

# A minerals research contract report



## **RECLAMATION AND POLLUTION CONTROL: Planning for Small Sand and Gravel Mining Operations**

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BUREAU OF MINES  
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## FOREWORD

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# INTRODUCTION

## OVERVIEW

The techniques used for planning sand and gravel mining operations continue to improve. Public concern for the environment has made it as important for the mine operator to consider reclamation and pollution control activities as to consider how and when bulldozers and haul trucks will be used during the mining operation.

Two important items which must be considered when planning and conducting a sand and gravel mining operation are community concerns and government regulations.

Citizens will often be concerned about the thoroughness of the land and water reclamation effort, as well as the techniques used to control pollution. There may also be a number of government regulations which apply to the mining operation. Such regulations could specify the standards by which reclamation would be judged a "success" or "failure," and the limits beyond which different types of pollution would not be tolerated. Government laws and regulations are often essential in protecting the public welfare; however, they are usually expensive to deal with, even though a mine operator may gain certain financial benefits by returning mined land to a usable condition. The most effective way to prevent the enactment of more regulations is to conduct mining in a safe and environmentally responsible manner. Operations planned and conducted in such a manner will be more acceptable to the public, and thus help to minimize community concerns. Good planning is an essential part of a safe and responsible mining operation.

## TERMINOLOGY

Several terms used in this guide require some explanation.

These are: mining site, mining operation, and reclamation.

The term mining site refers to the area, or areas, affected by the mining operation and its related activities. Examples include:

1. Areas used for roadways
2. The area covered by the mining pit
3. Areas where pollution control devices may be installed (sediment retention structures, vegetative filters, diversions, etc.)
4. Areas that may be used for support facilities (processing areas, waste disposal areas, maintenance shops, etc.).

Generally, the boundary of the mining site will be the same as the "permitted" area. In some cases, however, areas located outside the permitted boundary may be affected by the mining operation. Since the operator will need to plan to control the effects of the operation on these areas as well, they too should be considered as part of the mining site.

The term mining operation implies that the operation consists of three interrelated phases:

1. Premining planning
2. Extraction
3. Reclamation.

The premining planning phase includes the planning and other activities undertaken prior to any disturbance of the proposed mining site. The extraction phase includes site preparation and development,

and other activities related to the actual removal of the sand and gravel deposit. Reclamation refers to the activities (backfilling, grading, revegetation) undertaken to achieve the land use desired after mining. To the extent possible, the reclamation activities should be performed in conjunction with the extraction activities.

### **PURPOSE, SCOPE, AND USE**

The primary purpose of this guide is to provide information which sand and gravel mine operators can use to plan reclamation and pollution control activities at their mining sites. A major objective of the guide is to address techniques which can be used at both existing and proposed mining sites. The document is not a design manual. Rather, it presents planning information arranged in a logical and sequential order, to which the operator can refer throughout the mining operation (before, during, and after mining).

As implied in the title, the guide is intended for use mainly by small sand and gravel mine operators who:

1. Mine less than 200,000 tons of resources per year
2. Do not have technical planning personnel available within their company
3. Do not have the financial resources to acquire such technical planning assistance.

Although the guide is intended for use mainly by small operators, it also provides information which will be helpful to larger sand and gravel mining companies.

The guide is divided into four major sections.

Section I, "Planning for Reclamation and Pollution Control," addresses the importance of planning to a successful mining operation. It provides a brief overview of the concerns which citizens could have about an existing or proposed mining operation, and some of the regulatory, reclamation, and pollution problems which the operator could encounter throughout mining. The importance of conducting a detailed site analysis and determining sources where site-specific information could possibly be obtained is discussed in a more detailed manner. Information presented in this section actually provides the basis for subsequent sections addressing various techniques and procedures for dealing with those concerns and problems mentioned above. Most of the information presented in this section will be of particular use to the operator in the early stages of the operation (premining planning phase).

Section II, "Community Relations: Before, During, and After Mining," discusses some specific concerns which communities may have about sand and gravel operations. The importance of establishing a positive community relations program in an attempt to resolve public concerns in the early stages of the operation is stressed. Means by which citizens may voice their concerns and ideas are discussed. The need for the operator to anticipate community concerns, and procedures for dealing with such concerns are also discussed. Information presented in this section will be most useful to the operator during the premining phase. Many of the procedures can also be used to address problems which may arise during the later stages of the operation.

Section III, "Reclamation and Land Use Practices," deals with different types of land uses after mining, determining a suitable land use, and reclamation practices for achieving the desired land use. The benefits of identifying appropriate reclamation practices, and planning for their use before extraction is started, are also discussed. This section will help the operator understand the importance of the site analysis, as discussed in Section I, and its relation to the reclamation phase of the mining operation.

Section IV, "Pollution Control Practices," discusses various practices which the sand and gravel operator can use at his mining site to assist in controlling pollution. Again, identifying appropriate practices and planning for their use during the premining planning phase is stressed. Information contained in Sections III and IV will be use-

ful to the operator in all phases of the operation.

In addition to the information contained in the major sections, the guide contains other useful material. A glossary of selected terms and phrases, as well as several pertinent appendices, is included. The reader will also note that the beginning of each major section lists some of the significant points addressed within the section.

The guide presents information related to a wide range of conditions found at many sand and gravel mining sites and therefore some of the information may not be applicable to all situations. Community concerns, terrain conditions, regulatory requirements, and other factors affecting the operation will often vary from one place to another. Upon reviewing the guide, the operator must select those techniques which are most appropriate and suitable for use at his particular mining site.



## SECTION I. PLANNING FOR RECLAMATION AND POLLUTION CONTROL

Some of the significant points made in this section are:

1. Reclamation and pollution control are absolutely necessary.
2. A well-formed reclamation and pollution control plan insures the greatest degree of success at the lowest possible cost.
3. Planning for reclamation and pollution control requires:
  - knowledge of government requirements
  - dealing with the local community
  - analyzing existing site conditions.
4. Site-specific planning information may be available from several sources.

### OVERVIEW

In order to properly reclaim mined land and control pollution during and after mining, premining planning will be required. Reclamation as an afterthought to mining may be difficult, and attempting to correct or control problems such as air or water pollution after it has occurred can be very costly. Planning can save time and money and is usually necessary to comply with State and local laws and regulations.

Planning for reclamation and pollution control at a sand and gravel mining operation may involve performing environmental studies, reviewing regulatory requirements, and becoming familiar with land use and community issues. An understanding of equipment and facilities planning, and the use of qualified personnel to do the work will also be necessary. Capital expenditures and considerable effort will often be required on behalf of the operator. Additionally, a thorough ap-

proach to planning reclamation and pollution controls for sand and gravel mines will usually require coordination and cooperation among the operator and four major groups of people: the local community and local, state and federal government agencies.

The results of the premining planning effort are used in two important ways. First, to prepare and present necessary information to the regulatory agency in a permit or rezoning application, and second, and perhaps the most important, to provide guidelines for insuring adequate reclamation and pollution control during the extraction phase of the mining operation.

Figure 1 illustrates the general steps involved in the premining planning phase of the mining operation. These steps, and some of the important activities associated with each, are discussed throughout this guide. The operator should keep in

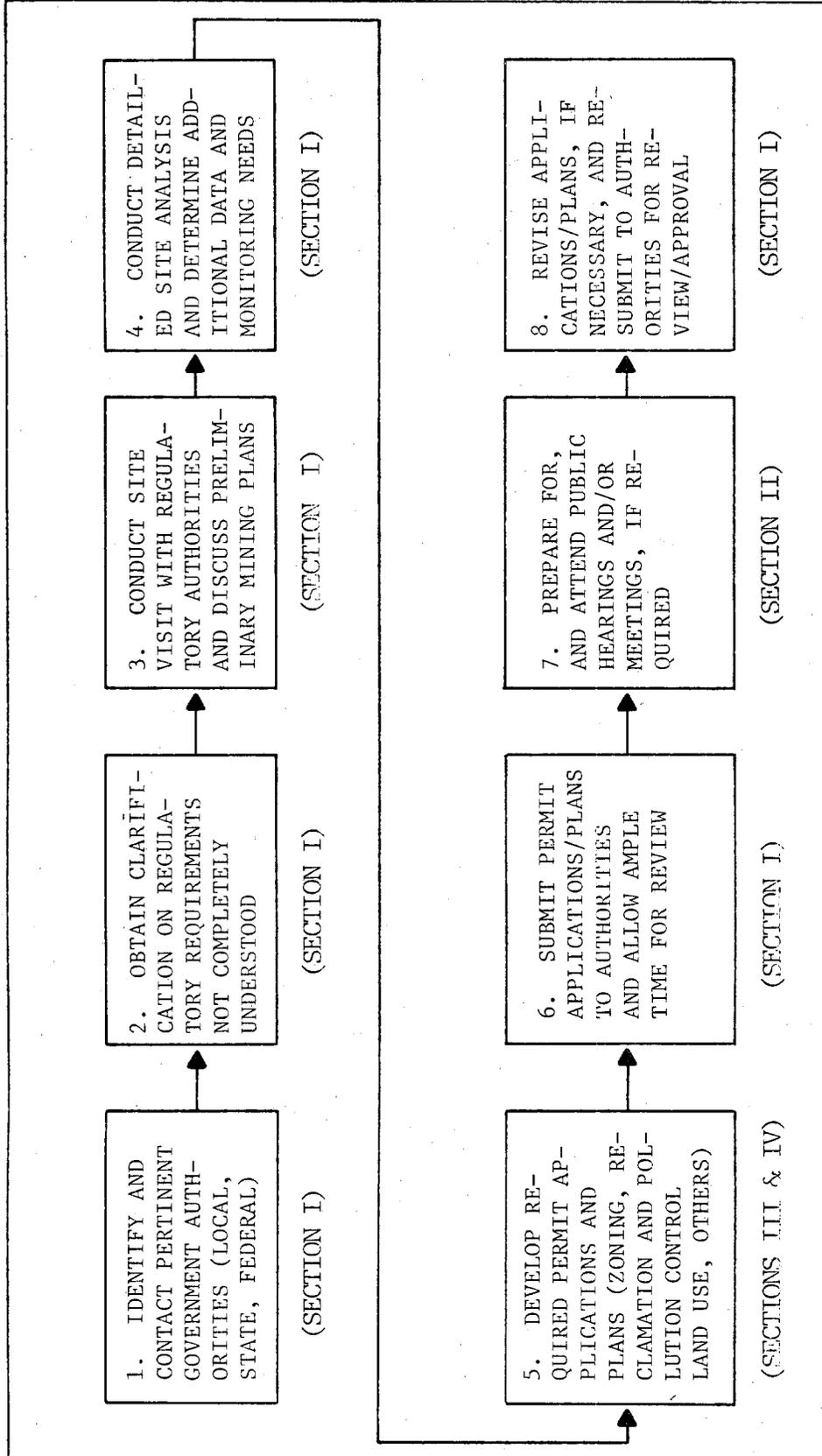


FIGURE 1. FLOW DIAGRAM OF THE GENERAL STEPS INVOLVED IN THE PRE-MINING PLANNING PHASE

mind that these steps may not apply to all situations and, in some cases, may not flow in the sequence shown. The basic purpose of the diagram is to acquaint the operator with some of the major elements involved in the planning process and provide background data which may help him anticipate and identify areas where problems are likely to occur. As the operator reviews Figure 1, he should realize that decisions concerning such things as engineering and cost feasibility and compliance with regulatory requirements may have to be made at various points throughout the planning process.

### THE IMPORTANCE OF PLANNING

Planning is essential for successful reclamation and pollution control. Planning begins well before mining and in some cases may take one year or longer to complete, depending upon government requirements. The best plans combine the operators capabilities (i.e. equipment, knowledge, capital, etc.) with the environmental limitations of the mine site. Production goals must be balanced with reclamation goals.

The natural environment of the mine site is the principal element to focus upon during the planning process. This means that site conditions such as climate, soil, surface and ground water, sand and gravel, bedrock, topography, overburden, vegetation, wildlife, and land use must be studied. Some of these conditions may have to be studied over several seasons to obtain a full picture of their importance to the environment. This is another reason why planning for a sand and gravel mine could take many months, if not longer. Once the environmental site information has been collected it is used to:

1. prepare, if required, an

assessment of the impacts which the mining operation could have upon the environment. (The resulting written assessment is sometimes referred to as an Environmental Impact Assessment (EIA). Many state and federal agencies can provide guidelines for the preparation of these documents)

2. compile resource extraction plans
3. compile permit or rezoning applications
4. plan and guide reclamation and pollution control activities.

The pre-mining study of the environmental conditions of the mine site provides "baseline" data. Baseline data are used for comparison with environmental data collected during the extraction phase of the operation. If environmental conditions change when the extraction begins, the operator can logically assume that the extraction activities are at fault. Pollution could be defined as a negative change in the premining site conditions. The baseline data are therefore used as a yardstick by the small operator and the regulatory authority to determine whether the mining operation is causing pollution. This system can also serve to protect the operator. If it were determined that the premining conditions were improving during the extraction phase, or that the type of pollution identified was coming from another source, the operator and his sand and gravel mining activities could not be accused of polluting.

Some important questions which the operator should ask during the planning process are:

1. Have I contacted all the pertinent regulatory agencies?
2. Do I have copies of all laws and regulations pertaining to the proposed operation?
3. Do I understand the reclamation and pollution control requirements and am I willing to comply with them?
4. Do I have enough time to prepare the permit application and stay on schedule?
5. How long will it take to complete an environmental assessment?
6. How long does it usually take to obtain a permit?
7. Have personnel from the regulatory agency visited the proposed site and made technical suggestions?
8. Am I prepared to accept the cost of reclamation and pollution control as "part of the cost of doing business"?
9. What is the prevailing community attitude towards sand and gravel mining? Do I anticipate stiff opposition and, if so, how do I plan to handle it?

### **THE ADDED COSTS OF RECLAMATION AND POLLUTION CONTROL**

It costs money to reclaim mined land and to control pollution during mining. More than likely the operator will not be able to mine unless he is willing to reclaim and control

pollution. The public should understand that even though environmental laws are to their benefit, a chain reaction, related to cost of resources, can be experienced. For example, when it costs the mine operator more to produce sand and gravel, because of laws and regulations, he passes the added costs along to his customers. The customers (construction companies, State Highway Departments, etc.) must then charge more for their goods and services. Ultimately, the general public pays for all price increases. Nothing is free, and that certainly applies to the protection of the environment.

Reclamation and pollution control need not be overly expensive, however. "Cost-effectiveness" practices may be used to produce the best results at the most reasonable costs. Operators should study alternatives during the premining planning phase and select "cost-effective" reclamation practices and pollution control techniques for use during the extraction phase. The cost of reclamation should be spread over the life of the mine. This procedure could help avoid the need for massive capital outlays at the conclusion of extraction activities. Operators who plan an effective reclamation program should consider the use of extraction equipment for reclamation during slack periods, as well as steps designed to keep reclamation as current as possible with extraction activities.

Since most sand and gravel mines are located in urban or heavily populated areas, a mined-out gravel pit, properly graded and stabilized, could become a valuable piece of property. In some cases, reclaimed pits are worth more than the gravel that was removed. Adequately controlling pollution during mining can also have positive bene-

fits, such as avoiding lawsuits due to pollution or property claims, and financial penalties resulting from fines or shutdowns due to violations of state or federal regulations.

Major cost items associated with reclamation generally include:

1. environmental analyses
2. preparing the mining and reclamation plans and the permit application
3. grading
4. respreading soil
5. seeding and planting
6. maintenance (e.g. irrigation, mowing, weeding).

By far, the most costly items are those requiring earth moving, grading, and soil spreading. This may account for 50% or more of the total reclamation costs. The second most costly expense could be the

pre-mining environmental work and preparing the permit application. Next would be maintenance costs, and the least expensive item would probably be seeding and planting (although anyone who has planted a lot of trees on their mine site may not agree).

Many regulations require a certain slope angle to be left inside and around the pit after mining. Typically, the slope has to be 3 to 1 (3 horizontal feet to 1 vertical foot) or flatter. Obviously, if the operator leaves gravel material in the pit, rather than using waste spoil material to shape the required slope, this is gravel that cannot be sold. Thus, this must be considered another cost of reclamation, although it is money not gained rather than money spent.

