoring station into the main drainageway.

Surveillance Facilities

The haul road under investigation will be divided into test sections of various length divided by drainage channels. The parameters to be recorded on-line will be monitored by two primary stations and four secondary stations. The primary and secondary stations are similar except that each primary station will activate two secondary stations and will contain a rainfall gauge, a temperature recorder, a pH analyzer and a conductivity analyzer.

The primary stations will contain the following operating instruments:

Automatic Sampler
Rain Gauge
Real Time Clock
Water Level Gauge
Strip Chart Recorder
Digital Magnetic Tape Recorder
Conductivity Analyzer
pH Analyzer
Turbidity Analyzer
Failsafe Power Supply



Flow chart for monitoring station operation and data recording
Figure 7

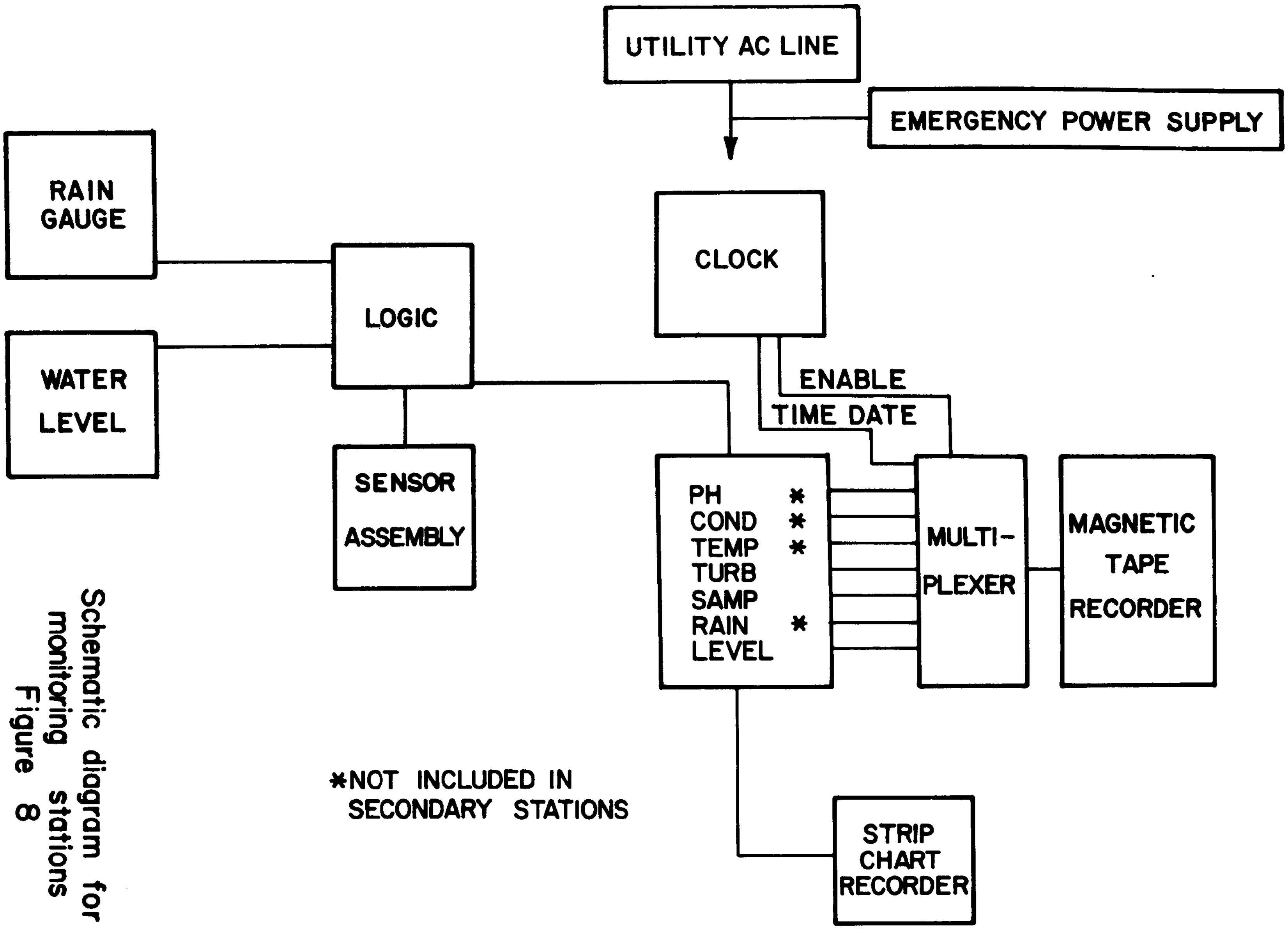


Figure 8
Schematic diagram for monitoring stations

The secondary stations will contain the following instruments:

Automatic Sampler
Real Time Clock
Water Level Gauge
Strip Chart Recorder
Digital Magnetic Tape Recorder
Turbidity Analyzer
Failsafe Power Supply

When a rainfall of a predetermined intensity occurs, the rainfall gauge at each primary station will activate its instruments and those of the secondary stations it controls. Data recording will be initiated at the individual stations by the presence of runoff of a preset level and will continue until runoff drops below that level. Simultaneous time signals will be recorded at all stations until all stations are without significant runoff and rainfall has ceased for a significant period. The system will then be secured. A flow chart depicting the logic of the monitoring station is shown in Figure 7 . A system wiring diagram for the monitoring stations is shown in Figure 8 .

The subsystems are briefly described below. All brand names are for general functional reference and do not imply endorsement by any agency of the Federal government or this Consultant.

(1) Water sensor contact system: provision must be made to bring the sensors into contact with the runoff water in a manner that will ensure representative and accurate data, protect the sensors during measurement, and secure the sensors in a favorable environment between runoff events. A sensor mounting assembly will be constructed which will open to a portion of the flow through the flume, exposing them to the moving water. On cessation of runoff, the sensors will be sealed, immersed in water from the runoff event. Conductivity and pH electrodes are best stored wet. Turbidity and temperature sensors are more indifferent to the storage mode, but will probably also be secured wet. The water level sensor, a float-type instrument, will not be located with the above four and will probably be secured dry.