Figure 2 provides an example of the amount of gravel that could be lost if used to shape and maintain a required 3 to 1 slope angle. If the pit is 30 feet deep, the slope would have to extend out 90 feet into the

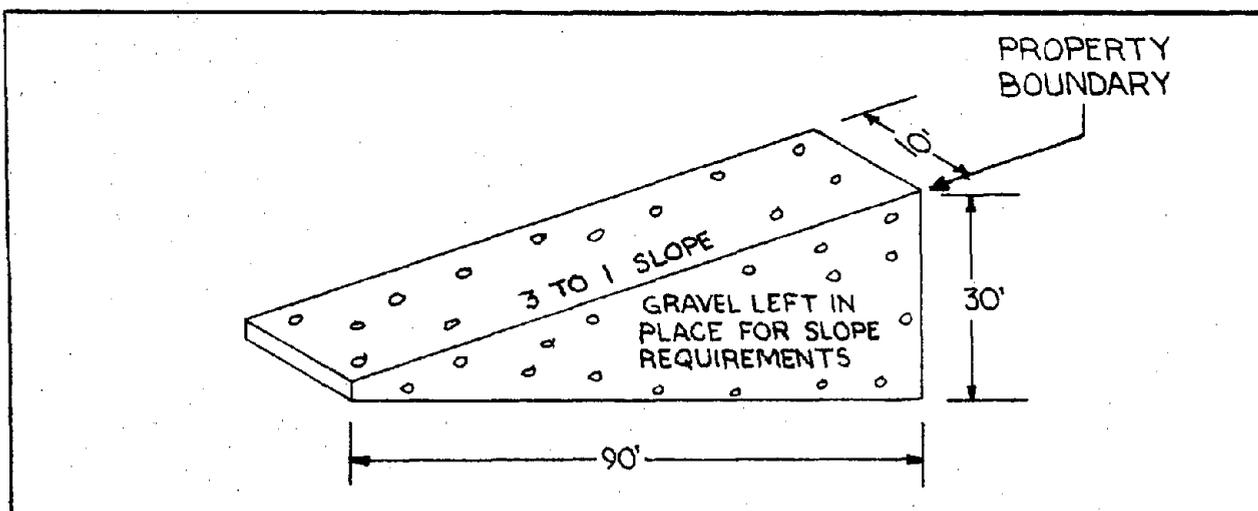


FIGURE 2. EXAMPLE OF GRAVEL RESOURCES LEFT IN PLACE TO MEET SLOPE REQUIREMENTS

pit in order to provide a 3 to 1 slope (3 horizontal feet for every 1 vertical foot). For the example shown in Figure 2, the volume of gravel which would need to be left would equal the area of the triangle times the length of the pit. This is better illustrated below:

$1/2 \text{ base} \times \text{height} \times \text{length} = \text{volume}$   
or  $1/2 (90 \text{ ft}) \times 30 \text{ ft} \times 10 \text{ ft} =$   
 $13,500 \text{ cubic feet or } 500 \text{ yards.}$

So, in this instance the operator would lose 500 cubic yards of gravel in potential sales. Naturally, as the pit deepens, the more gravel the operator would lose for sale.

## GOVERNMENT REGULATIONS

Government regulations affecting the sand and gravel mining industry are often complex and sometimes overlapping. Where necessary, the small operator will have to comply with federal, state, and local laws and regulations to open and conduct a sand and gravel mining operation. There is no question that compliance with these regulations increase the cost of the resource. On the other hand, there is little question that most regulatory requirements are beneficial to some degree. By understanding all the pertinent regulations, the operator can save both time and money and at the same time greatly improve the chances for approval of his permit or rezoning application.

It would be very difficult to list all the agencies and regulations affecting the sand and gravel mining industry. Laws and regulations vary from state to state and from county to county. Some basic similarities, however, do exist just about everywhere, including:

1. A permit, zoning approval,

variance, conditional use permit, or some other sort of government approval is generally required

2. To obtain government approval, the operator must usually explain what he plans to do
3. operator must usually explain how the environment will be protected during mining
4. The operator may need to show how public welfare and property will be protected
5. The operator will usually be required to explain how the mining site will be restored to a usable, productive condition.

It is advisable to expect that, in most cases, the above explanations will be required. The operator should be prepared to spend the time and money needed to comply with these and other government requirements.

Laws controlling mining are passed by federal or state legislatures. Regulations are usually written by the federal or state agency that is in charge of administering the laws. Regulations are not laws; however, for all practical purposes, they must be strictly followed. At the local level (e.g. county or city) zoning ordinances or approved land-use plans are generally the tools used for controlling mining activities. Zoning can be called a "police power" granted to counties or cities that allows them to control land use within their borders, even though the land may be privately owned. Authorized land-use plans are neither laws nor or-

dinances; however, they usually serve as the official guidelines by which Planning and Zoning Commissions make decisions concerning land use.

It is important to determine the degree of flexibility which a regulatory agency might have. Some requirements may be more or less extensive, depending upon the specific mine site conditions and the regulatory agency's past experience with a mine operator. The operator would also be well advised to find out if processes exist for appealing decisions of a regulatory agency.

#### **Federal Government**

There is no federal law which directly regulates the sand and gravel mining industry. There are some federal laws, however, which may have to be complied with during the mining operation. Table 1 lists

some federal laws which may affect the operation.

Almost all federal air and water quality standards must be met. The Environmental Protection Agency (EPA) may require a National Pollutant Discharge Elimination System permit (NPDES Permit) if water, contained in the pit or used for other purposes such as cleaning the resource, will be discharged from the mining site. Certain archaeological and historic sites, especially those included in the National Register of Historic Places, must be protected, as must endangered wildlife species. Mining and other land use and development activities are also strictly controlled in National Parks, National Forests and on other types of federal land. Several federal laws concerning occupational health and safety will generally apply to sand and gravel operations.

**TABLE I. FEDERAL LAWS POSSIBLY AFFECTING SURFACE MINING**

The Clean Air Act
The Federal Land Policy and Management Act
The Federal Water Pollution Control Act
The Fish and Wildlife Coordination Act
The Surface Mining Control and Reclamation Act (coal only)
The Wild and Scenic Rivers Act
The Fish and Wildlife Act
The National Environmental Policy Act
The Rivers and Harbors Act
The Mine Safety and Health Act

Naturally, it is difficult to contact every federal agency and to review every federal law. If the operator feels any of the requirements mentioned above may apply to his operation, the appropriate agency should be contacted. Appendix 1 lists a number of federal agencies which may have some control over sand and gravel mining operations. When attempting to contact federal agencies about specific questions, the operator should be prepared to make several calls and continue calling until the appropriate authority is reached. When contact is made, he should then ask for suggestions which will help him comply with legal requirements, and determine if the agency can provide any technical assistance in planning the operation.

### **State Government**

Currently, approximately thirty states have surface mining and reclamation laws affecting sand and gravel mining operations. Appendix 2 summarizes many of these laws and lists the appropriate regulatory authority.

When a decision is made to obtain a permit, the operator should contact the State Surface Mining Agency (sometimes called the Division or Department of Mining and/or Reclamation) and request copies of the laws and regulations pertaining to sand and gravel mining. He should identify the general area of the mine and ask if there is a specific agency or individual within the agency assigned to answer questions or provide information about the area. He should also inquire about the need to coordinate the proposed mining operation with county and city agencies, or other state agencies that might have a concern or legal interest. As an example, the State Surface Mining

Department may request the State Air Quality Department to review the possible effects of the proposed operation on air quality. Also, some agencies may be able to provide site information or technical planning assistance. If the operator believes it would help to eliminate problems in obtaining a mining permit, he might suggest a field trip to the proposed mining site with the regulatory individuals most involved in approving permit applications. The operator should not hesitate to ask for any assistance he feels to be reasonable.

An important item to determine as early as possible is the government jurisdiction (i.e. state, county, or city) under which the permit application will be reviewed and hopefully granted. Some state governments allow local jurisdictions to take the lead. Others maintain the right of final permit approval. To the extent possible, the operator should try to avoid duplicate applications, double delays, double bonding, and administrative difficulties between different agencies. For example, an operator might learn from state government that he needs county approval before the state will consider a permit application, but on the other hand, the county may require state approval first. To avoid this type of situation, the operator should try to determine the chain of authority as quickly as possible. He then needs to develop a strategy for compiling the permit application and a schedule for its submission. The operator should inform all regulatory authorities of any potential problem and attempt to arrive at an effective solution.

### **Local Government**

Usually, in the case of sand and gravel mining operations, the final authority to approve or deny a

permit application rests with the county, township, or city government. Some states require such local approval before a state permit will be issued.

Local government controls surface mining in one of several different ways. Sand and gravel mining can be subject to zoning ordinances, conditional or special use permits, land use plans, and variances. Occasionally a local government will have a special permit requirement which allows mining in certain zoned districts. A rezoning action is frequently required, particularly if the land use proposed after mining differs from that prior to mining. At a minimum, a mining and reclamation plan may need to be submitted to, and approved by, a local government. Approval may be required by the County Commission, the Planning and Zoning Commission, the Board of Variances or Adjustments, town supervisors, or by some special committee or agency. Public notice and public hearings are required in many cases.

A careful review of all pertinent government requirements should be conducted. This review should start long before the permit application is prepared and any field work undertaken.

### Permit Scheduling

There are a number of time-consuming factors which the small sand and gravel operator should consider when scheduling the preparation and submission of a permit application. Some of these include:

1. the time required to gather environmental data (sometimes on a seasonal basis)
2. the time required to pre-

pare the mining, reclamation, and pollution control plans, as well as other parts of the permit application

3. the time involved for administrative review by the regulatory agency(ies) and required public hearings/meetings (the operator should encourage the regulatory agencies to coordinate the scheduling of such hearings)
4. the time required in dealing with other pertinent agencies
5. the time required in determining the limitations and conditions of permit approval, as well as revising plans and applications
6. the time required in arranging and posting bond.

Many regulations specify mandatory time spans within which a review and decisions must be made. But, since there are so many variables involved, these time spans are not always reliable.

To determine an absolute minimum length of time required to obtain all necessary approvals, the operator should ask the regulatory agencies about provisions concerning timing. The operator can also question the length of time it "usually" takes the regulatory agency to review and approve the permit applications. He can also ask other operators who have gone through the process how long it "actually" takes to obtain an approved permit.

Final approval of a sand and gravel mining request can take any-

where from 30 days to several years, depending on the state, county, environmental, and community conditions. Community opposition is probably the greatest cause of delay in the sand and gravel permitting process.

Permit scheduling should provide for more time than either the operator or the regulatory authority has estimated. Government action on a mining request will almost always take longer than anticipated. Such actions rarely take shorter periods of time than anticipated.

If permit approval is being withheld due to one or two points, a limited mining operation may be allowed by the regulatory authority. That is, the operator may be allowed to clear some property and construct drainage diversions or sediment ponds prior to final permit approval. It is not a good idea, however, to always count upon this possibility.

### **Bonding**

A bond (sometimes called a performance bond or surety) is cash or cash equivalent provided by the sand and gravel operator, and held by the regulatory authority to insure that mining and reclamation are properly conducted. The bond serves as a guarantee that the conditions of permit approval are complied with. The amount of the bond often varies, but usually it is set at an amount equal to what the regulatory agency estimates it would cost to reclaim the site. Most bonds are set on a per acre basis. Some are set depending on the anticipated difficulty of reclamation and the potential degree of environmental impact.

Some government agencies have certain flexibility in determining the amount of bond. If an operator

has an acceptable compliance record and has successfully reclaimed previous mining sites, the bond requirement amount may be lowered. This is a cost-effective reason why sand and gravel operators should properly plan their reclamation and pollution control activities, and further conduct their operation in an environmentally acceptable manner.

To get the bond back, the operator has to apply for, or request, bond release. The regulatory authority will decide if the bond can be released, based on the quality of the reclamation effort. If it is within the regulatory agency's power to do so, the operator should encourage the agency to provide bond releases proportionate to the amount of reclamation. In many cases, prior to releasing a bond, the regulatory agency may be required to make a site inspection to judge the success of reclamation. Two important features, most likely to be examined, are the stability (steepness) of graded slopes, and the amount of ground covered with vegetation.

The operator should make sure that the conditions for bond release are clearly written. He should understand fully what is required, and request bond release only when reclamation standards described in the permit are accomplished.

Bonding is a legal issue and should be reviewed by a lawyer. On a case-by-case basis across the country, many different situations can arise. One example of the need for legal counsel arises when both a state and local government require bond for the same operation. It may be possible that one bond will be adequate, and thus, the operator may be able to avoid double-bonding.

## Working with Regulators

The best way to insure practical and fair legislation concerning sand and gravel mining is to become involved before laws are enacted. This applies to regulations as well. Almost all law-making bodies and regulating agencies encourage private sector comment (public hearings, written comments, planning meetings, etc.). It is much more difficult to change a law, after it has been passed, than to provide suggestions during the time it is being considered for enactment.

On a local level, it is wise to encourage what is sometimes referred to as "mineral deposit designation." This involves having a state agency (most likely the Geological Survey) locate, map and describe sand and gravel deposits. The map then needs to be officially recognized as one which designates areas where future mining could be allowed. The map can then be used by the local Planning and Zoning Board, or other official body, to make decisions affecting sand and gravel mining. The designation of a parcel of land as a mineral resource area (e.g. sand and gravel deposits) alerts the decision makers to the following:

1. A request for a permit to mine in this area can be expected at some time in the future
2. If residential development is allowed within these areas, community/industry conflicts will most likely occur.

Mineral resource designations can often help speed up the permitting process, since this designation implies "this is where the resource is located, so this is where the mining will likely occur."

## COMMUNITY INVOLVEMENT

Citizens or groups of citizens may object to a proposed sand and gravel mining operation. Generally, the more people living near the mine site, the greater the chance of opposition.

Basically, there are two options for dealing with the local community. One, mine plans and permit applications can proceed through the regulatory review without citizen involvement, or, two, the community can be involved in the planning and permitting process. The first option is dangerous because the further along an operator is into the permitting process, the more costly and time consuming it is to change plans. Frequently, community groups will raise objections to a proposed sand and gravel mine well into the planning process. It is advisable for the operator to contact local residents, homeowners groups, and environmental groups prior to submitting a permit application to the regulatory authority. Initial plans should be discussed and an effort should be made to determine if there are specific concerns. The operator should be prepared to answer citizen questions in the event a public hearing is required.

To work best, community involvement should be a two-way street. The operator should explain the need for sand and gravel, how it is used everyday by everyone, and what the difficulties are in mining it. He should also be prepared to discuss specific plans aimed at alleviating local concerns. The concept of "tradeoffs" should be stressed in discussions. An example of a tradeoff is "if we can't mine aggregates at this location, they will have to be trucked over longer distances, thus raising the aggregates' price." The tradeoff is

clear -- a local supply of sand and gravel, or substantially increased construction costs. Such tradeoffs, however, would have to be balanced against valid issues raised by the community. Such issues might include:

1. Pollution
  - Noise
  - Dust
  - Water Pollution
  - Visual Appearance
2. Vehicular Traffic
3. Site Safety
4. Reclamation - "what will be left after mining"
5. Property Values
6. Overall Quality of Life.

Many operators feel that the less the community knows about the mining plans the better. This approach may have worked in the past but, in most cases, will not work today. In fact, if a citizens group feels that a hearing to discuss a permit application has taken place without proper notice, the intensity of the opposition can be greatly increased. Enabling citizens to voice their concerns and suggestions will generally help to avoid conflicts and problems at a later date. Advice and educational materials can often be obtained from local, state and national trade organizations, dealing specifically with the sand and gravel industry, to help the operator in his public relations efforts.

The mine operator should seriously inform local citizens that the sand and gravel company is just as much a part of the community as they are, and that he also shares environmental and social concerns.

He should also stress that, by working together with the regulatory agency, the end results can serve a variety of interests.

During some public hearings or meetings, overemotional pleas to ban mining (based on environmental grounds) may be forthcoming. It is important for the operator not to respond to emotional pleas with more emotional pleas, but instead, respond to the issues in a positive and clear manner. Additionally, if the operator believes it is impossible, or economically impractical, to comply with a request, he should not promise to do so. He should carefully explain the technical and economic constraints involved and suggest a compromise action.

## **SITE ANALYSIS**

An analysis of the natural environment of the proposed sand and gravel mine site is critical to good planning. Sometimes it is a regulatory requirement that such an analysis be performed. If so, the operator should find out, during the early stages of planning, what is required during the analysis.

In most cases, when performing an analysis, data should be gathered on the climate, soils, sand and gravel deposit, material underlying the deposit, surface water, ground water, vegetation, wildlife, land use and other significant features. This data can be used for compiling the permit application, to prepare mining, reclamation, and pollution control plans, as well as an environmental impact assessment, if required. The regulatory authority may also wish to review the data to determine what they feel will be the possible adverse environmental impacts of mining.

The site analysis should be

completed before the permit application is prepared and submitted to the regulatory agency. It should be noted that, in some cases, one year or longer may be required for the site analysis, particularly if data covering seasonal variations are required.

### **Climate**

As part of the site analysis, three important aspects of weather should be considered: temperature, prevailing wind directions, and precipitation (rainfall and snow). If special weather conditions leading to pollution are found to sometimes exist, such as frequent temperature inversions which stagnate the air, they too should be studied. Wind studies are important to determine the direction fugitive dust could blow. Rainfall information is used to determine when peak flows (run-off) can be expected and to determine the best time to plant or seed to take advantage of plentiful water. Knowledge of heavy rainfall periods can also help in planning the use of techniques to assist in controlling erosion and sedimentation. The operator should attempt to minimize the acreage of land disturbed during high rainfall times of year, since soil is much more susceptible to erosion once vegetation is removed.

### **Soils**

It is important to determine during the premining planning process how soils will be handled during excavation and reclamation. The thickness, volume and fertility status (nutrients, potassium, phosphorus, and nitrogen) of the soils should be determined. Prior to mining an area, the soils should be removed and stockpiled for use during revegetation efforts. If stockpiled soil material must be saved for a

long period of time, quick-growing grasses should be established on it to help control erosion. Once the resource is removed, the pit can be regraded and the stockpiled soil material spread over the regraded land. To prepare the soil for planting and/or seeding, it should be roughened and fertilized. Fertilizer is used in amounts determined through soil tests. Lime may be required if the soil pH is low (too acid). Mulching may also be necessary.