(2) Sensor signal conditioner system: the most suitable commercial equipment for measuring the significant parameters will be purchased. Several manufacturers produce highly reliable equipment for the parameters to be measured, but a number of constraints narrow the list of applicable types. Primary among these constraints is the selection of 12 volts DC as the operating voltage of as many of the parametric analyzers as possible. This voltage was selected as the optimum, considering the availability of equipment, the economics of uninterruptible power supply, and availability of high-current power for mechanical systems. Where 12-volt systems are not available, it may be desirable to choose standard 110-volt AC-powered equipment and live with the risk of data loss for particular parameters.

The following are tentative selections of available equipment, which can be changed if it becomes apparent that other selections are desirable:

(a) pH: Great Lakes Instrument, Inc., Model 70 W-1; conductivity, Great Lakes Instrument, Inc., Model 70 W-3, temperature, Great Lakes Instrument, Inc., Model 70 W-4. UNILOC can supply DC-powered units for pH, conductivity, and temperature on special order.

(b) Turbidity (suspended solids): several good turbidity units are available, but relatively few can operate on 12-volt DC. Since turbidity is one of the most important parameters of the system, it is important that this parameter be protected from power failure. If no suitable 12-volt DC suspended solids monitor can be located, this parametric analyzer may be independently powered by a 12-volt DC to 110-volt AC inverter supplied from the uninterruptible power supply. The unit of choice in this event is the Biospherics, Inc., Model 53.

(c) Water level: the volume of water moving through the drainage system in question will be monitored by measuring the level of water as it passes through a flume. This will probably be a float system suspended from a cable and drum. The Leopold and Stevens Type F instrument is one which should perform satisfactorily. The drum would be connected to a potentiometer that would transmit level in terms of voltage.

(d) Rainfall: rainfall would be monitored using a tipping bucket rain gauge. This type of instrument has been selected because of its characteristic of requiring no power during its continuously ready standby condition. This gauge would activate the monitoring system during rainfall by bringing the system to a ready conditon and polarizing and conditioning sensors. The monitoring system would commence recording when the level-sensing unit indicated significant flow through the flume.

(3) Digital data-recording system: the primary data-logging system will use digital recording on magnetic tape. Because of the large quantity of data which will be acquired during individual runoff events and during the period of the demonstration and because of the need for correlation between stations and parameters, it was decided that provisions for automatic data handling should be made. The availability of small, reliable digital tape recording systems makes this type of acquisition feasible and desirable. Several systems are available, the most attractive of which is the Datel LPS-16, which is a 12-volt DC unit employing a Norelco-type cassette and handling 16 channels of analog information plus two channels of internal timing and identification.

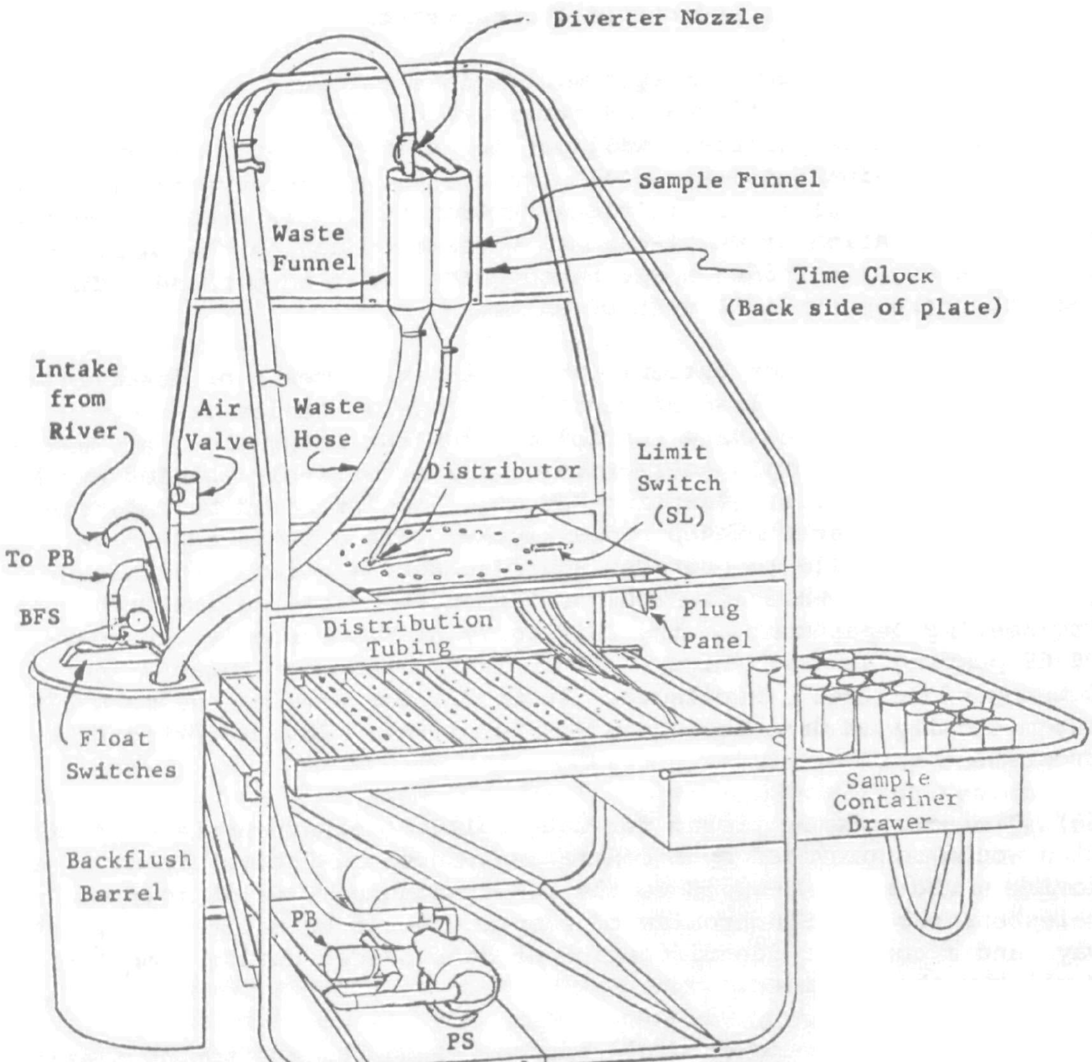
Datel LPS-16 recorders will be used, simultaneously recording information from the sensors, station identification, and time and date from a central real-time clock. Information from the cassettes will be read on a Datel tape reader into a computer in house at Environmental Systems Corporation, where it will be compiled, printed out in engineering terms, and stored for correlation and interpretation.