### **Geology**

The most important part of the geologic analysis is to characterize the sand and gravel deposit itself. Resource thickness, and percentage of gravel, sand, silt, clay, and waste material should be determined. Potential pollutants contained in the gravel deposit, such as clay, which could be washed away to silt up streams, should be identified. Any material located above the sand and gravel deposit that is not marketable, but must be removed to obtain the sand and gravel, is called waste material or overburden. Topsoil material, or material to be used for topsoiling, should not be considered as waste. The geologic report should describe the waste material in detail, and attention should be given to any potential use of the material during the reclamation phase of the mining operation. The presence of major faults, geologic hazards (potential for landslides, subsidence, flooding or earthquakes, etc.) should be addressed in the geology report.

The geologic analysis may also include an investigation of the location and type of materials present below the gravel deposit. Regulatory agencies may require such information since it relates to ground water protection. The material be-

low the gravel deposit may be an aquifer (i.e., holds water) or it may serve as an aquifer recharge (i.e. water passes through the rock and collects elsewhere as ground water). The material below the gravel can be determined in three basic ways: (1) by reviewing maps and reports that describe the local geology, (2) by examining outcrops (i.e. surface exposures), and (3) by drilling a test hole down through the gravel to recover samples of the material below.

## **Water**

An important part of any mine site analysis is the determination and description of the water supply in the area of the mine. Features which should be investigated include water on the surface of the ground, such as streams and ponds, and ground water. Ground water is part of the total water supply that collects in the rocks and earth material below the water table. The depth beneath the earth's surface to ground water (or the water table) can be either shallow or very deep. Generally, the closer the water table is to the surface, the more important it becomes to study all aspects of water supply in the area.

All surface water in and around the mine site should be described. This includes streams, ponds, reservoirs, drainage ditches, springs, and irrigation canals. The description should include the location of the water body, the area and depth of ponds, the volume and direction of stream flow, and any other pertinent characteristics. The regulatory authority will often require such information to determine if the mining operation could affect water supply.

Information which should be collected for ground water includes

depth to the water table, direction of ground water movement or flow, and local use of the ground water. Particular attention should be given to water wells used for domestic or agricultural purposes. A permit application may require information on the location and ownership of water wells. If these wells dry, or become depleted during mining, the regulatory agency may require the mine operator to drill a new well.

Ground water studies may require the installation of observation wells in or around the proposed mine site. Ground water that is pumped from the excavation pit, or that drains from storage areas, could affect surface water supplies. For this reason, the quality of the water, as well as the amount, should be determined during the site analysis.

## **Wildlife**

Forms of wildlife, which should be considered during the site analysis, include birds, land animals, and aquatic wildlife. Since mining can permanently alter wildlife habitat, the analysis should provide a description of the existing wildlife habitat conditions.

Minimum habitat conditions which should be investigated include:

1. vegetative cover
2. water and food availability
3. species variation and relationship
4. migratory routes and reproduction areas.

A count or inventory of wildlife occupying the site may have to

be made. Such inventories may have to be accomplished over several seasons, particularly if some wildlife species do not use the area all the time.

In some cases, a list of the species present at the site may be required. Particular attention should be given to endangered, threatened, and rare species. State or Federal Wildlife Agencies can often provide a list of such species. The regulations governing endangered species are strict, but regulations governing threatened and rare species are often less strict. There are endangered species in almost every area of the country, so the operator should take care to check local lists, which are usually available through Federal or State Wildlife Agencies.

Other information which will also be useful includes:

1. Name of species
2. Population (number)
3. Population density (distribution)
4. Diversity of species
5. Food chain description
6. Types of habitats occupied.

## Vegetation

Vegetation in and around the pit area is usually destroyed by extraction activities. Many regulations require the site vegetation to be inventoried before mining. This is done to determine if any unique vegetation is present. Additionally, the vegetation inventory can be used by regulatory authorities to judge the wildlife habitat value of the site. Three general types of

vegetation can be present on the mine site. They are trees, shrubs, and grasses.

The vegetation inventory should provide the following types of information:

1. Types of vegetative species present
2. The approximate amount or percent of ground cover for each species
3. Vigor, maturity, height, etc., of each species
4. Value of vegetation for wildlife habitat
5. Identification of any unique vegetation.

Replanting or reseeding the same types of native vegetation that were destroyed by mining can be a favorable proposal. The fact that certain species of vegetation were already growing on the site is an indication that they could be well suited to the area after mining.

Any economic potential, for example, the value of existing mature trees, should also be explored during the site analysis.

## Topography

The topography of the mine site refers to its surface shape or geometry. It is an important factor in mine planning because it affects drainage, ground water, slope stability, erosion potential, and reclamation practices. The best way to display the topography is through the use of topographic maps. Some topographic maps are available from the U.S. Geological Survey. These maps are at a scale of 1" - 2,000 feet, which in some cases may not be

large enough to be useful for mine planning. It is wise to check with the regulatory authority about map scale requirements.

Arrangements can be made with an aerial mapping company to fly the site and prepare a map of predetermined scale and contour interval. Some engineering firms also develop maps from ground surveys. For a small site, it would probably cost less if this method was used for developing the map.

The topographic map should show the elevations of the mine site (by contour lines), water bodies, roads, utilities, buildings, etc. The property boundary and the permit area should also be shown. The map may cover only the mine site itself, or it may cover the mine site and adjacent areas.

A well prepared topographic map can be used as a base map for plotting additional mine site data such as soils, vegetation, mining plans, reclamation plans, and the location of mine facilities and pollution control structures. If possible, the map should also indicate the steps to be taken in coordinating extraction and reclamation activities.

### **Cultural Resources**

More and more government regulatory agencies are requiring information on cultural resources. Cultural resources are historical and archaeological sites considered valuable to the public. They require careful consideration during the premining planning phase of the operation. Archaeological sites are areas where evidences of the prehistoric activities of man are found. Indian dwellings and camps are examples of archaeological sites.

Operators should check to see if there is a State Archaeological Survey or Agency. If so, they usually have a complete inventory of known archaeological sites in the state. Private archaeological clubs or societies may also keep local records of such sites. If an archaeological survey is required and no information can be found, help may be sought from an archaeological consultant or university department. In the event such assistance is not available, the operator may wish to engage a qualified archaeologist to conduct a cultural resources survey, which is a pedestrian investigation of the mine area to locate and identify any cultural resources that might be present.

Even if the operator states in the permit application that no archaeological sites are present, he may still be required to stop mining if evidence of such is uncovered. The usual procedure is to call in trained experts and have the find examined.

Historic sites may include roads, railroad structures, houses and other buildings, towns, camps, battlefields, etc. The operator should pay particular attention to the National Register of Historic Places. Also, state and local historic preservation societies may be able to help with the inventory.

If historic or archaeological sites are not present at the mining site, a simple statement to that effect in the permit application is usually sufficient. Where such sites are present, it does not necessarily preclude mining, but some salvage and preservation plans may be required.

A third and less common type of cultural resource is scenic or scientific sites of interest. Occasionally, state and local laws will

protect such areas. Such areas may include scenic overlooks, spectacular outcrops or landscape features with high local identity, and fossil localities. If such features exist at or near a proposed mine site, plans for their preservation and enhancement may be needed.

### **Natural Hazards**

During the site analysis, efforts should be made to identify areas of potential natural hazards. The two most common types of natural hazard areas include: areas which are prone to landslides, and areas which are potentially subject to flooding.

The early identification of such areas will allow the operator to develop mining plans aimed at avoiding or bypassing such areas during extraction. He will also be able to prepare adequate plans for dealing with resultant problems should such areas and conditions be encountered during the operation.

### **Land Use**

Collection of land use data for the mine site and adjacent area may be required. This type of information is often shown on a map developed for the mine site. Land use categories can be obtained at County or City Planning Offices, or may be determined in the field by visual observation. The categories of land use described should match the categories used by local planning agencies.

Some common land use categories include:

1. Residential
2. Commercial
3. Industrial

4. Public Use (e.g., schools, hospitals, churches etc.)
5. Agricultural/Forest Lands
6. Open Space, Greenbelt, or Park
7. Recreational
8. Vacant
9. Wildlife
10. Public Lands (state and federal lands)
11. Mining and Extraction.

The regulatory authority can use the land use data to determine if the proposed gravel operation is "compatible" with surrounding land uses. Compatibility is sometimes difficult to determine, but land use data collected in the planning stages of the operation can be very valuable in identifying potential land use problems which could later develop.

### **MINING AND RECLAMATION PLANS**

Once the site analysis has been completed, the operator can start work on developing mining and reclamation plans. These are two of the most important components contained in the mine permit application. These plans, when reviewed with the environmental data collected on the proposed mine site, allow the regulatory authority to reach a decision on whether or not a permit should be issued. Mining and reclamation plans are prepared using the data collected during the site analysis. Such plans should be presented in a fashion that will enable the decision-making body to readily establish that measures to protect the environment were carefully considered.

The preparation of both the mining and reclamation plans should be closely coordinated. The first load of material removed or transferred from the site should be handled and managed with reclamation in mind. It is generally more expensive to restore land that was mined without consideration for reclamation than to restore an area where reclamation was considered during the planning process. Concurrent mining and reclamation, sometimes referred to as "in-progress-reclamation," (which has been achieved by planning for reclamation in advance of extraction activities), can assist the operator in achieving the greatest degree of success at the lowest possible cost.

Figure 3 shows a mined gravel pit where excavation extended to the property boundary. The options for grading and revegetating this slope are limited. Before various reclamation laws were passed by state and local governments, many operations such as this one maximized gravel extraction by excavating the entire property. If there is a slope requirement, for example, three feet horizontal to one foot vertical, some marketable gravel material must be left in place. The other alternatives would be to purchase neighboring property (to carry the slope back), or to bring in fill material and build up the proper slope. Both alternatives would probably cost more than the value of the gravel

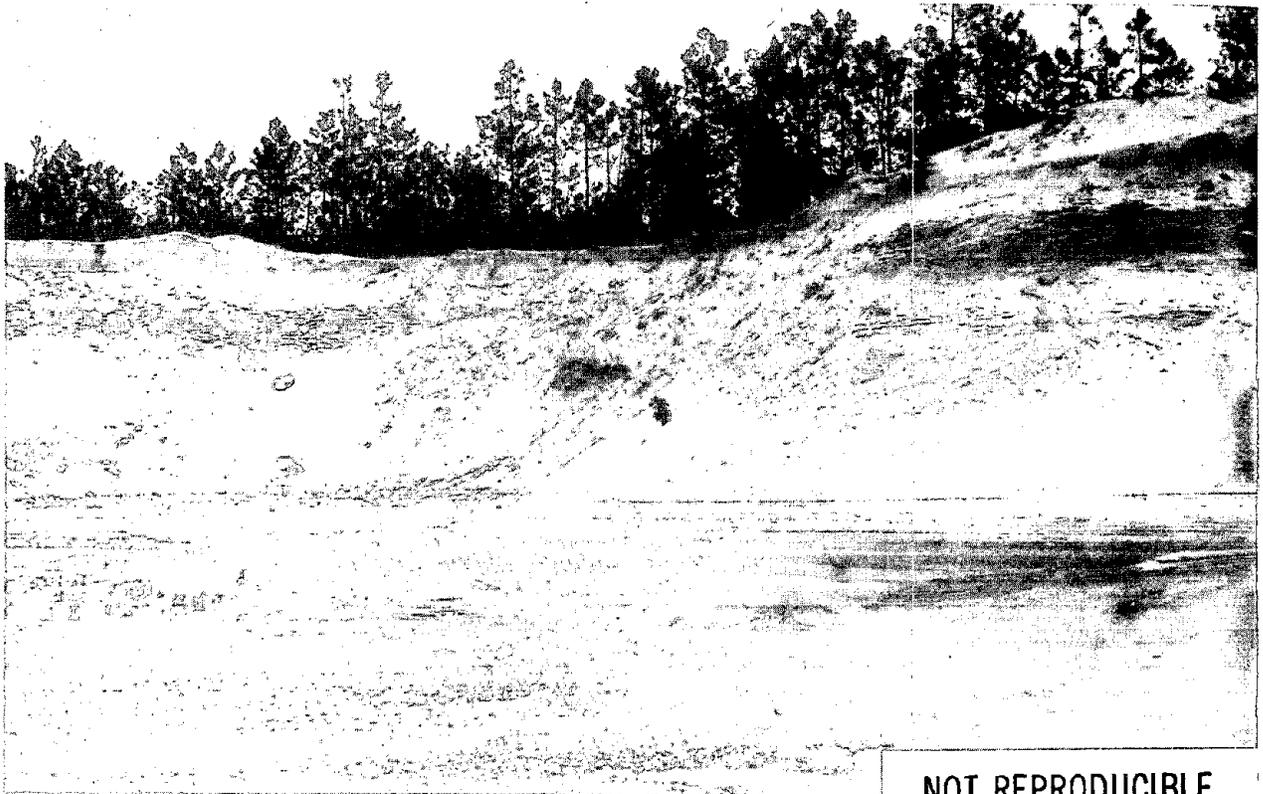


FIGURE 3. MINED GRAVEL PIT WITH EXCAVATION EXTENDING TO PROPERTY BOUNDARY

that would have to be left unmined and used to attain final slope requirements. Each of these alternatives should be carefully considered when preparing the mining and reclamation plan.

The mining plan should address the schedule of mining activities, the direction in which mining will advance, and the anticipated duration of the operation. The reclamation plan should discuss such items as regrading activities and schedules, the types of vegetation to be planted, and the time of year during which planting and seeding will be conducted.

The plans are best presented by using maps with an accompanying text. The maps should show the property boundaries, with extraction areas clearly indicated. The direction in which mining will proceed and the anticipated time required for extraction and reclamation activities may also be shown. A good procedure to use when preparing plans for submission to a regulatory authority is to indicate and show that both extraction and concurrent reclamation will be accomplished in stages. Figure 4 shows an example of this procedure. Under this concept, excavation begins on one part of the property (Stage I, Figure 4). As soon as extraction of the resource is completed in this area, soil spreading, grading, and revegetation activities are undertaken, and extraction is started in an adjacent area. This procedure enables the operator to keep reclamation current with extraction throughout subsequent stages of operation. Proposal of such a plan can demonstrate to the regulatory authority that the operator will not delay reclamation until the end of the operation. Also, the operator can spread the costs of reclamation over the life of the mine and not have to

pay all such costs at one time.

Mining and reclamation plans should also address the following items:

1. entrance and exit to the site
2. access and haul roads
3. pit area(s)
4. stockpile areas (including soil and material storage areas)
5. location of sediment ponds and drainage diversion
6. discharge points
7. visual screen locations
8. preparation plant area(s), and
9. other site facilities.

In addition to depicting reclamation activities and showing the locations of pollution control structures, the operator should explain why they are needed and how they will function. For example, the operator might state that the site layout and direction of mining would be designed to screen the initial excavation activities from public view. Later in the operation, the initially excavated area can be reclaimed and serve as a visual buffer for future operations. He might also indicate that a sediment pond would be located in the most advantageous place to catch runoff from the mine site, as well as enhance the postmining use of the land.

Overall, the most successful plans are those that provide a balance between the operator's produc-

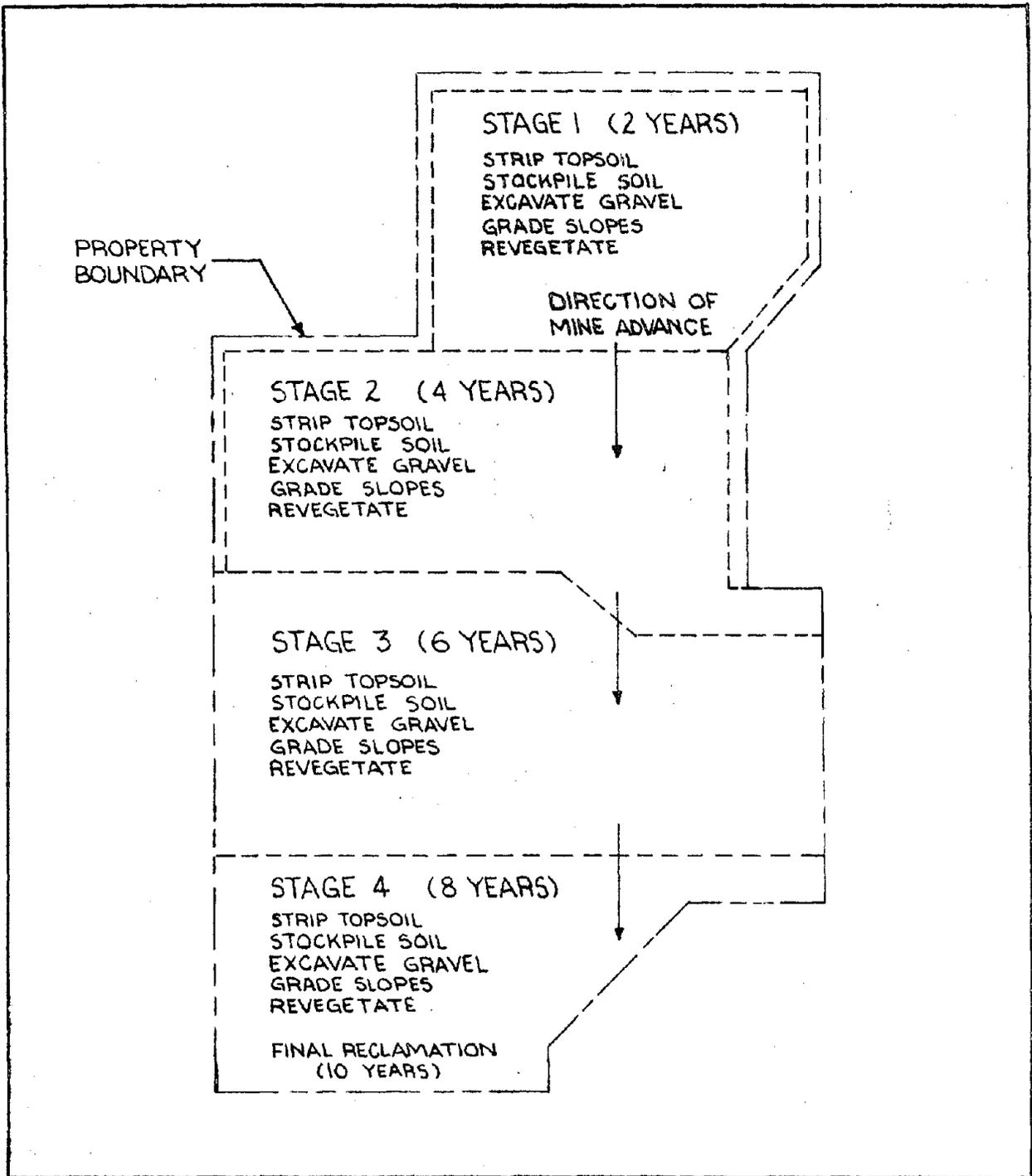


FIGURE 4. ILLUSTRATION OF THE 'IN-PROGRESS' OR 'CONCURRENT' MINING AND RECLAMATION CONCEPT.

tion requirements and environmental and reclamation requirements.

## SOURCES OF ASSISTANCE

### Government Agencies and Other Organizations

In preparing mining and reclamation plans, or permit applications, the operator can either do it himself or pay a consultant to assist him. In either case, it is important to determine the government agencies which provide free information and technical assistance upon request.

Areas in which the operator may require assistance or information include:

1. Weather (data)
2. Wildlife (data)
3. Vegetation and Revegetation
4. Soils
5. Geology - both the sand and gravel and the material beneath it
6. Surface drainage (streams and ponds, etc.)
7. Ground water (water table elevation and location of wells)
8. Land Use Planning (the reclamation plan)
9. Vehicular Traffic Planning.

The operator should make the effort to inquire about information or assistance which may be available from federal, state, and county or city government agencies, nonprofit

organizations, universities, and local groups or organizations such as garden clubs, Audubon clubs, Wildlife clubs, etc. Asking for information from agencies or organizations such as these could be very beneficial. In fact, many organizations are formed with the sole purpose of gathering and dispensing information.

Permit applications generally require a substantial amount of environmental data about the mine site. These data do not necessarily have to be collected by, or at the expense of, small mine operators. If pertinent existing data can be found, which was obtained close to the proposed sand and gravel mine, it can often be used in preparing the permit application. The operator may have to do some field work, but available data should be used to the extent possible. If existing data is used, however, the operator should verify that such data accurately reflects conditions applicable to his site. Most regulatory authorities encourage the use of existing data as cost and timesaving mechanisms for the preparation of permit applications.

The operator must remember that responses to requests for information take time. As with all mine planning, this activity should be started as soon as possible after a decision to mine has been made. The operator should ask each person contacted if they are aware of other sources of information or advice. People are often surprised to learn just how much information really does exist concerning water, soils, wildlife, etc. Often in a short period of time, a great deal of useful information can be assembled at low cost to the operator.

Table 2 provides information on potential sources of assistance and data.

**TABLE 2. POTENTIAL SOURCES OF ASSISTANCE AND INFORMATION**

Area of Concern	Potential Sources
Weather (Data)	<ul style="list-style-type: none"> <li>● National Oceanographic and Atmospheric Administration</li> <li>● National Weather Service</li> <li>● State Air Quality Agencies</li> <li>● Libraries - Weather Records</li> <li>● Records from Previous Operations (Mining Companies)</li> </ul>
Wildlife (Data)	<ul style="list-style-type: none"> <li>● U.S. Fish and Wildlife Service</li> <li>● State Wildlife Agencies</li> <li>● National Audubon Society and Other Wildlife Organizations</li> </ul>
Vegetation/Revegetation	<ul style="list-style-type: none"> <li>● U.S. Soil Conservation Service</li> <li>● County Agriculture Extension Services</li> <li>● Land Grant Colleges (Agriculture Departments)</li> <li>● Local Garden Clubs</li> <li>● U.S. Forest Service</li> </ul>
Soils	<ul style="list-style-type: none"> <li>● State Departments of Agriculture</li> <li>● U.S. Soil Conservation Service</li> <li>● Local Conservation District Offices</li> <li>● County Agriculture Extension Services</li> </ul>

TABLE 2. (CONTINUED)

Geology	<ul style="list-style-type: none"><li>• State and U.S. Geologic Surveys (Topographic Maps/Aerial Photographs)</li><li>• Universities and Colleges (Geology Departments)</li><li>• Drilling Records from Previous Mining Operations (Mining Companies)</li></ul>
Water (Surface/Ground)	<ul style="list-style-type: none"><li>• State and U.S. Geologic Surveys, Water Resource Division</li><li>• State Water Agencies</li><li>• State/County Water Boards</li><li>• Water Records from Mining Operations (Mining Companies)</li><li>• U.S. Soil Conservation Service</li><li>• U.S. Forest Service</li><li>• U.S. Environmental Protection Agency</li></ul>
Land Use	<ul style="list-style-type: none"><li>• Local Planning Agencies</li><li>• Regional Planning Agencies</li><li>• State Planning Agencies</li></ul>
Vehicular Traffic Planning	<ul style="list-style-type: none"><li>• U.S. Department of Transportation</li><li>• State Highway/Transportation Departments</li><li>• Local Road and Bridge Departments</li><li>• State/Regional/Local Planning Agencies</li></ul>

## Consultants

Technical requirements for obtaining a mining permit are at times complex. Specialists such as geologists, surveyors, hydrologists, wildlife biologists, soil scientists, revegetation experts, meteorologists, land use planners, etc. may be needed. Many small sand and gravel operators neither have nor want large engineering and environmental staffs. As a result, a consulting company may be used to conduct certain specific tasks or to handle the entire planning and permitting program.

To decide upon the use of a consultant, the operator should ask himself the following questions:

1. Can the job be done without using a consultant?
2. Will the use of a consultant help or hinder the chances for permit approval?
3. Are there regulatory requirements to use "certified," "registered," or "professional" people to do certain things?

4. Can I afford the cost of a consultant?

If the decision is made to use a consultant, choose one that has local experience and recognition, is familiar with sand and gravel regulations, and is able to provide as many of the needed services as possible. More than one consultant may have to be used to meet all the requirements.

In public hearings or meetings, an expert witness may be needed. It would be best to use one of the consultants who help prepare the permit application. Any expert witness used by the operator should have knowledge of the local political situation.

When retaining a consultant, be as specific as possible about the work to be accomplished. The operator should attempt to determine what kind of reputation the consultant has with the regulatory authority or the decision-making body. If an individual or company has successfully assisted in obtaining permits for previous sand and gravel operations, the chances are they are capable, reliable, and well respected by the regulatory agency and other public groups.

## SECTION II. COMMUNITY RELATIONS: BEFORE, DURING, AND AFTER MINING

Some of the significant points discussed in this section are:

1. Extraction and reclamation activities must be planned to produce minimal social and environmental impacts.
2. Operators should effectively communicate with citizens to stress the need for sand and gravel mines, and to convey proposed mining operation plans.
3. Significant community concerns about the proposed mining operation plans should be determined as quickly as possible.
4. Mine operators should understand what is legally required to mine. They should determine additional steps they are willing to undertake to reduce community concern. Operators should not promise to do more than they are willing and able to do.

### OVERVIEW

It is important to involve the community in the sand and gravel mine planning process. Residents living near the proposed mine site could very well oppose the operation if they feel the mining activities might create problems resulting in personal loss. Public decision makers generally respond to citizen concerns, and the operator should expect that some adjustments will have to be made in mining and reclamation plans to reduce community and citizen concerns.

The operator should attempt to communicate with citizens before any public hearings, and carefully note their concerns and complaints. He should be prepared to address these concerns and complaints during public hearings or meetings. The small sand and gravel operator should stress that he is a concerned member of the community, and should not hesitate to discuss the methods he will use during mining to protect the environment and the quality of the community. The operator has a

legal right to request mining approval, and he should show that all steps are being taken to comply with laws and regulations.

The operator should not agree to anything that he does not intend to do, can't do, or of which he is not certain. Such action could label him as a "promiser" and not a doer.

There will always be people unwilling to compromise and likely to demand permit denial on a "no growth-no development" basis. Such individuals should be asked to note specific areas of concern, so that the operator may respond to each issue. If this action fails, the operator has to rely on the judgment of elected or appointed decision makers.

### DEALING WITH THE COMMUNITY

In the past, many mine operators preferred to keep quiet about their mining plans, an approach that

is no longer acceptable. The operator's chances for obtaining an approved mining permit can be jeopardized if the community and the decision makers feel that enough information has not been made available.

Depending on local circumstances, it may be necessary to educate the community in order to obtain a permit. Such education efforts should center on: (1) the construction aggregate industry in general, and (2) the specifics of the operation in question (being proposed). In terms of the location of the proposed operation, it should be pointed out that sand and gravel resources can only be mined where deposited by nature. Explaining the geologic occurrences of sand and gravel resources may be helpful (Figure 5).

When discussing the sand and gravel mining industry and its essential functions, the operator should explain why aggregates (sand and gravel) are needed. Many individuals are not aware that roads, concrete, asphalt, houses, commercial buildings, and many other types of structures and products require aggregates. These aggregates can be supplied at a relatively low cost if the source (the mine site) is located close to the market area. Haul distance is a critical factor in the price of sand and gravel. If the industry is required to seek remote, unpopulated areas to mine their product, the price could rise significantly.

Extraction and reclamation plans for the proposed mine site should reflect local concerns. The operator should inform interested parties of his plans to deal with their concerns. Zoning ordinances, special or conditional use permits, and state mining and reclamation

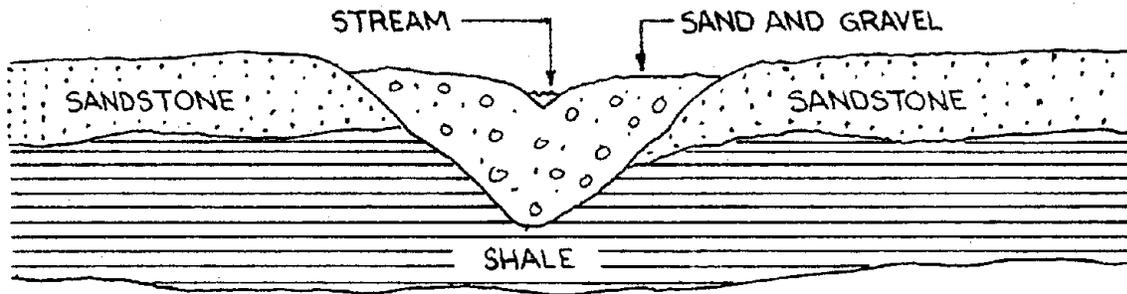
permits all recognize the negative impacts of mining, but they also recognize that these impacts can be significantly reduced.

Practices such as visual screening, dust and noise control, vehicular traffic control, pollution abatement, and reclamation all cost money, but the operator must be willing to use these practices if he is to obtain permission to mine. The use of these practices is, in fact, an attempt by the operator to deal with community concerns.

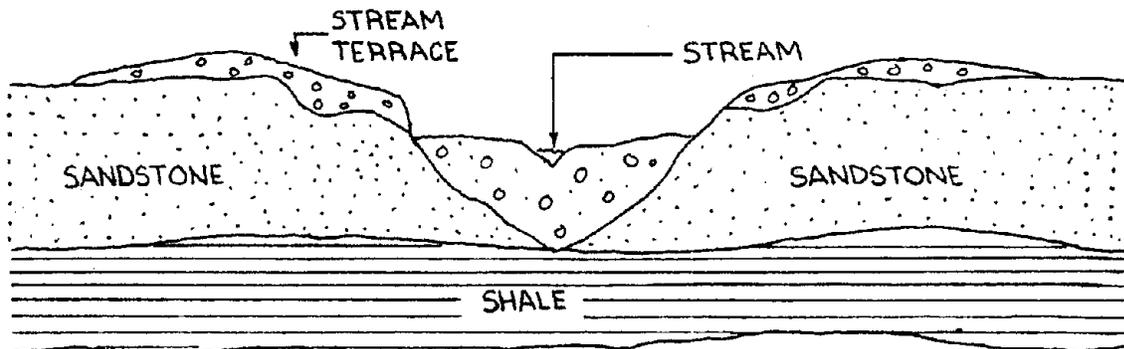
Operators have a legal right to request a mining permit, but they also have the responsibility to control environmental and social impacts. The community also has a responsibility to accept the operator's legal right to conduct business, to acknowledge the need for aggregates, and to recognize that, if the community wishes to build and grow, it must share part of the responsibilities of meeting raw material demands. Such rationale can be used effectively by the small operator when addressing concerned citizens, especially those individuals who may be opposed to any type of mining in or near the community.

When addressing local citizens, the operator should always discuss the value of sand and gravel resources as a maintenance material. Even if further construction never occurs, a considerable volume of sand and gravel material would be needed just to maintain existing structures and roads. Road repair, home maintenance and additions, road sanding, fill material, and concrete all require aggregates in the normal course of maintenance and repair. The volume of construction sand and gravel needed for maintenance alone requires the location and extraction of new reserves.

EXAMPLE 1 : STREAM BED SAND AND GRAVEL DEPOSIT (ALLUVIAL DEPOSIT)



EXAMPLE 2 : STREAM TERRACE SAND AND GRAVEL DEPOSITS



EXAMPLE 3 : UPLAND SAND AND GRAVEL DEPOSITS

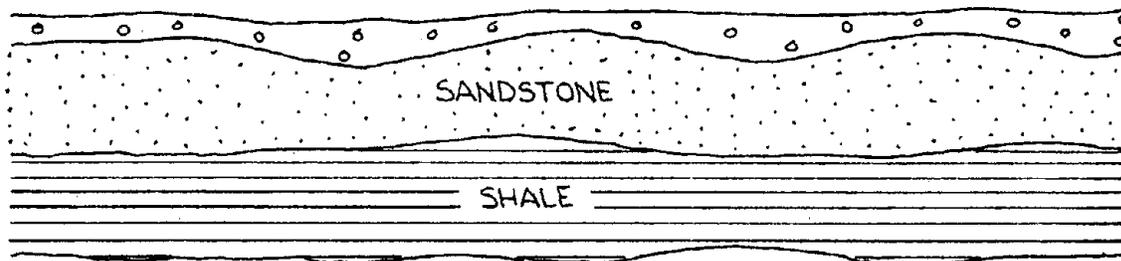


FIGURE 5. ILLUSTRATION OF COMMON GEOLOGIC OCCURRENCES OF SAND AND GRAVEL DEPOSITS

As previously mentioned, the price of sand and gravel depends greatly on haul distance. The farther away from the market area the material is mined, the farther it has to be hauled. The farther it is hauled, the higher the price is. Ultimately, this increased price will be passed on to the general public. When confronted by community opposition, the operator should never fail to address this valid point. Naturally, few people want a gravel pit close to their homes, but neither do they want rising construction costs. The problem, of course, is that the mine site is immediately visible, while future increases in costs are not so obvious. The operator should stress that tradeoffs or compromises are often necessary in the best interests of all concerned.

#### **PUBLIC HEARINGS: THE FORUM FOR CITIZEN INPUT**

Most regulatory systems provide for public hearings and comments. The most common include zoning hearings, town meetings, and other local government hearings. During these procedures, the decision-making body (e.g. County Commissioners, Planning and Zoning Boards, etc.) will normally listen to the mine operator's plans and provide private citizens with an opportunity to comment. Witnesses, questioning, cross-examination, and other courtroom-type procedures may be used during these meetings. In some cases, the operator may be required to prepare for such hearings as if he were preparing for a jury trial.

An important aspect of the public hearing process is what the operator does before the hearing. Entering a public hearing without being adequately prepared can often lead to permit denial. Prior to public hearings, the operator should:

1. Review the regulatory agency's comments
2. Become thoroughly familiar with applicable zoning ordinances and all pertinent laws and regulations
3. Determine significant community concerns and issues which may be raised
4. Attempt to determine the attitudes of the decision makers
5. Make sure that expert witnesses completely understand the proposed extraction and reclamation plans
6. Arrange for legal representation to be on hand.

The operator should consider who will present information at a hearing. Should an operator allow a lawyer, expert witnesses, or consultants to present information and plans, the public may feel that the operator himself is neither interested nor concerned. The operator must remember that decision makers and the general public know that he will provide overall direction of the mining operation, and that the public will hold him responsible for complying with regulatory requirements.

Detailed notes on the hearing should be taken. If possible, all information presented at hearings should be recorded and transcribed. Particular attention should be given to requests for information and actions not specifically required by law. Occasionally an operator may be asked to do more than is legally required. The operator should make note of all such requests and determine his willingness to comply. If an operator plans to undertake mea-

asures to protect the environment and the community which are beyond legal requirements, they should be pointed out clearly. Every compromise the operator makes should be identified. Demonstrating a willingness to undertake such measures improves the operator's chances of obtaining speedy approval of the permit application.