(4) Strip chart recording system: digital recording will be backed up by inexpensive multi-channel recorders or several single-channel recorders. These recorders will provide useful records during calibration and maintenance and will give system redundancy for increased dependability. Single or multiple Rustrak recorders produced by the Gulton Corporation or multi-channel recorders such as the Elnik or Esterline Angus machines would be adequate for this purpose. These manufacturers provide 12-volt DC units.

(5) Sample collection system: the most direct means of determining the suspended solids load of runoff is to take samples at closely spaced intervals, separate the solids from the suspension, and weigh the dry solids. Sample collection can be effectively carried out by some sort of automatic sampling device. Samples would be collected and stored for later pickup and analysis. While it is expensive, it would be worthwhile to provide each secondary station with this device. One such sampler which is highly recommended by the Agricultural Engineering Department of the University of Tennessee is the Model PS-69 pumping sampler (Figure 9) built by Product Manufacturing Company of St. Paul, Minnesota. Up to 72 pint samples can be collected automatically at preselected intervals or on a flow-proportional program.

(6) Timing system: timing for data collection sequence and identification would be provided by a centrally located real-time clock. This device would be hard-wired to the remote stations, using inexpensive telephone cable. Synchronism of sampling would be maintained in this way, and a code for identification of data needed during compilation would thus be provided.

(7) Power supply: power would be applied to the monitoring stations as 110-volt AC from the utility power at the site. This power would be converted to 12-volt DC for routine use of the stations and for charging the standby batteries. On loss of utility power, the system would continue on standby storage batteries until utility power was restored. It is believed that this system provides maximum reliability while not requiring the installation of heavy power lines. Large current drains by mechanical equipment during start-up and securing and sampling could be supplied by batteries.



PS-69 Pumping water sampler

Figure 9

A list the instruments and equipment which are suggested for use in this project.

Runoff is a hydrologic quantity necessary for this project, and the selection of the most appropriate measuring device is important. It is not necessary that the device have the sensitivity to measure every flow event, but it must be capable of measuring the significant ones. The amount and character of the sediment in the flow must be considered in the design of a flow meter. Since high levels of sediment are expected to pass the monitoring station, a weir was considered inappropriate, because sediment tends to collect behind weirs due to the decreased velocity at the weir approach and accumulated deposits above the weir can alter the flow measuring characteristics of the weir. The sizes of the watersheds involved in this project are small, ranging from 10 to 40 acres. In the past, flow measurement from small watersheds was accomplished by using the Parshall flume; however, sediment deposition significantly affected the accuracy. It has been replaced by a H-flume, which is the standard measuring device developed by the U.S. Department of Agriculture and is used extensively by the U.S. Forest Service Experiment Station at Berea, Kentucky in their hydrologic investigations. This flume is trapezoidal in plan with vertical sidewalls, producing a trapezoidal opening which provides satisfactory sensitivity over the range of flows for which it is designed. When a sediment deposition problem is anticipated, a sloping bottom can be added in the flume approach box, which concentrates the flow, thus maintaining velocities, which, to some extent, reduces the settling of sediment and helps to alleviate the problem. The H-type flume will be used in this project. The water level will be measured and converted to discharge as per the stage-discharge characteristics of the flume.