Graphic aids can be effective tools for use at public hearings. Maps, photographs, and slides can portray present conditions as well as proposed plans for conducting a safe and environmentally sound mining operation. In any event, plans should be clearly and simply presented. Complicated engineering drawings (unless requested) should be avoided, if possible, and the presentation of information should be geared toward a non-technical audience.

The operator must stay calm during the hearing process, particularly when emotional comments are presented. In some instances, homeowner groups or other community organizations may conduct their own meetings prior to the formal public hearings. During such meetings, some individuals may become extremely dissatisfied with the mining proposal. When confronted with such attitudes during public hearings, the operator should calmly respond and offer to meet with the individuals to discuss an agreeable solution. Using such an approach will show local citizens the operator is truly concerned about the community and the protection of the environment. The operator must remember that decision makers and the general public will be judging him as much as they are judging the extraction and reclamation plans.

Finally, mine operators should not expect quick decisions on issues

addressed at hearings. In most cases, the stiffer the opposition, the longer the wait. The operator should not rush to commit equipment or capital to an impractical schedule, but should be prepared to wait a reasonable period for decisions and approvals. If the operator pushes for a quick decision, such action may be viewed as an attempt to hide problems or to exclude individuals wishing to comment on the proposed plans. Naturally, the operator has a right to expect a decision within time frames established by law, but even these types of decisions are subject to delay. By planning on a "longer-than-anticipated" review and comment period, the operator can often avoid problems with decision makers and the community. When people recognize that the operator is making a sincere effort to address community concerns, much of the opposition to the proposed mining operation disappears. Both vocal and emotional opposition are strongest in the early stages of planning. Should the operator demand a decision during this stage, the decision could be greatly influenced by the fact that sufficient information may not be available (or provided) to show there are no unresolved problems.

The small mine operator may find it helpful to meet with community groups privately, before any public hearings. This approach could provide an introduction to the operator's plans, and can also enable the operator to identify significant issues and concerns which will have to be addressed.

## **COMMUNITY CONCERNS**

The small sand and gravel mine operator should expect to be confronted with a variety of community concerns throughout his operation. To the extent possible, he should

anticipate these concerns and attempt to deal with them early in the premining planning phase. Some significant concerns which citizens could have about proposed mining operations are discussed in this portion of the guide.

### Site Safety

Site safety is a common issue of community interest. Citizens often view a sand and gravel mine site as a hazardous situation, particularly if children live and play in the area. Equipment, steep slopes, stockpiles, and ponds can all be considered dangerous, yet attractive to children. They are especially attracted to gravel pits filled with water.

The operator cannot expect to simply construct a fence or place no-trespassing signs around the mine site, and secure compliance. Main-

taining a safe site, along with being aware that children are not always stopped by fences and signs, is the better approach. There are certain legal implications attached to this concern which can generally be referred to as "maintaining an attractive nuisance."

"Maintaining an attractive nuisance" is a phrase commonly applied to sand and gravel mines, especially in neighborhoods where young children are present. The theory is that steep sandy slopes, with a pond located at the base, represent an irresistible combination to children. They are "attracted" to the site, but could be injured while playing there (the nuisance).

There are several methods that can be used to prevent access to the mine site. No-trespassing signs, fences (see Figure 6), and even



FIGURE 6. EXAMPLE OF A TECHNIQUE TO ASSIST IN KEEPING CHILDREN AWAY FROM THE MINING SITE (CHAIN LINK FENCE)

guards can be used. These practices do not always work, particularly during periods when the site may be inactive. Some additional practices can be used. Chemicals, oil, fuel, etc. can be safely stored and located, and all equipment secured. Gentle and stable slopes can be maintained where possible. Perhaps the most effective practice would be to talk with adults and request their help in keeping children away from the site. If problems persist, prosecution of one or two offenders may be required to get the message across.

### **Vehicular Traffic**

Vehicular traffic, particularly truck traffic, is often a concern to the community. Over 90 percent of the nation's sand and gravel resources are moved by truck. Rail and barge transport are localized and usually serve very large, long-term operations. The regulatory authority may or may not require a plan to control vehicular traffic, but the community will usually want to see and hear it addressed during public hearings and meetings. This concern applies not only to the operator, but to trucking contractors as well. This can be a serious issue, especially where hauling routes traverse residential communities. If at all possible, pedestrian access, residential areas, and school and hospital zones should be avoided.

Some primary concerns associated with truck traffic are:

1. Gravel trucks start slowly, drive slowly, and stop slowly, and can interfere with other traffic (see Figure 7).
2. Gravel trucks are noisy.
3. Gravel trucks can create

dusty conditions and gravel can fall off the truck, possibly damaging or breaking windshields or headlights.

4. Heavy gravel trucks can damage roads.

Several approaches may be used to minimize these concerns. Initially, a vehicular traffic plan can be prepared and included in the permit application. This plan may include vehicle counts on anticipated haul routes, accident frequencies, and adjustment of haul routes to insure travel on roads designed to carry heavy loads.

Some solutions to traffic complaints are summarized below.

1. Interference with other traffic

- Construct acceleration and deceleration lanes leading from the pit to the public road. This allows trucks to speed up and slow down without affecting other traffic.
- Use a flagman and/or signs to warn oncoming drivers of slow trucks entering the road.
- Route trucks to roads designed for heavy loads.
- Limit hours of hauling to low-level travel times, if possible.

2. Noisy gravel trucks

- Keep trucks off resi-



FIGURE 7. EXAMPLE OF GRAVEL TRUCKS INTERFERING WITH OTHER TRAFFIC

dential streets, if possible.

- Maintain engines and muffling systems to decrease noise.

3. Dust and gravel spills

- Do not overload trucks.
- Cover trucks with a tarpaulin.
- Spray load with water before leaving the site (see Figure 8).
- Control speed of vehicle.

4. Damage to public roads

- Assess any previous damage to haul routes.
- Control speed and load limits.
- Use haul routes designed to handle heavy vehicles.

If the operator plans to use a contractor for hauling the resource, the contractor should be encouraged to develop an adequate vehicular plan. The regulatory authority and the community may require that the operator exercise some control over independent trucking contractors.

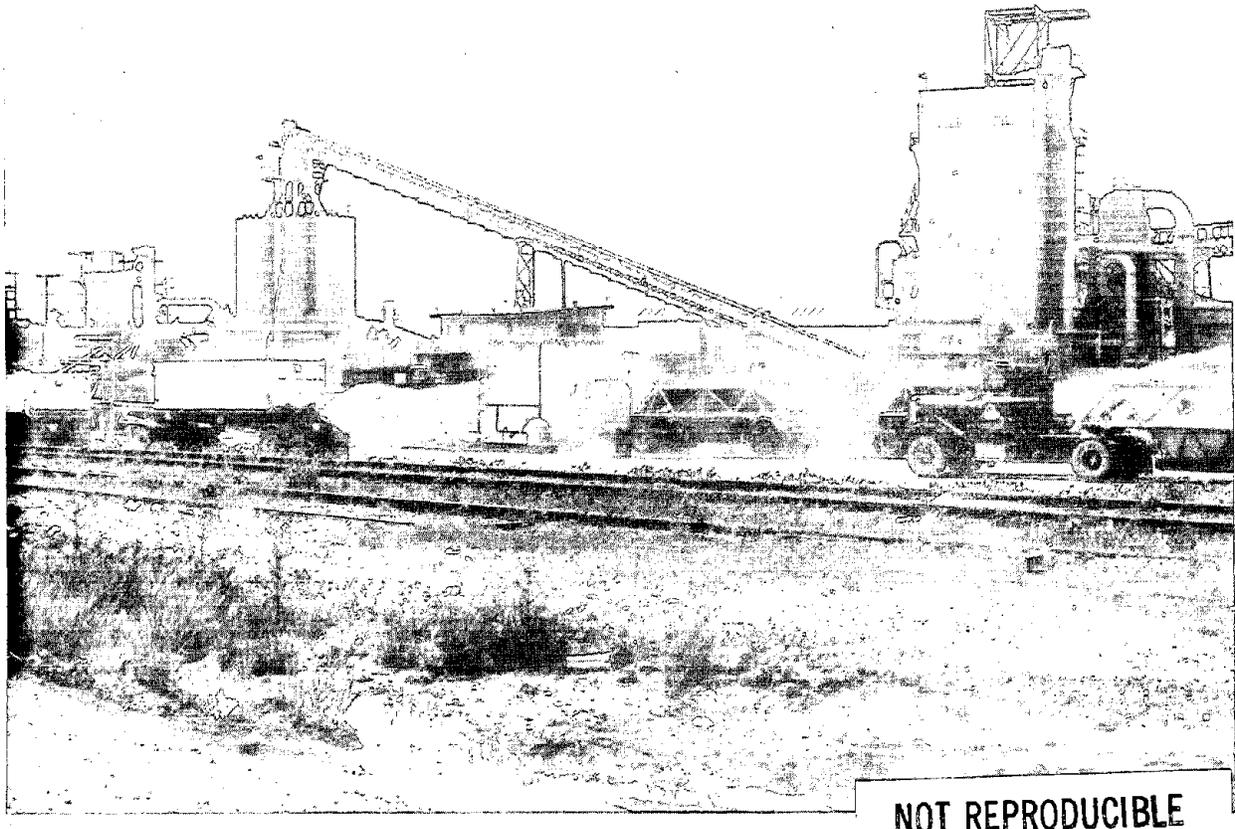


FIGURE 8. HAUL TRUCK BEING SPRAYED WITH WATER BEFORE LEAVING MINE SITE

The operator must consider that changes in haul routes could also increase the cost of the resource and, in effect, cancel any geographic advantages of the mine. Every extra mile could add 10 to 15 cents per ton to the price of the gravel. Therefore, it is important to attempt to balance the benefits of re-routing truck traffic with the potential increased cost of the aggregate.

Additionally, in today's energy and environmentally conscious society, fuel consumption and potential air pollution should be considered. When considering all factors, the operator may conclude that it is better to properly control vehicular traffic on the shortest possible route, rather than increase haul

distances and experience increased costs.

### Pollution

Community concerns will usually encompass some of the broader environmental impacts of mining, as well as more specific issues such as vehicular traffic and site safety. Even though the mine site may be located miles away from population centers, people will generally be concerned about air, water, noise, and dust pollution.

Since degrading the environment can ultimately affect everyone, it is important for the operator to take time to explain the reclamation and pollution control plans to in-

terested members of the community. Efforts to explain such plans can be effective in laying public fears and concerns to rest at an early stage. Additionally, this approach enables the public to be involved in the planning process, demonstrating that the mine operator is not attempting to hide any details of the proposed mining operation.

The best response to environmental objections is the preparation of good reclamation and pollution control plans, backed up by performance throughout the operation. Should individuals claim that words and plans accomplish nothing, the operator must point out that, should he not comply with environmental performance standards, citizens have a number of alternatives available in seeking compliance.

Deposits extracted from sand and gravel mines, unlike coal or metal mining deposits, generally do not produce toxic, acid, or chemical pollutants. Some pollutants can result from the extraction activities, however. Pollution associated with sand and gravel mining can include stream sediment, fugitive dust, noise, and fuel, oil, and grease spills.

### **Wildlife Disruption**

Small sand and gravel mining operations will generally result in short-term impacts to wildlife.

There is little question that wildlife habitat located in the pit area will be completely destroyed. In fact, most wildlife will be driven off during site development activities.

However, there are positive opportunities to develop improved habitat during the reclamation phase. Many abandoned and reclaimed

gravel pits provide some of the best wildlife habitat in an area, particularly when a pond is left after mining.

Due to the fact that most gravel mines are located either in or near urban areas, the possibility of an operator disturbing previously unaffected wildlife habitat is almost nonexistent. Unlike commercial or residential developments, reclaimed mine sites do offer the opportunity to improve wildlife habitat.

### **Property Values**

Citizens many times express the concern that a proposed sand and gravel mining operation could reduce residential property values. There is no conclusive evidence for this claim, however. Experienced real estate brokers have not proven that sand and gravel mines lower property values. One reason may be that so many factors must be considered in determining real estate values that no single influence could significantly reduce property value. In fact, there are cases where reclaimed sand and gravel mines have greatly increased property values. Reclamation to achieve recreational areas, wildlife sanctuaries, parks, and other types of open space definitely improve property values.

With noise and dust controls, sediment controls, visual screening, in-progress reclamation, vehicular traffic controls, etc., there is no reason to expect a decline in property values. One common sand and gravel mining practice that could affect adjacent land, however, is the extraction of the resource right up to the property boundary, leaving a near-vertical slope. Extraction conducted in this fashion not only eliminates many reclamation options,

but also increases the potential for slumping and erosion that can affect adjacent property (see Figure 9). This practice was previously discussed in Section I.

Naturally, there are no guarantees that a particular sand and gravel mine will not contribute to lower property values, but neither can guarantees be provided where other types of land development are concerned. The operator can guarantee, however, that reclamation and pollution control plans will be carried out to the best of his abilities.

### **Visual Appearance**

Visual appearance (or visual quality, esthetics, etc.) is a very

subjective and sometimes very important community concern. It is subjective because what is attractive to one individual may not be attractive to another. Visual appearance is important because people living in residential areas or subdivisions may be trying to avoid any move toward industrial land use in their vicinity. They may feel that a gravel operation looks bad and could affect property values, as well as the overall quality of life.

Gravel mines are not the only land-use development where visual appearance is controlled. Many subdivision regulations and covenants prohibit unusual colors on houses, nonconforming fences, junked-car parking, mobile home and boat storage, signs, and a variety of other



**FIGURE 9. EXAMPLE OF SLUMPED AND ERODED VERTICAL GRAVEL BANK WHERE EXCAVATION WAS EXTENDED TO LIMITS OF THE PROPERTY BOUNDARY**

items which could be considered unappealing. Features of sand and gravel operations that are usually considered visually unappealing include:

1. The excavation pit and other devegetated areas
2. Processing machinery and heavy equipment
3. Stockpiles and conveyors
4. Sediment ponds, slime ponds, and drainage diversions
5. Ungraded waste dumps and refuse (see Figure 10)
6. Haul and access roads.

In short, there is not much about a gravel operation that most people would find attractive. Complaints could even be made about night lighting or night welding for emergency maintenance.

This potential concern is important to remember while planning and conducting the operation. The best practice is to hide or screen as much of the operation as possible. The amount of visual screening that may be required depends on several factors:

1. How scenic is the surrounding area? If the pit is located in a heavily industrialized area, there would be less concern than if it is located in a residential area or in view of a scenic overlook.



FIGURE 10. VISUALLY UNAPPEALING WASTE MATERIAL LEFT AT SAND AND GRAVEL MINE SITE

2. How many people see the site on a frequent basis? If only a handful of people see the site frequently, and nobody lives or works in the area, the problem could be minimal.

If the site is remotely located, but has recreational or scenic value, there may be concerns -- even if the recreational or scenic area is visited only in summer months. If the site is located within view of residences, commercial shopping centers, or other high-use areas, there may also be a high degree of concern. Occasionally, the operator may find it necessary to determine the "visual sensitivity" of a site proposed for mining. This could provide an indication of how much time and money he may have to devote to visual screening.

The planning and use of visual screening techniques are discussed in detail in Section IV.

### Quality of Life

"Quality of life" is a term frequently heard in public hearings and meetings. It is generally used by opponents of the mining proposal who want to imply that mining an area will lower the quality of life for nearby residents. The phrase can cover many concerns, including the following:

1. Mining may pollute the air and water.
2. Mining may be unsightly.
3. Mining may be dangerous for children, and trucks may rumble through neighborhoods.
4. Mining may ruin land and decrease property values.

5. Mining may cause water wells to dry up, and exaggerate natural hazards such as floods or landslides.

6. Mining may be noisy.

Just as it is difficult to measure what is nice to look at and what isn't, it is difficult to measure something as subjective as the quality of life. The operator should make clear that efforts will be made to control or alleviate problems, and that the quality of life is due, in some small part, to the availability and relatively low cost of aggregates. Construction of streets, sidewalks, houses, foundations, and driveways requires the use of aggregates. As in dealing with groups and organizations, the operator should remain calm and objective, responding to individual criticism in a positive fashion.

### Reclamation and Land Use After Mining

One of the most common community concerns is reclamation and land use after mining. The length of time needed to mine and reclaim a gravel pit often presents problems. People who are concerned about the proposed mining operation and its impacts over one or two years will not be satisfied should reclamation require 10 to 15 years. "In-progress" reclamation should be planned to avoid delays in reclamation. "In-progress" or "concurrent" reclamation is an environmentally sound practice and demonstrates to the community the operator's commitment to protect the environment.

An integral part of the reclamation plan is the development of a plan for the final land use of the mine site. Local regulations may require that a specific final land

use be selected and approved before the permit or rezoning application is approved. Others may require that the land be returned to a beneficial and productive condition, capable of supporting a variety of different land uses. The latter requirement appears to be a more practical approach since it can be very difficult for an operator to select a specific type of land use many years ahead of time. Economic, social, and political conditions fluctuate rapidly, and the land use selected may not be appropriate by the time it is achieved.

Should a specific land-use selection be required, and should the operator have no plans for developing the site for residential or commercial use, the selection of wildlife habitat or open space may be beneficial. These uses provide flexibility for many types of future development, while accomplishing the goals of land stability and vegetative cover.

Existing local and state land-use plans and guides should be consulted when selecting a final land use. Such plans provide guidelines for land development by indicating areas suitable for certain types of use. For example, should the local land-use plan recommend residential use for a particular parcel of land, any proposal for residential development should be viewed favorably by local decision makers. Conversely, a proposal for industrial development could be disapproved.