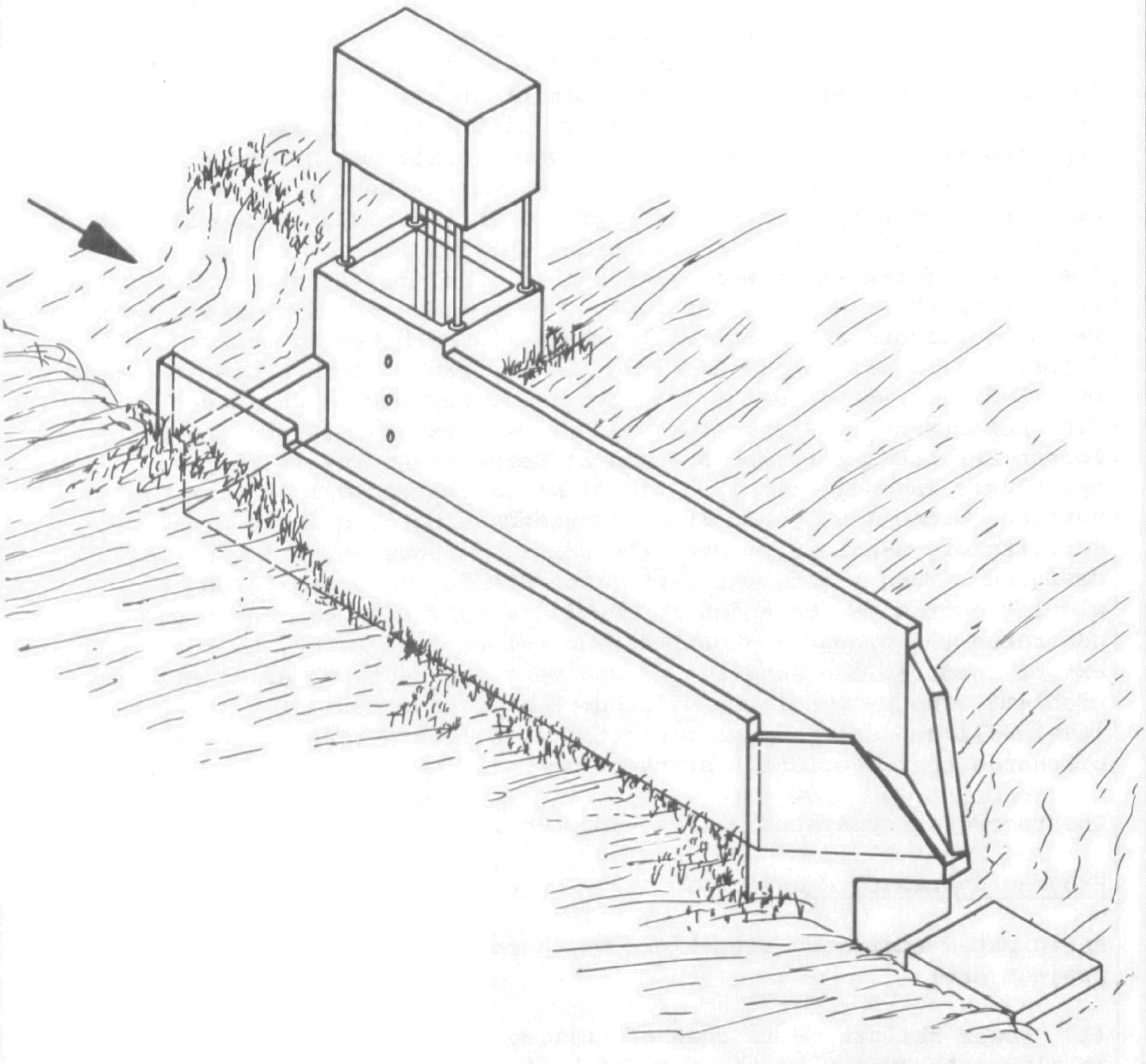
The recording apparatus will be secured in a steel enclosure.

Program Emergency Procedures

Anticipated emergency situations which could adversely affect the project are:

(1) Power failure -- in case of utility power failure, there will be an alternate supply in the form of batteries, which has been explained in the instrumentation section;

(2) Flume washout -- it is possible that a flow could be experienced which would exceed the capacity of the flume, in which case there would be no dependable flow measurement; the flume will be designed so that this probably will not happen; however, inability to measure such a flow would not affect the overall project; an attempt will not be made to measure every event, only the significant ones;



Typical flume installation
Figure 10

SUGGESTED MONITORING STATION EQUIPMENT MODELS AND MANUFACTURERS

Automatic sampler: Product Manufacturing Company, Model PS-69

Clock: ESC design and assembly

Conductivity analyzer: Uniloc, Model 711

Digital magnetic tape recorder: Datel, Inc., Model LPS-16

Fail-safe power supply: ESC design and assembly

Logic: ESC design and assembly

Magnetic tape reader: Datel, Inc., Model LPS-16R

pH analyzer: Uniloc, Model 1002

Rain gauge: Weather Measure, Inc., Model P-1501

Sensor assembly: ESC design and assembly

Strip chart recorder: Rustrak, Model 388

Temperature indicator: Rustrak, Model 2144

Turbidity analyzer: Biospherics, Model 53

Water level gauge: Leopold and Stevens, Type F (potentiometer added by ESC)

All equipment may be substituted on an equivalent basis for reasons of availability or other reasons. The brand names are for equal reference only, and do not imply endorsement by any agency of the Federal government or this Consultant.

(3) Extreme low temperature -- the monitoring stations will be secured and inoperative when some predetermined temperature below freezing is experienced. This will not have any effect on the project, because if the ground is frozen, there will be no erosion and the precipitation will not be the eroding type but in the form of snow.

Grab Samples

In addition to the automatic samples taken as described herein, grab samples will be taken throughout the life of the projects. These grab samples will be used both to calibrate the on-line instruments, but also to measure certain parameters not included in the automatic system. The following is a minimum of the items for which the grab samples will be analyzed:

1) pH
2) Conductivity
3) Turbidity
4) Hardness
5) Alkalinity
6) Iron
7) Calcium
8) Magnesium
9) Manganese
10) Suspended Solids
11) Settleable Solids
12) Sulfate
13) Other items requested by the funding agencies

SECTION VII

COST ESTIMATE AND BUDGET

A cost estimate has been prepared that is adequate to carry out the project as described herein under the general conditions set forth below.

(1) The coal operator will construct a basic road at no cost to this project in accordance with the existing regulations of Kentucky.

(2) The operator will be willing to install, or permit to be installed on the road, the design parameters set forth in this report. The cost for this work is included in this project.

(3) There is no disturbed land above the road.

(4) The road can be divided into at least six definable segments or sections.

(5) The haul road will be used for normal coal hauling during the period that monitoring is desired.

The cost estimates used herein were based upon an actual site in eastern Kentucky, but the estimates can be used for any other reasonably similar site. Because final engineering design has not been done at this time, extreme accuracy in cost estimating is not possible. Most figures have, therefore, been rounded to the nearest thousand dollars.

Labor costs shown herein include the overhead for labor, but do not include profit, which is a separate line item.

An allowance was made for vandalization of instruments in the field. The Consultant will be responsible for replacing vandalized instruments up to the amount shown herein.

A breakdown of the estimated costs are shown in Tables 1 through 8 with a summary of these costs preceding these Tables.

SUMMARY OF COSTS
(Six Road Sections, Monitoring For Two Years)

Table No.	Item	Engineering Construction	Monitoring Phase Year 1	Monitoring Phase Year 2	Report Preparation	Total
(1)	Engineering					
	Road, Control Structures	18,000				
	Instrument Design	10,000				
	TOTAL	28,000				28,000
	Construction					
(2)	Control Parameters (Materials and Labor)	129,000				
(3)	Monitoring Stations (Six)	25,000				
(4)	Instruments (2 primary, 4 secondary)	65,000				
(5)	Instrument Installation	23,000				
(6)	Construction Inspection and Supervision	20,000				
	Replace Vandalized Instruments	20,000				
	TOTAL	282,000				282,000
(7)	Operation and Monitoring					
	Technical and Professional Personnel		104,000	79,000		
	Supplies and Maintenance		5,000	5,000		
	Sample Analysis		16,000	16,000		
	TOTAL		125,000	100,000		225,000

SUMMARY OF COSTS CONTINUED

Table No.	Item	Engineering Construction	Monitoring Phase Year 1	Monitoring Phase Year 2	Report Preparation	Total
(8)	Report Preparation					
	Professional Personnel				48,000	
	Technical and Clerical Personnel				8,000	
	Travel, Living and Supplies				3,000	
	TOTAL				59,000	59,000
GRAND TOTAL		310,000	125,000	100,000	59,000	594,000

TABLE 1. ENGINEERING

Roads And Control Structures

Direct Labor	14,000
Supplies and Material	500
Travel and Living	2,000
Profit	1,500
TOTAL	18,000

Instrument Design

Direct Labor	8,500
Travel and Living	700
Profit	800
TOTAL	10,000

Table 2. CONTROL PARAMETERS MATERIALS AND LABOR

	Item	Cost
Section 1: Control Section - Sustained Grade of 10%		No Cost
Section 2: 6% Grade, Check Dams,	Check Dams	$ 1,300
Drainage Convergence Down Fill Slope	Slope Drainage	$ 5,700
Section 3: Ditch Lining	Ditch Liner	$ 4,000
Section 4: Surfacing	Gravel	$ 10,000
Section 5: Control for Chemical	Bitiminized Fiber	$ 5,000
Soil Stabilization (Control Section)	Slope Drains	
Section 6: Chemical Soil Stabilization	Soil Stabilizer	$ 13,000
Application on Fill Slope	Bituminized Fiber	$ 5,000
	Slope Drains	
	MATERIALS	$ 44,000
	LABOR	$ 74,000
	PROFIT	$ 11,000
TOTAL DEMONSTRATION PARAMETERS MATERIALS AND INSTALLATION COST		$129,000

Table 3. MONITORING STATIONS (LESS INSTRUMENTS)

For Each Primary or Secondary Station

Concrete	$2,000
Steel Flumes	1,000
Instrument Housing	800
Profit	367
TOTAL	$4,167

Total cost for six stations
6 x $4,167 = $25,000

Table 4. MONITORING STATIONS INSTRUMENT COSTS

Primary Stations:	
Automatic Sampler	Clock
Conductivity Analyzer	Logic
Digital Magnetic Tape Recorder	Rain Gauge
Fail-Safe Power Supply	pH Analyzer
Sensor Assembly	Strip Chart Recorder
Temperature Indicator	Turbidity Analyzer
Water Level Gauge	
TOTAL COST (Less Installation)	$11,000 each
Secondary Stations:	
Automatic Sampler	Clock
Digital Magnetic Tape Recorder	Logic
Fail-Safe Power Supply	Sensor Assembly
Strip Chart Recorder	Turbidity Analyzer
Water Level Gauge	
TOTAL COST (Less Installation)	$ 9,000 each
Magnetic Tape Reader (one required for project)	
TOTAL COST	$ 2,000
2 Primary Stations @ $11,000	$22,000
4 Secondary Stations @ $9,000	36,000
1 Magnetic Tape Reader	2,000
Profit	5,000
TOTAL COST	$65,000

Table 5. INSTRUMENT INSTALLATION
(For 2 Primary And Four Secondary)

Direct Labor	$12,000
Power Supply	7,000
Travel and Living	2,000
Profit	2,000
TOTAL	$23,000

Table 6. CONSTRUCTION INSPECTION AND SUPERVISION

Direct Labor	$14,000
Travel and Living	4,000
Profit	2,000
TOTAL	$20,000

Replaced Vandalized Instruments: Estimate of $20,000

Table 7. OPERATION AND MONITORING

1st Year

Direct Labor	$ 92,000
Travel and Living	2,000
Supplies and Maintenance	5,000
Sample Anlysis	16,000
Profit	10,000
TOTAL	$125,000

2nd Year

Direct Labor	$ 70,000
Travel and Living	1,000
Supplies and Maintenance	5,000
Sample Analysis	16,000
Profit	8,000
TOTAL	$100,000

Table 8. REPORT PREPARATION

Professional Labor	$44,000
Technical and Clerical Labor	7,000
Travel, Living, and Supplies	3,000
Profit	5,000
TOTAL	$59,000

SECTION VIII

IMPLEMENTATION AND OPERATION PLANS AND REPORT SCHEDULE

The firm of Mayes, Sudderth, and Etheredge, Inc., will have overall responsibility for the project. Personnel from the firm of Environmental Systems Corporation (ESC) will provide assistance with regard to instrumentation and laboratory sample analysis.

SCHEDULE OF ACCOMPLISHMENTS

(1) Engineering: during this phase, the new haul road will be designed, including the erosion control demonstration techniques and their incorporation into the new road. The road will be surveyed and located in the field. Drawings will be prepared for the haul road with details of all factors pertinent to its construction. Drawings will also be made of the monitoring station installation, including the flume details. These drawings will be complete and suitable for competitive biddings for all work not to be accomplished by the consultant or operator. The design of the monitoring instruments is essentially complete. The instruments have been specified and will not be put out for bidding unless so required by Federal procurement regulations. This phase is estimated to require three months.