It is important for the operator to stress to the community the concept known as "multiple-sequential" or "interim" land use. This means that any property containing sand and gravel reserves has the potential for a sequence of different land developments. Agricultural land, for instance, could be the initial use, already having an associated value. If the gravel were mined, the land use would then be mineral resource extraction. This too would have value. After resource extraction, final reclamation may be aimed at returning the land to agricultural production or some other use. This use would also have an associated value. The sequence of land uses would then be complete, and the maximum value of the property realized. If the site were left unreclaimed, the sequence would be broken and the maximum value of subsequent uses would not be achieved. By the same token, if the gravel were not mined and, for example, a housing development were built on the agricultural land, the value of the gravel would be indefinitely lost. This type of action would also reduce the maximum property value. The gravel could be mined and then the subdivision could be built, thus achieving "multiple sequential land use" with the highest possible land value.

Reclamation and land use after mining are discussed more fully in Section III.

## SECTION III . RECLAMATION AND LAND-USE PRACTICES

Some important points addressed in this section are:

1. Reclamation must be considered as a part of the total mining operation, and conducted in conjunction with extraction activities whenever possible.
2. Reclamation is aimed at achieving the land use desired after extraction activities have been completed. Mine sites can often be reclaimed to a condition suitable for a variety of uses.
3. Reclamation and land-use plans must generally be approved by the regulatory authority. Technical assistance in developing reclamation and land-use plans may be available from several federal, state, and local government agencies.
4. Natural soils, which may occur over a gravel deposit, are extremely valuable, and should be saved whenever possible for use in reclaiming disturbed areas.

### OVERVIEW

The ultimate goals of reclamation are to return the mine site to a stable, usable condition, or to return it to a specific land use. The mine site should not be left "as is" when extraction is finished.

Frequently, a gravel mine operation will continue for five to ten years or more, which makes the selection of a future land use very difficult. For example, to specify that a mined area will be used at some time in the future for a residential subdivision may not be a justifiable commitment. Therefore, it is important for the mine operator to concentrate on a reclamation plan that will create a stable and usable parcel of land; one which has sufficient flexibility to be used in a variety of ways.

Some state and local governments may require that a specific after-mining land use be determined before a permit is issued. If this becomes necessary, and no determination has been reached, it is wise to choose wildlife habitat or open space. These land uses are frequently acceptable, if not desirable, and do not commit the operator to a program or project that may prove to be impractical in the future.

Mine operators should work with state and local decision makers to select a land use capable of being converted to a variety of uses at a later date. Choosing a very specific land use, years ahead of time, may not always serve the best interests of the local government, the community, or the operator.

Virtually all reclamation involves revegetation. Obviously, if a sanitary landfill or industrial site is planned, revegetation will be limited to buffer plantings. In many cases, however, large-scale revegetation is done. Whether small or large areas must be re-seeded, some basic principles apply. These principles are discussed in this section.

Key items to remember when discussing reclamation are "stability," "self-maintaining," and "pollution-free." These conditions are accomplished by backfilling and grading to create gentle slopes, and by establishing vegetation capable of regeneration.

## **LAND USE AFTER MINING**

In selecting uses for land after mining, the operator should keep the following in mind:

1. Be certain you have the physical and financial capabilities to achieve the desired land use or land condition.
2. Make sure that the land use or land condition selected complies with local land use plans and zoning ordinances.
3. Attempt to determine the community's attitude toward the selected land use.

When preparing the reclamation plan for the permit application, the operator should first state the desired land use and then describe how it will be achieved.

### **Residential**

Converting a sand and gravel

mine site to a residential subdivision requires a knowledge of the local housing types as well as the requirements for residential development, including minimum lot size and density requirements, drainage requirements, and road layout and design. Generally, the smaller the mine site, the fewer the options for subdivision layout. If the mine site is too small for good subdivision layout, adjoining land could be purchased to make the development more attractive.

The nature of the soil and fill material is also important. Soils and fill should be properly compacted, well drained, non-swelling, and should have the proper bearing capacity for foundations. Also, the suitability for individual well and septic systems should be determined.

Since residential building sites are more desirable on level ground, additional filling and grading might be necessary. These extra costs should be examined when considering residential land use.

### **Commercial**

Commercial development of a mined sand and gravel site can be beneficial. The operator should determine the types of commercial development needed in the local area. In order for a reclaimed mining operation to be used as a site for commercial development, it must be accessible to population centers, and it must be compatible with surrounding land uses. A commercial development in or near a residential area, for example, may not be considered compatible.

### **Industrial**

Large sand and gravel mine sites are frequently well suited for warehouses, lumberyards, light manu-

facturing, wrecking and salvage yards, etc.

Operators sometimes develop their own industrial sites as a business enterprise separate from the gravel operation. This can be a viable and profitable alternative to selling the mine site to another developer.

### Recreational

Most sand and gravel mine sites have some degree of recreational potential. Many have excellent potential, especially if water is available on the site. Swimming, boating, fishing, and park and picnic areas all represent possible recreational uses.

Recreational land uses offer good economic return for the expense required to develop the land. They also create favorable reactions from regulatory authorities and the community. Recreational sites are almost always welcomed, especially in densely populated urban or suburban areas.

Recreational sites can be turned over to the local government, possibly in return for certain tax benefits. In some cases, a depleted sand and gravel mine may be one of very few sites available within the area that is suitable for recreational usage.

Important considerations in selecting a recreational land use are:

1. Compatibility with surrounding land uses
2. Location and access from population centers
3. Size and shape of mined area

4. Vegetation
5. Topography
6. Water (a pond or lake is a major recreational factor).

### Water Storage

Once a sand and gravel site has been mined, the pit area could be used for water storage. In such situations, the pit is allowed to fill with water, either from a groundwater supply, diversion of surface drainage, or rainfall. The water can be used at a later date, or as needed. The water can often serve several useful purposes. For example, water may seep into the ground and recharge the local water table. This procedure could serve to raise the water level of any surrounding wells that may have dropped during mining. A proposal to recharge the groundwater supply will often be considered favorably by regulatory authorities.

Another use for a mined gravel area, once it has filled with water, is that of a surface water reservoir. The water can be used for domestic, commercial, industrial, or agricultural purposes. During rainy seasons, surface drainage can be diverted to fill up the pit area. Water will then be stored for use during dry seasons.

Any proposal to utilize the pit area for water storage, or to promote groundwater recharge, should be studied by an experienced hydrologist or other professional. The regulatory authorities will probably want to know all possible impacts resulting from these procedures. A report covering the impacts on groundwater, surface water, water rights, total water supply, and wildlife will generally be required.

Water storage, as described above, should not be confused with recreational or wildlife uses. Sand and gravel pit areas filled with water are frequently used for fishing, wildlife sanctuaries, or other recreational purposes. If this is the intent, the requirements for design and construction are different from those for water storage facilities.

Figure 11 shows groundwater ponded in a mined gravel pit. In time, the water in this pit could seep into the surrounding material and recharge the local groundwater supplies.

### **Sanitary Landfill**

A mined sand and gravel pit can sometimes be used as a sanitary

landfill area. Many areas of the country need such facilities, and may look favorably on a reclamation plan proposing such an end use. If the operator considers such a plan, coordination with the local and state governments will be required to:

1. Determine if a landfill is needed
2. Determine if zoning ordinances and land-use plans would allow a landfill in the area
3. Determine if the state has requirements for sanitary landfill siting and construction
4. Determine if there are any



FIGURE 11. GROUNDWATER PONDED IN MINED GRAVEL PIT

federal requirements that must be met.

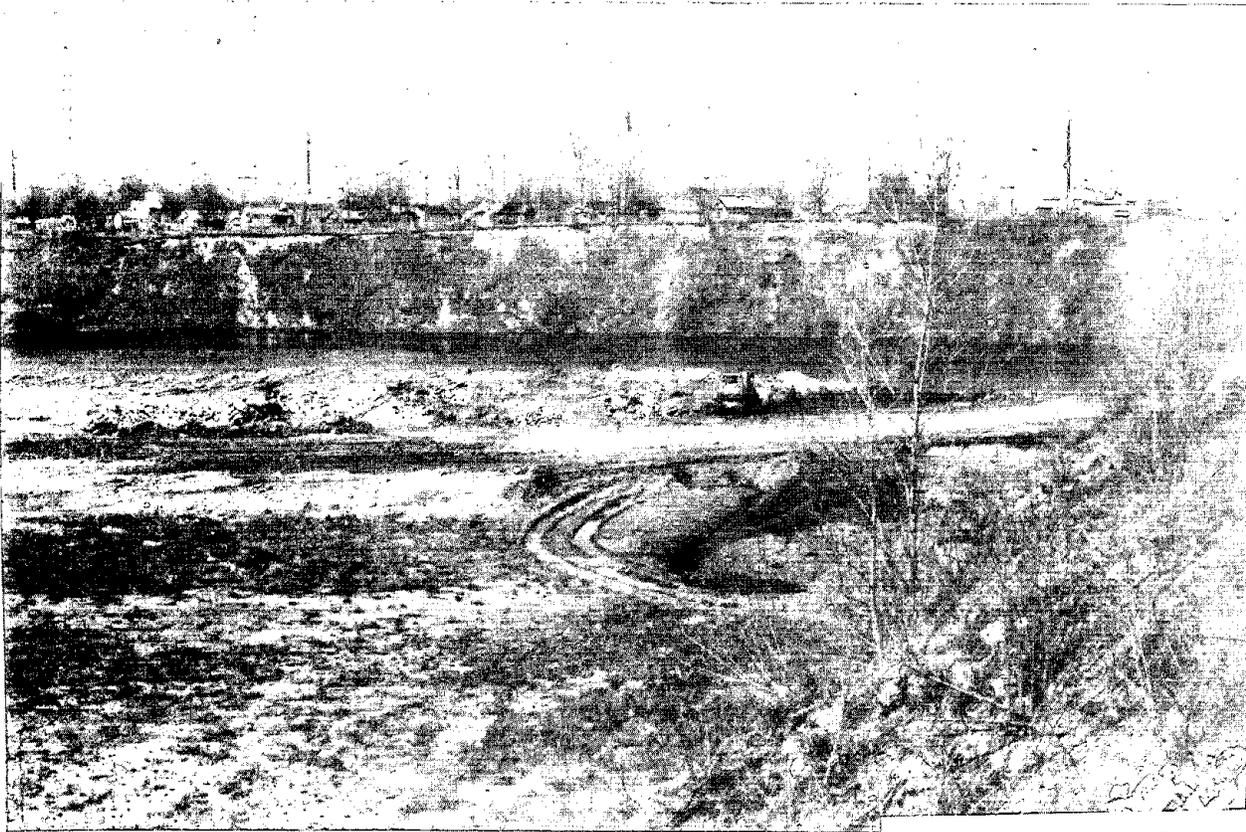
The elevation of the water table is a critical factor that must be considered when planning landfills. If the water table is close to the surface, the landfill may pollute groundwater; if the water table is deep, pollution is of less concern. Surface drainage is also important. Streams, drainage ditches, irrigation canals, etc. would have to be diverted around the landfill. Other considerations include visual appearance, accessibility to trucks and other vehicles, and the attitude of the surrounding community. If local citizens are opposed to a landfill, the proposal to create one may encounter problems. Figure 12 shows a mined gravel pit area being used as a

sanitary landfill. The site is in the very early stages of development and the material being disposed is waste concrete and asphalt.

Methane gas, a flammable by-product of decomposing organic waste (such as leaves and garbage), can form underground in sanitary landfills. This gas can create a hazard, but at the same time may also serve as a useful source of energy. The possibility that methane gas may form in the proposed landfill must be addressed. Sometimes it can be vented through pipes or pumped out to burn as an energy source.

### SOILS

Soils are a valuable mine site resource, and should be removed and saved for reclamation. Soils sal-



**NOT REPRODUCIBLE**

FIGURE 12. MINED GRAVEL PIT BEING USED AS A SANITARY LANDFILL

vaged before mining are much better for growing plants than waste fines or other unmarketable material left after mining. Many state and local laws require that soil be salvaged.

Basic steps to be followed in proper soil handling are:

1. Remove the soil before extraction to a depth determined during the pre-mine survey.
2. Store or stockpile the soil close to the area where it will be reused for reclamation, but in an area where it will not be disturbed by mining activities. Avoid storing soil on steep slopes or unstable areas, and avoid proximity to streams or groundwater springs.
3. After an area has been graded, respread the soil over the area, and try to avoid excessive compaction. Conduct soil tests to determine how much, if any, fertilizer or lime is needed to assist in vegetative establishment.
4. After spreading the soil, break up large clods and roughen (or scarify) the soil surface to assist the preparation of a suitable seedbed.
5. Seed grasses soon after spreading to help establish vegetation and reduce the effects of wind and water erosion.

### **The Nature of Soils**

Soils are formed on sand and gravel deposits by the weathering of

these materials -- referred to in soil science as the "parent material." When the parent material breaks down, minerals and elements in the deposit are changed and soils are created. Usually, soils consist of three different layers, called horizons. The three layers are often identified as the A, B, and C horizons, with the A horizon at the top, the B in the middle, and the C at the bottom.

The A horizon usually contains the most organic material and is usually the most fertile. It is generally the best layer for growing plants. The B horizon contains much clay and typically is the thickest of the three soil layers. The C horizon is the parent material. In some cases, the C horizon is the top of the sand and gravel deposit. It may be too weathered to be of value as sand and gravel resource.

The B and C horizons are usually not as fertile as the A and may not be able to support plants. Figure 13 illustrates an example of a typical soil profile.

Many soil scientists believe that each soil layer should be respread in the same order that they were originally removed. This is a difficult and expensive procedure. For example, if one foot of soil is present and the A horizon is only three inches thick, it would be virtually impossible to remove the A without getting some of the B. In most cases it is acceptable to remove the A and B soil layers without separating them. The A and B horizons will be thoroughly mixed, but this mixed soils material will still be more fertile than waste material.

Another important soil characteristic is compaction. For good plant growth, water, air, nutrients, and microbes must be able to move

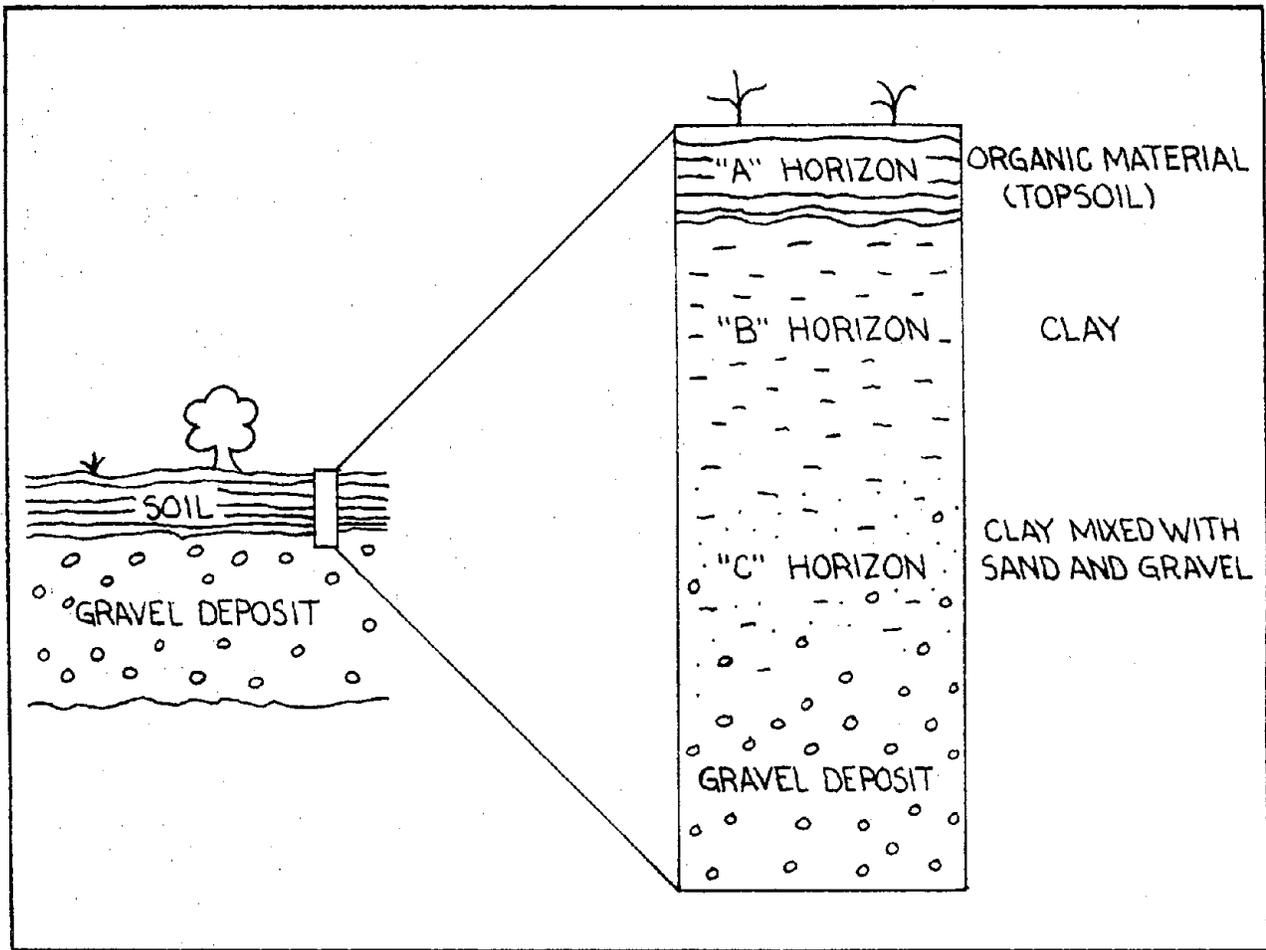


FIGURE 13. TYPICAL SOIL PROFILE OVERLYING A GRAVEL DEPOSIT

through the soils to the plant roots. This movement is accomplished through air pockets present in the soil. If the soils are highly compacted by equipment and handling, the air pockets may be squeezed shut and the movement of plant nutrients and water restricted. Figure 14 illustrates the effects of soil compaction on plant growth.