(2) Construction: a relatively small amount of construction is anticipated in this project. The operator will construct a new haul road in his normal course of operation, during which the erosion control structures will be installed integrally with the road. Other construction will consist primarily of the flume and approach box and the housing for the instruments (which will be done by a construction firm on the basis of competitive bid). Some of the items in the equipment requirements are not commercial items and will be designed and fabricated in the shop of ESC. These items are the logic for sequencing the system functions, the digital clock for providing date and time information and intervalometry, the fail-safe power supply, and the sensor assembly, all of which must be custom-built for the project. The personnel of ESC will install and calibrate the monitoring

instruments. The consultant will supervise all construction to ensure conformance with the plans and specifications essential to the proper functioning of the demonstration. Photographs will be taken throughout this period.

This phase of the project is expected to require four months:

(3) Monitoring: the monitoring program will be carried out under the general supervision of the consultant, whose representatives will make frequent visits to the site. A responsible local person, with a technical background will be retained to make daily visits to the site, take grab samples, and oversee the monitoring equipment at the site. This person will be on the payroll of the consultant.

The instrumentation and sample analysis will be done under the supervision of the personnel of ESC. They will be responsible for the instruments, operation and maintenance, and the laboratory analysis of grab samples.

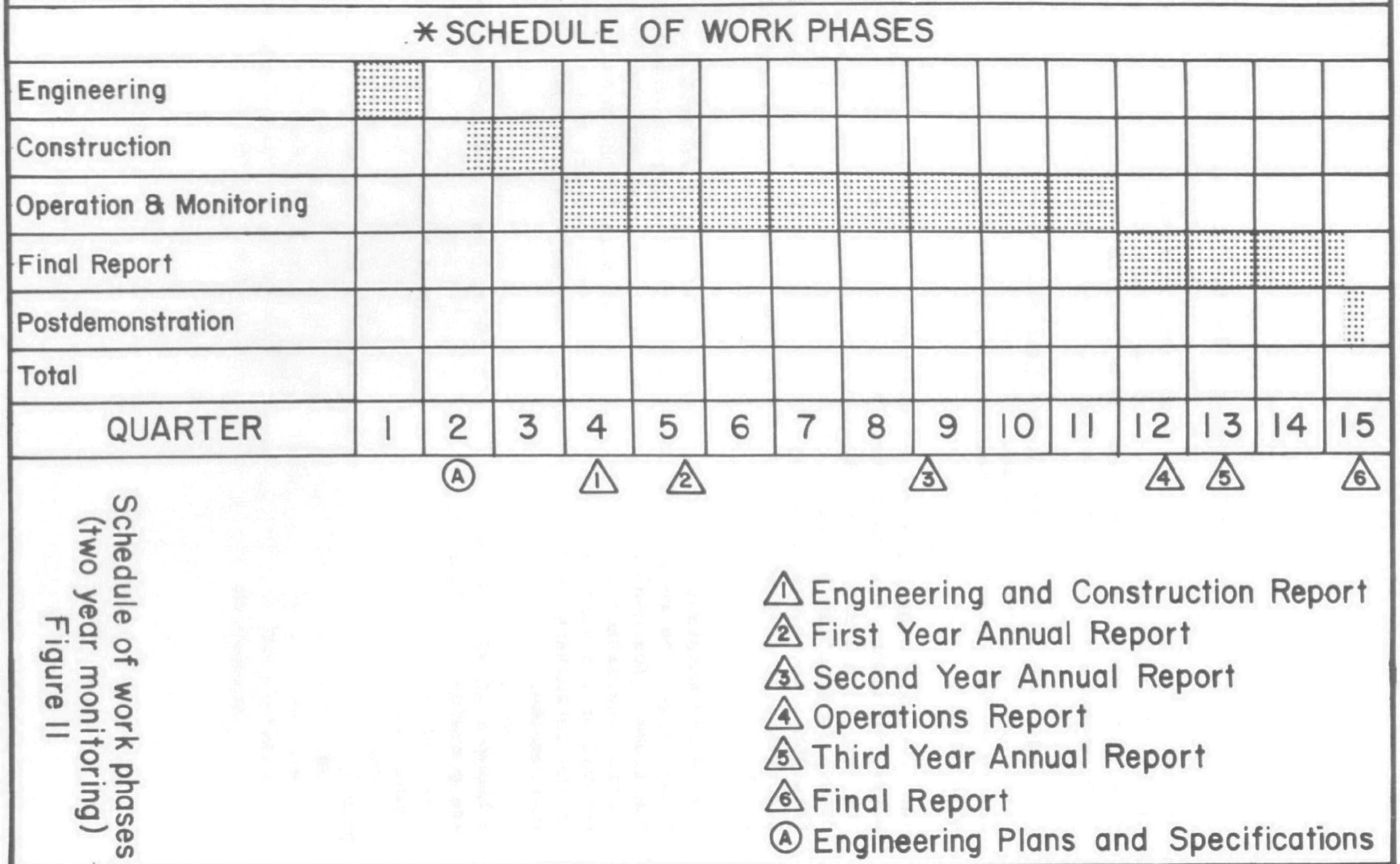
(4) Reports: the final report shall be the basic responsibility of Mayes, Sudderth, and Etheredge, Inc., with assistance from ESC regarding the sample analysis and compilation and interpretation of the accumulated data. In addition to the final report, interim reports will be submitted throughout the project monthly, quarterly, and annually by Mayes, Sudderth, and Etheredge, Inc. This phase is expected to require 10 months.

(5) Postdemonstration: the postdemonstration period will consist primarily of the removal of the instruments, instrument housing, and the flume. The haul road will continue to be used, and the erosion control facilities will remain an integral part of the road. The removal of the monitoring devices will be the primary responsibility of the consultant, with ESC personnel performing the removal of the instruments.