When removing, handling, stockpiling, and respreading soil, the operator should try to avoid unnecessary compaction. Eliminating the compaction problem is one reason the surface is harrowed or roughened after soil respreading. This procedure reverses some of the effects of compaction by creating air pock-

ets or voids in the soil.

#### Removal of Vegetation

In order to properly remove soils, vegetation should first be removed. If soils are removed along with the vegetation, much of the soil could be lost and weed seeds would be present. In areas where soils do not have much organic material, such as the arid regions, removing the soil and vegetation together may be a good idea. The mixture of decaying vegetation and soil could eventually provide organic matter.

The removal of vegetation should be kept to a minimum in order

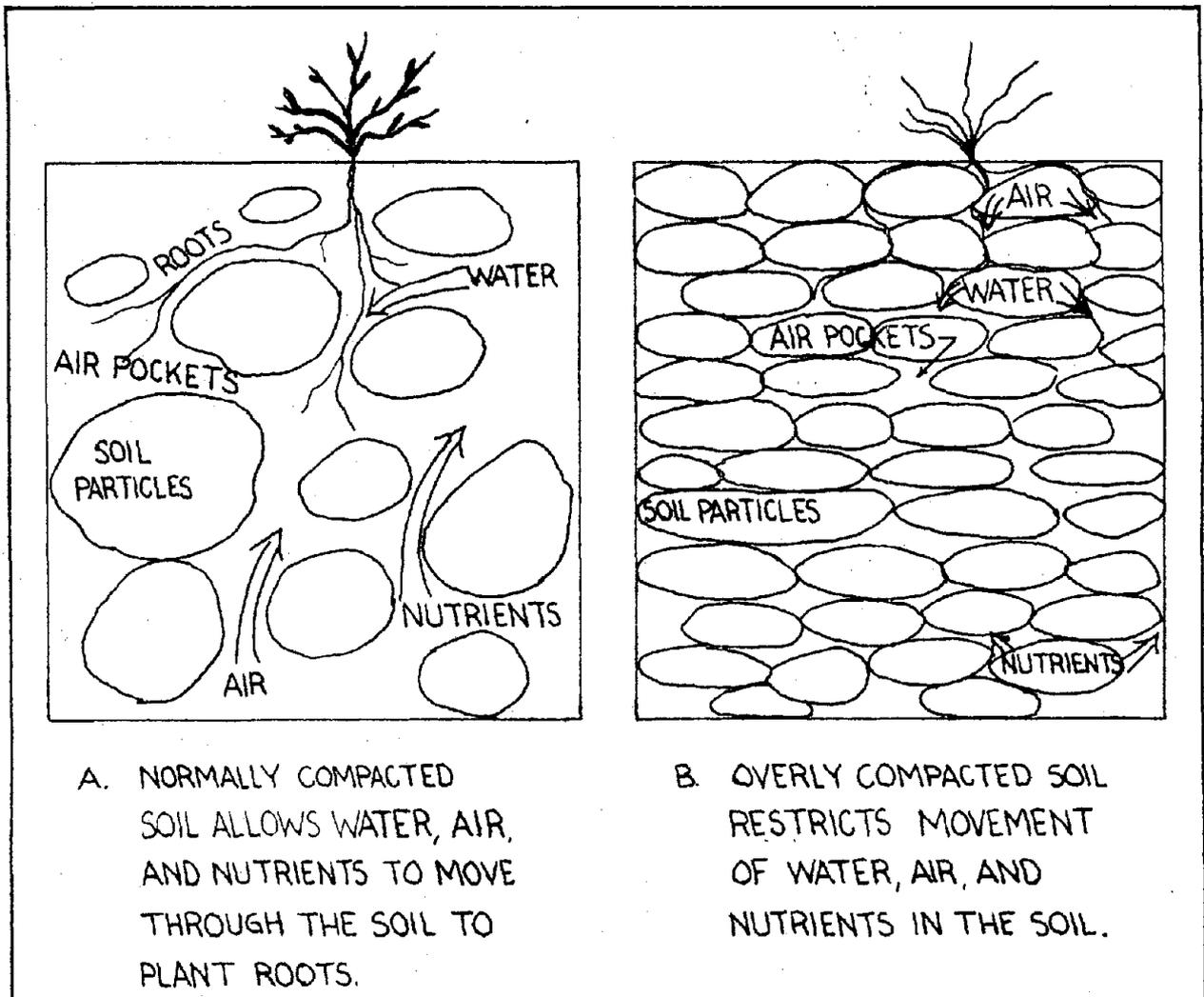


FIGURE 14. EXAMPLE OF THE EFFECTS OF SOIL COMPACTION ON PLANT GROWTH

to reduce the possibility for soil erosion. Also, the vegetation should not be removed until it is absolutely necessary.

If trees are present on the mine site, the operator should investigate the possibility of selling the timber. Also, some mine operators have taken seeds from the plants growing on the mine site and saved them for use during revegetation. This procedure can insure that replanted species are native to the mine site and adapted to the soils and climate of the area. This

helps to attain a higher success rate when vegetation is replanted.

#### Removal of Soil

Pan scrapers and bulldozers can be used to remove the soil. The pan scraper is often preferred, because its action is horizontal rather than vertical. Equipment with blades that move vertically, such as dozers, loaders, or shovels, can detach gravel or other non-soil material beneath the soil layer. Some subsoil material will undoubtedly be mixed with the soil when it is re-

moved, but the less the better.

Reducing the amount of handling and the distance the removed soil must be transported will help preserve soil structure and fertility. The ideal situation involves removing the soil from one place and immediately respreading it on a mined and regraded portion of the site. If this not possible, soils should be stockpiled in a convenient yet protected area.

### **Saving the Soil**

In most cases, removed soil has to be stockpiled. This is necessary because the active pit may be in the early stages of development, or the mining plan does not call for immediate use. The length of time and depth to which soils are stockpiled should be minimized.

The location of soil stockpiles is an important consideration. The following lists some factors which the operator should consider:

1. Locate soil stockpiles where visual impact would be low. Stockpiles are often visible because they protrude above surrounding ground level.
2. It may be possible to stockpile soils in such a way that they create a visual screening berm. For example, soils could be stockpiled along a road running past the site. If this were done, the soil piles should be seeded with quick-growing grasses and legumes.
3. Planting a grass cover on soil stockpiles will reduce erosion, make the piles more visually at-

tractive, and add organic material to the soil. The longer the soil is stored, the more important establishing the plant cover becomes.

4. Locate soil stockpiles in stable, water-free areas, where they will not be disturbed by normal mining activities. Do not create a situation where stockpiles have to be moved again before respreading.
5. Try to locate soil stockpiles close to the areas where they are to be respread. This reduces both handling costs and unnecessary disturbance of the soils.
6. Reduce wind and water erosion on soil stockpiles. This is done primarily by establishing quick-growing grasses.

Figure 15 shows a soil stockpile which serves two basic purposes. First, the active pit (located to the left of the photo) can be covered with soil after backfilling and grading. Second, the road to the right of the photo (beneath the utility lines) has been completely screened from the operation by the stockpile.

### **Respreading the Soil**

Just before or after the soil is respread on graded areas, it should be tested for nutrient status and pH. Though some soil tests may have been previously conducted, soil characteristics could change during the stockpiling period. The results of these tests will indicate how much fertilizer should be applied, as well as how much lime may be



FIGURE 15. SOIL STOCKPILE WITH PROTECTIVE VEGETATIVE COVER

needed if the soil has become too acid. Figure 16 illustrates the potential effects of soil pH on plant and crop growth.

The soil should be respread in horizontal layers, to approximately the same thickness as before removal. In some states, the actual thickness is specified by law.

Figure 17 shows soil respread over a portion of graded banks on a mined pit area. The area on the right of the photo has received the soil layer; the area on the left has not. Shown in the foreground of the photo is well-established vegetation. The trees in the background form an excellent visual screen.

## MINING AND RECLAMATION AT THE SAME TIME

### Planning

Mining and reclaiming simultaneously (which is sometimes called in-progress or concurrent reclamation) is both environmentally acceptable and cost-effective. In almost every case, materials handling is the most expensive part of reclamation. Concurrent reclamation reduces unnecessary materials handling and allows reclamation work to be started right away. If all reclamation activity is left until the end of mining, it can become very expensive to finance without cash

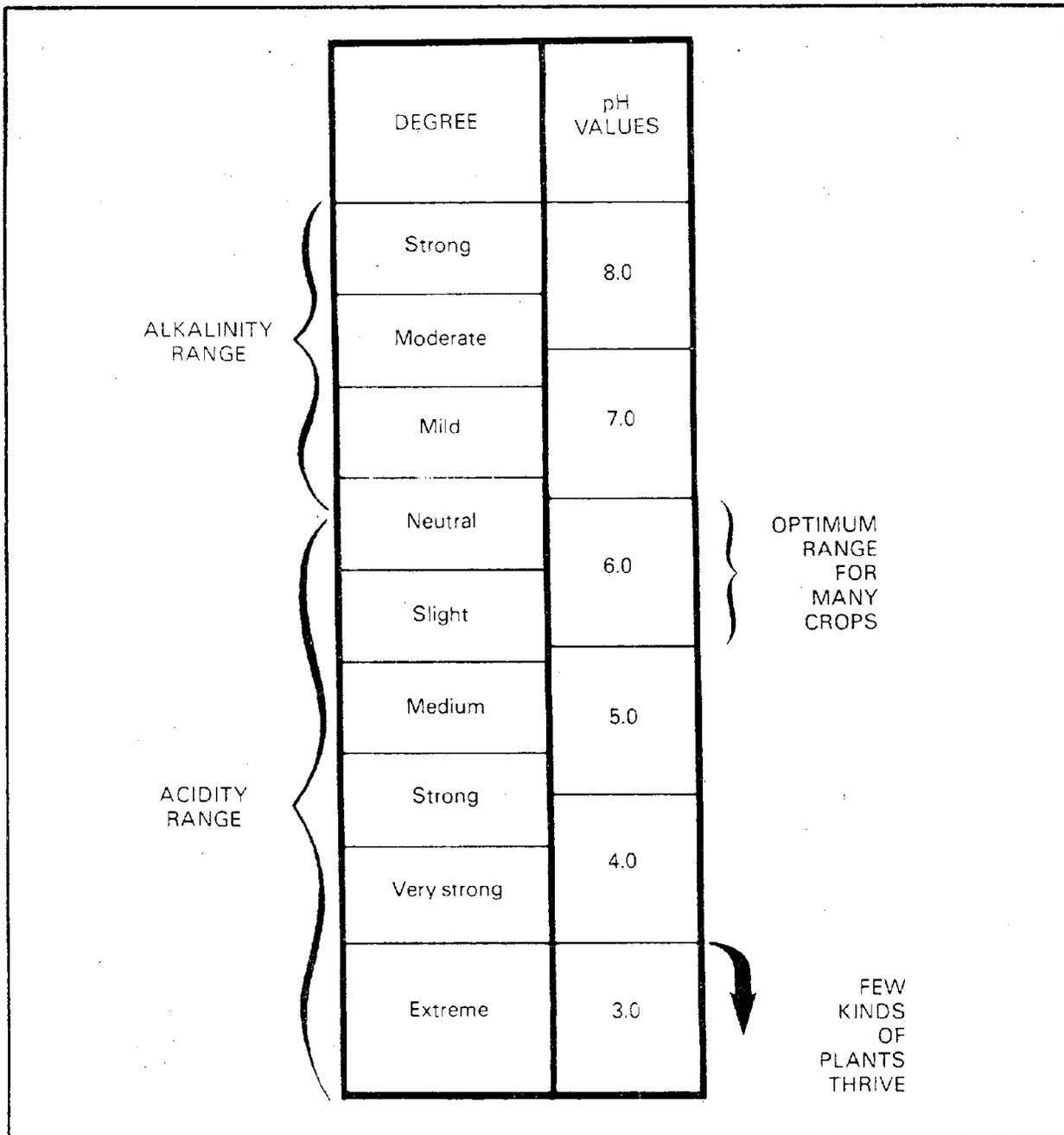


FIGURE 16. SOIL pH SCALE AND ITS EFFECTS ON PLANTS AND CROPS

flow generated from the sale of gravel.

The three major materials handling activities in reclamation are backfilling, grading, and soil spreading. Therefore, the more an operator is able to combine these activities with extraction, the more

he increases the potential for the success of the overall operation.

The operator should plan the mining operation so that removed soil can be immediately taken to a graded area for respreading. If this is not possible, he should allow for the shortest possible stockpiling period.

NOT REPRODUCIBLE



FIGURE 17. SOIL PARTIALLY RESPREAD OVER GRADED PIT SLOPE

During extraction and material preparation, the operator should plan to place waste materials in previously mined areas. Again, if this is not practical, these unmarketable materials should be transported and stored near an area where they will be used for backfilling.

In many cases, very little backfill material is available for use during reclamation. As a result, the reclamation plan will often call for grading to gentle slopes, respreading soil, and planting vegetation. It may be beneficial to leave some gravel in place rather than excavating to the full extent of the property boundary. This method enables the operator to avoid grading a vertical cut to a gentle slope. As previously dis-

cussed (Section I), this means leaving some sand or gravel in place, which in turn means a loss of money. However, this approach may still be cheaper than importing backfill material for reclamation. Berms constructed before extraction, for visual screening purposes, should also be considered in reclamation planning. Berms can often remain as part of the final land use. If a visual berm is intended to remain, it should be constructed and stabilized with permanence in mind. If the berm is going to be removed, the material can be used during backfilling activities.

Preparation plants and plant areas may also have to be reclaimed. Whether "permanent" or portable plants are used, someday they will no longer be needed. When machinery

is removed, the area on which it was located may also have to be reclaimed.

Significant items which the operator should consider when preparing the reclamation plan are outlined in Table 3.

### Waste Material

Waste material is the earth material located between the soil layers and the marketable sand or gravel resource. In many cases, this material consists of clay layers, sand layers, or areas of very large boulders (too large to be processed into the final product). Generally, any waste material present is removed and placed in an area away from the extraction activities. Figure 18 shows an example

of some common waste materials associated with sand and gravel deposits.

Waste materials can be used for reclamation and, in some instances, for pollution control, depending upon their composition. All waste materials, for example, could be used as backfill material. Clay can be used to line the bottom of sediment ponds to help prevent seepage into groundwater. Clay materials are relatively impermeable; that is, they retard the flow of water. If a waste disposal site is proposed, a clay lining can be used to help prevent the percolation of leachates into the groundwater system.

Large boulders uncovered by mining can sometimes be used as riprap. Riprap is placed in drainage-

**TABLE 3. ITEMS TO CONSIDER IN RECLAMATION PLANNING**

● BACKFILLING	
<ul style="list-style-type: none"> <li>A. Method of Backfilling</li> <li>B. Final Landform Contour and Configuration Specifications</li> <li>C. Equipment to be Used</li> <li>D. Backfilling Schedule</li> </ul>	<ul style="list-style-type: none"> <li>B. Equipment and Methods to be Used</li> <li>C. Surface Preparation</li> <li>D. Applications:               <ul style="list-style-type: none"> <li>1. Fertilizer and other additives:                   <ul style="list-style-type: none"> <li>a. Types</li> <li>b. Rates</li> <li>c. Method</li> </ul> </li> <li>2. Vegetation:                   <ul style="list-style-type: none"> <li>a. Types</li> <li>b. Rates</li> <li>c. Methods</li> </ul> </li> <li>3. Mulch:                   <ul style="list-style-type: none"> <li>a. Types</li> <li>b. Rates</li> <li>c. Methods</li> </ul> </li> </ul> </li> <li>E. Anticipated Schedule:               <ul style="list-style-type: none"> <li>1. Fertilizer and other additives</li> <li>2. Seeding and planting</li> <li>3. Mulching</li> </ul> </li> <li>F. Maintenance:               <ul style="list-style-type: none"> <li>1. Requirements</li> <li>2. Schedule</li> </ul> </li> </ul>
● GRADING	
<ul style="list-style-type: none"> <li>A. Cross-Section of Final Grading</li> <li>B. Equipment to be Used</li> <li>C. Method of Topsoiling:               <ul style="list-style-type: none"> <li>1. Topsoil or topsoiling materials to be spread</li> <li>2. Average thickness of final grade</li> </ul> </li> <li>D. Grading Schedule</li> </ul>	
● REVEGETATION	
<ul style="list-style-type: none"> <li>A. Areas to be Revegetated:               <ul style="list-style-type: none"> <li>1. Short-term</li> <li>2. Long-term</li> </ul> </li> </ul>	

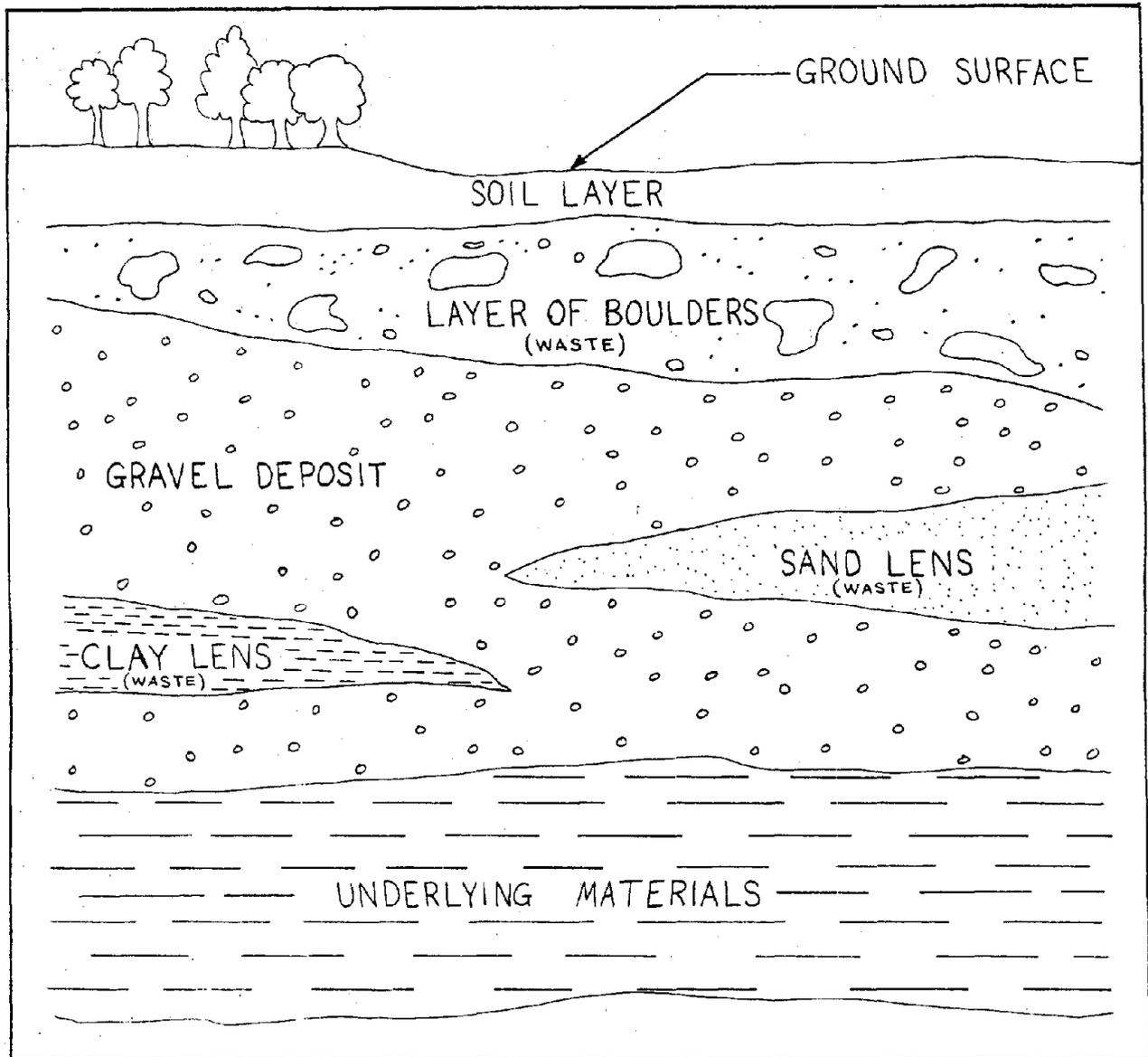


FIGURE 18. SOME COMMON WASTE MATERIALS ASSOCIATED WITH SAND AND GRAVEL DEPOSITS

ways or along the banks of streams and sediment ponds to help control erosion and slumping.

If waste materials are known to be present, their handling and disposal should be planned in advance. A good gravel deposit may contain as little as five percent waste material, in which case the disposal problem is minimized. However, if the percentage of waste material is higher, it may be uneconomical to extract the gravel deposit.

### Processed Waste Materials

Processed waste materials represent a major problem for the sand and gravel operator. This material consists of sand, silt, or clay-size particles derived during the mining process or from preparing (such as washing) the mined resource for sale.

After the sand and gravel resource is excavated, it is usually transported to a processing plant

located somewhere near the active pit. The main function of the processing plant is to separate the marketable sand and gravel from the unusable sand, silt, and clay. This is done by screening, washing, and sometimes by crushing. The material that is separated from the resource (i.e., the processed waste material) is usually piled near the plant.

Some operations use part of their fine-grained waste material for mixing with coarser sands or gravel to meet certain construction specifications or special commercial uses. It is frequently used for road sanding or mortar sand; however, operators are usually left with large volumes of these unmarketable materials.

Processed materials can sometimes be used:

1. For visual and noise screening
2. As backfill material
3. To create desired land forms in reclamation.

Establishing vegetation on this material is difficult because it contains few plant nutrients. To encourage vegetative establishment, soil can be spread over the fines, and needed amounts of fertilizers and organic matter added. An important consideration with respect to the costs of handling waste fines, is the amount of handling and the distance of transport. The operator should plan to minimize these handling costs by placing processed waste materials near the area in which they will be used.

Another type of fine-grained waste material with which the operator must deal is silt or slimes collected in ponds. Many operations

recycle process water and return it to the holding pond, where a large volume of silt is deposited. Large volumes of silt are also common in sediment ponds used to control water pollution.

Ponds which trap both processed waste material and sediment have to be cleaned periodically to keep them in proper working order. These materials are extremely wet and very slow to dry. In some cases, it may take years to dry the slimes to the point where they can be adequately handled. There are chemical and mechanical methods for assisting in this process, but they are often too costly for the small or medium-sized operation. Probably the cheapest and most effective way to dry slimes is to spread them on the ground, where excessive erosion can be controlled, and allow them to dry in the sun.

Once slimes have been removed and dried they can be used in much the same way as waste sands. Like processed waste materials, they have few plant nutrients and make poor soils for plant growth. The operator should use the same procedures for planting on slimes as for planting on waste sands: cover with soil, fertilize, and add organic matter.

Fine-grained waste material and holding-pond slimes are easily eroded. In such material, particles are small and lightweight, and flowing water can easily carry them away. Also, slumping and sliding of the waste piles may take place when they are wet. For these reasons, waste fines should not be left exposed to rainfall for extended periods, nor should they be placed near streams or other drainageways. Reducing the height and steepness of the slopes on piles of fine-grained waste material will help. The most effective

method of preventing the erosion of fines is to backfill the fines into the mined pit area, grade them, cover with soil, and establish vegetation.

Figure 19 shows a large pile of process waste sand. This material is not marketable as a construction aggregate and will be used in backfilling and regrading the pit area. A problem likely to be encountered with such a large waste pile is that removal costs will be significant, and will be required at once. In-progress grading of the sand could allow such costs to be spread over the life of the mine.

Figure 20 is a photograph of sheet erosion on a steeply sloping pile of waste sands. In sheet ero-

sion, material is eroded in horizontal sheets rather than gullies. When waste piles become too large, the "angle of repose" of the material is exceeded and gravity will often cause it to slump (see Figure 21). For many materials, the angle of repose is about  $30^\circ$ . Sheet erosion may also occur on unvegetated slopes.

The primary problem associated with this type of erosion is that the sands can be transported by runoff into the surface drainage system. The sediment then becomes suspended in streams and affects flow, disturbs fish and other aquatic wildlife, and can eventually build up in lakes and reservoirs. Erosion problems can be reduced by the operator through the use of vegetative and diversion techniques.



FIGURE 19. LARGE PILE OF WASTE FINES GENERATED FROM PROCESSING

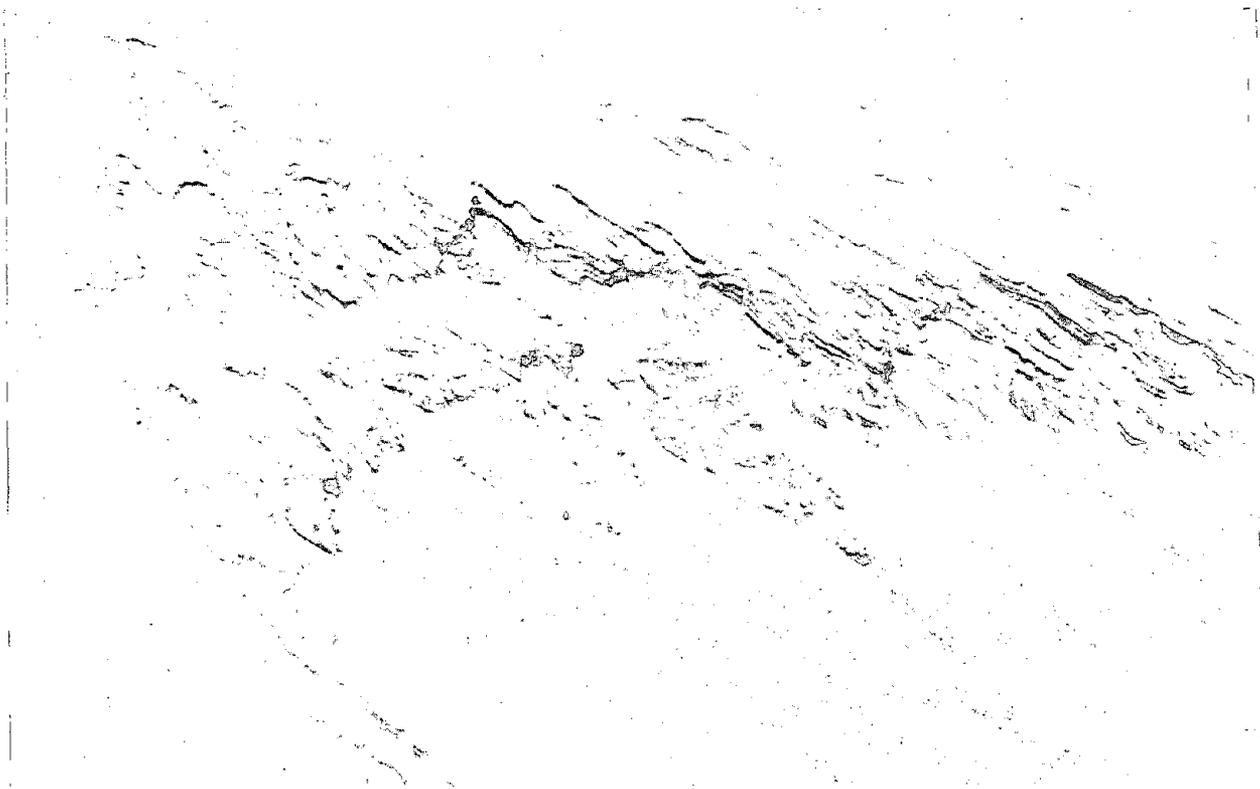


FIGURE 20. SHEET EROSION ON STEEPLY SLOPING PILE OF WASTE SANDS



NOT REPRODUCIBLE

FIGURE 21. SLUMPING AND EROSION OF FINE-GRAINED WASTE MATERIAL

## Backfilling

The procedures used for backfilling will depend on the proposed end use of the mine site. If the backfilling is intended merely to fill the pit area for grading and revegetation, complex engineering designs may not be necessary. If, on the other hand, structures are to be built, specifications for backfilling may have to be developed by a licensed professional.

Backfilling to create a desired landform or to raise the base grade of the pit area should be done with material that is free of large boulders, trash, and organic matter such as tree stumps. The presence of these materials can lead to uneven settling and subsidence. Surface settling can cause soil erosion and disrupt the growth of new vegetation.

One way to avoid surface subsidence is to backfill the pit area in "lifts," or layers of a certain thickness. This is accomplished by alternately placing a layer of material in the pit, then compacting it with a dozer. There will always be some settling of this material, but excessive settling can be minimized by backfilling in lifts.

The moisture content of the backfilled material is also important to consider. Too much or too little water can lead to future problems. Local or state regulatory authorities should be contacted for assistance in determining the proper moisture content for the type of fill material being used.

If backfilling is being done to create a flat parcel of land, engineering principles must be applied to the procedure to insure that fill material has sufficient bearing capacity to support any planned struc-

ture. Different types of buildings require different bearing capacities. Parking lots, buffer zones, and other features associated with new construction require specific backfilling and grading specifications.

Many gravel pits are not backfilled because there is insufficient material available. In these cases, backfilling is done to create some special landforms in or around the pit area. Most of the reclamation in these circumstances involves grading the slopes and pit bottom, and shaping stockpiles to blend with surrounding topography.

## Grading

Grading is the most common reclamation activity conducted by sand and gravel operators. The slopes and floor of the pit are usually graded, and backfilled material shaped to create the desired landforms.

When grading backfilled material, either on slopes or on the pit floor, the creation of perfectly smooth surfaces should be avoided. Smooth surfaces are not as desirable as rough ones, since roughness helps keep soil in place. If soil is spread over a smoothly graded surface, slippage along the contact could occur. Rough spots help bind the soil to the graded surface.

Roughness is also desirable (as it is with respread soil surfaces) for vegetative establishment. Surface roughness provides important protection for young plants. The small mounds help protect seeds and seedlings from wind and sun while the depressions trap water for plant use (see Figure 22).

Pit slopes that are long and relatively steep may require some

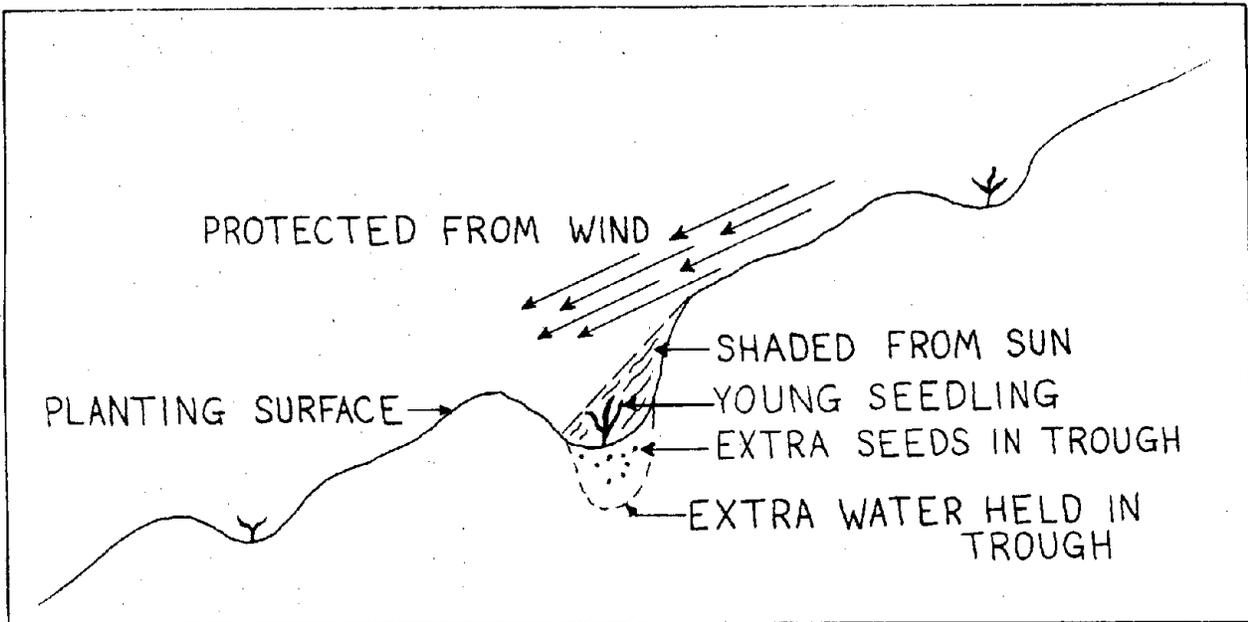


FIGURE 22. EXAMPLE OF THE PROTECTION PROVIDED TO PLANTS BY SURFACE ROUGHNESS

extra grading. The creation of terraces, berms, and furrows (see Figure 23) during grading can help reduce erosion on slopes.

Terraces constructed across sloping pit banks are flat areas used to slow runoff. When sediment-laden runoff moves across the terrace, its velocity is reduced and some sediment is deposited. Terraces are seeded with grasses and other vegetation to help trap the sediment. Vegetation will also absorb some of the runoff that infiltrates into the terraces. In addition to providing a pollution control device, terraces can add to the visual quality of the reclaimed site.

Berms are mounds or little ridges, constructed across sloping pit banks. These also have the effect of slowing runoff and trapping sediment. As with terraces, berms should be seeded with vegetation.

Furrows, or contour furrows, are small ditches constructed across

slopes. They do not have to be large; in fact, they can be as little as one foot wide and one foot deep, or less. Furrows also slow runoff and trap sediment. Seeds carried by runoff will sometimes be deposited in the furrows. By the time the furrows fill, the slopes will have a protective vegetative cover and their purpose will have been served.

Proper grading reduces the potential for erosion and sedimentation. Figure 24 shows a gravel pit bank that has been graded to a gentle slope (in this case about 3 to 1). There is undoubtedly some gravel left in this bank, but bypassing this material is still cheaper than mining the gravel and then hauling material to backfill.

Figure 25 shows a regraded gravel pit area. Most of the surface area has been "roughened," but a smooth area extending from the front center of the photograph to the right is visible. If seeds were spread on this area they would have