Schedules of work phases and reports for two-year and one-year monitoring are contained in Figure 11.

Figure 17

DEMONSTRATION OF COAL MINE HAUL ROAD SEDIMENT CONTROL TECHNIQUES



Schedule of work phases
(two year monitoring)
Figure 11

SECTION IX

BEDDING DOWN AND ABANDONMENT

Coal haul roads are temporary by nature, and there usually comes the time when they are abandoned. There are existing erosion control guidelines for bedding down roads on forested mountainsides after their useful life has ended. Sometimes such roads are utilized to provide access to the forest areas; however, the type and volume of traffic are vastly different than when heavy coal trucks made many trips per day along the road. Erosion control techniques which could not be applied during heavy coal hauling can be successfully applied to the seldom traveled or completely abandoned road. It makes a difference, obviously, whether the road is to be completely abandoned or kept open for forest management use. The U.S. Forest Service has published some guidelines relative to bedding down forest roads and erosion control on lightly used roads [12, 17].

Quantitative data relative to the sediment produced by runoff from abandoned coal haul roads is nonexistent. There exists an excellent opportunity to obtain such data on the road considered in this demonstration project. The instruments will already be in place, and it will be necessary only to continue the monitoring phase as deemed necessary.

SECTION X

PRINCIPAL INVESTIGATORS

This demonstration project will be accomplished through the Office of Planning and Research, Kentucky Department for Natural Resources and Environmental Protection, for the Bureau of Mines, Division of Environment, U.S. Department of the Interior.

The principal investigators will be staff personnel from the Office of Planning and Research, Kentucky Department for Natural Resources and Environmental Protection, with technical assistance from the consulting engineering firm of Mayes, Sudderth, and Etheredge, Inc., Lexington, Kentucky, and instrumentation specialization from Environmental Systems Corporation, Knoxville, Tennessee. Listed below are those who will be directly involved in this project.

Robert E. Nickel, Chief
Office of Planning and Research
Kentucky Department for Natural Resources
  and Environmental Protection
Sixth Floor, Capital Plaza Tower
Frankfort, Kentucky 40601

Bachelor of Arts in physical geography, Eastern Kentucky University, 1969

Mr. Nickel has extensive experience in directing and coordinating planning, research and demonstration projects, and studies related to surface mining and other areas concerning protection of the natural environment. He also has considerable experience in water-related research and hydrology investigation.

Mr. Nickel has personally completed research papers dealing with problems associated with the surface mining of minerals and planning, coordination, and development for natural resource management and utilization.

William S. Kelly
Research Program Coordinator
Office of Planning and Research
Kentucky Department for Natural Resources
and Environmental Protection
Sixth Floor, Capital Plaza Tower
Frankfort, Kentucky 40601

Bachelor of Arts in biology, University of Louisville, 1972

Mr. Kelly has served as a project coordinator and is presently research program coordinator for the Kentucky Department for Natural Resources and Environmental Protection. He has been involved in all phases of research and studies related to mining, reclamation, and other areas concerning environmental protection, including grant applications, progress reviews, and progress reports.

Mr. Kelly has recently been directly responsible for studies concerning water quality, revegetation, slope stability, and surface mining systems.

William F. Grier, President
Mayes, Sudderth, and Etheredge, Inc.
Suite 410, Lexington Building
201 West Short Street
Lexington, Kentucky 40507

Bachelor of Science in civil engineering, Georgia Institute of Technology, 1955
Registered Professional Engineer in Kentucky and several other states

Mr. Grier has extensive experience in work involving hydrology and water management. He has carried out studies involving water control in Alabama, Washington, Georgia, and other states. He has also had considerable experience with computers and their application.

The following is a partial list of publications and reports of which Mr. Grier is the author or a principal contributing author which are applicable to the project:

Groveland Lake: An Evaluation of Hydrology, Soils, and Ecology

Comprehensive Water and Sewer Plan for the Kentucky River Area Development District

Dacca Southwest Project (flood control and irrigation study at the confluence of the Ganges and Bramapulra Rivers in Balgladesh)

Regional Water and Sewer Planning in Kentucky

Carlos F. Miller
Senior Engineer
Mayes, Sudderth, and Etheredge, Inc.
Suite 410, Lexington Building
201 West Short Street
Lexington, Kentucky 40507

Bachelor of Science in civil engineering, University of Kentucky, 1966
Master of Science in civil engineering, University of Kentucky, 1968
Registered Professional Engineer in Kentucky

Mr. Miller has an extensive background in water resources. He was responsible for surveying and inspection of small earthen dams for the Kentucky Division of Water. He has had broad experience with photogrammetric map compilation with the U.S. Army Map Service. Mr. Miller was chief engineer, water utilities, with the Kentucky Public Service Commission for six years, during which time he worked extensively in eastern Kentucky in close contact with the problems associated with coal production.

His master's thesis was on the hydrology of small watersheds, utilizing computer modeling to simulate runoff characteristics.

James D. Womack
Research and Development Associate
Environmental Systems Corporation
P.O. Box 2525
Knoxville, Tennessee 37901

Bachelor of Arts and Master of Arts, University of Tennessee

Mr. Womack has extensive experience instrumentation relative to earth sciences, particularly with dye tracer operations in the field, including the utilization of surface sampling and airborne remote sensing techniques, and has utilized these for a number of water resources engineering applications.

SECTION XI

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SECTION XII

GLOSSARY

Appalachia: an area in the eastern United States covering 13 states, including portions of southern New York, western Maryland, southeastern Ohio, eastern Kentucky, southwestern Virginia, western North Carolina, the eastern half of Tennessee, northeastern Mississippi, the northern half of Alabama, northern Georgia, northwestern South Carolina, all of West Virginia, and most of Pennsylvania.

Base section: a section on the haul road which is left unaltered or constructed according to the prevailing practices and used as a base for comparing the demonstration road sections which contain certain erosion control parameters.

Bedload: the load of material in the bed layer where suspension is impossible due to fluid dynamics.

Berm: a shelf that breaks the continuity of a slope; a barrier.

Check dam: a structure used to stabilize the grade or to control erosive velocities in artificial or natural channels by hydraulic gradient reduction.

Coal operator: an individual or organization engaged in mining coal.

Conductivity: a measure of water's capacity to convey an electric current, which is related to the total concentration of the ionized substances in water and the temperature at which the measurement was made.

Crown: grading a roadway surface downward each way from the center line, resulting in the center line's being the highest point in the surface cross section, allowing surface drainage to flow both ways.

Cut face: the exposed area resulting from cutting through or into the side of a hill or mountain, i.e., for a road.

Denuded: bare, stripped

Deterioration: the state of being worse or of lower quality.

Discharge: a volume of fluid passing a point per unit of time, commonly expressed as cubic feet per second, gallons per minute, million gallons per day.

Ditch relief culvert: a conduit used to divert water, under the road, from a roadside ditch before the flow gains sufficient volume or head to cause erosion.

Diversion ditch: a channel constructed to intercept, collect, and transport water, which would otherwise flow over an erodible surface, to a stabilized area.

Drainage basin: all of the area between drainage divides; watershed.

Environment: the aggregate of surrounding conditions, things, and influences that affect the existence of an organism or group.

Erodible: susceptible to erosion.

Erosion: the wearing away of the earth's surface by the forces of wind, water, ice, and gravity.

ESC: Environmental Systems Corporation, the instrumentation consultants on this project.

Fill slope: the inclined surface of the material used to build up a road to a desired elevation or spilled down a hillside in the construction of a cut and fill road section.

Filter strip: a strip of undisturbed vegetation that retards the overland flow of water, causing deposition of the suspended material, thus reducing the amount of sediment reaching the local drainage network.

Flexible downdrain: a flexible conduit of heavy fabric used usually to conduct water over an erodible surface.

Flume: a specially designed channel forming a fluid flow-measuring device based on critical flow characteristics; the flow rate through the channel can be determined by measuring the depth of flow in the channel and applying the depth-discharge relationships particular to the channel.

Grab sample: water samples taken manually and stored for chemical analysis.

Gradient: change in elevation, pressure, etc., per unit length, slope.

Haul road: the access road used to transport material (coal) from the point of extraction to the point of delivery or to the local transportation network.

Hydrology: the branch of physical geography which is concerned with the origin, distribution, and properties of the waters of the earth.

Inslope: the grading of a roadway surface downward to the roadside ditch on the cut side of a cut and fill road section.

Instrumentation: the conglomerate of instruments which is used to measure and record the various climatological factors and the water quality and water quantity descriptors and including the entire philosophy and logical methods of operation.

Integral: belong as part of the whole; necessary to the completeness of the whole.

Monitoring station: the actual physical apparatus and structures necessary for collecting the required data at a specific location, including the flume, instruments (which could vary among stations), instrument housing, and electrical connections.

Open-top culvert: a structure for removing water from the road surface.

Outfall: point where water discharges from a drainage structure.

pH: the logarithm of the reciprocal of the hydrogen ion concentration (more precisely, of the hydrogen ion activity) in moles per liter, the pH value represents the instantaneous hydrogen ion activity.

Pollute: to make foul or unclean.

Riprap: rock or boulders placed on erodible surface, such as channel bottoms and banks, for protection against the abrasive action of water.

Roadside ditch: an artificial channel in juxtaposition with the road, which collects drainage from the road surface and contiguous areas and transports it to a stabilized area.

Runoff: that portion of the precipitation on a drainage basin that is not retained in the area; it occurs as overland flow and groundwater flow and is discharged from the area in stream channels.

Sectional slope drain: a sectional conduit of half-round, third-round made of bituminized fiber used to conduct runoff from one elevation to another.

Sediment: the byproduct of erosion;the material that is transported by water, wind, or ice.

Sedimentation: the deposition of accumulation of sediment.

Slope: an inclined or slanting direction from the horizontal; a term to describe the magnitude of inclination from the horizontal, commonly calculated as a ratio of the vertical distance to the horizontal distance, expressed as a percentage.

Splash apron: rocks, concrete, asphalt, or some other erosion-resistant material placed at points of concentrated drainage discharge to provide an area for impact.

Swale: a low place in a tract of land.

Turbidity: an expression of the optical property of a water sample which causes light to be scattered and absorbed; turbidity in water is caused by the presence of suspended matter.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/2-76-196		

4. TITLE AND SUBTITLE Demonstration of Coal Mine Haul Road Sediment Control Techniques	5. REPORT DATE August 1976 (Issuing Date) 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) William F. Grier, Carlos F. Miller James D. Womach	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department for Natural Resources & Environmental Protection Commonwealth of Kentucky Capitol Plaza Tower Frankfort, Kentucky 40601	10. PROGRAM ELEMENT NO. EHE623; 05-01-04A-01 11. CONTRACT/GRANT NO. S-802682
12. SPONSORING AGENCY NAME AND ADDRESS Industrial Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268	13. TYPE OF REPORT AND PERIOD COVERED Final Feasibility Report 14. SPONSORING AGENCY CODE EPA-ORD

15. SUPPLEMENTARY NOTES

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16. ABSTRACT

This Report examines the feasibility of demonstrating the most effective methods of controlling erosion which results when land is disturbed and altered by the construction of access roads to coal mining operations in the steeply sloping areas of Appalachia. The methods of controlling erosion on haul roads as examined herein are techniques that can reasonably and economically be constructed by conventional equipment that is normally used or is available to coal operators.

A method to collect qualtitative data, by remote instrumentation, for evaluation of the effectiveness of the erosion control methods is also described.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Surface Mining *Drainage *Access Roads Erosion Control Sedimentation	Eastern Kentucky Haul Roads	13/B 08/G 08/H

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 82
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE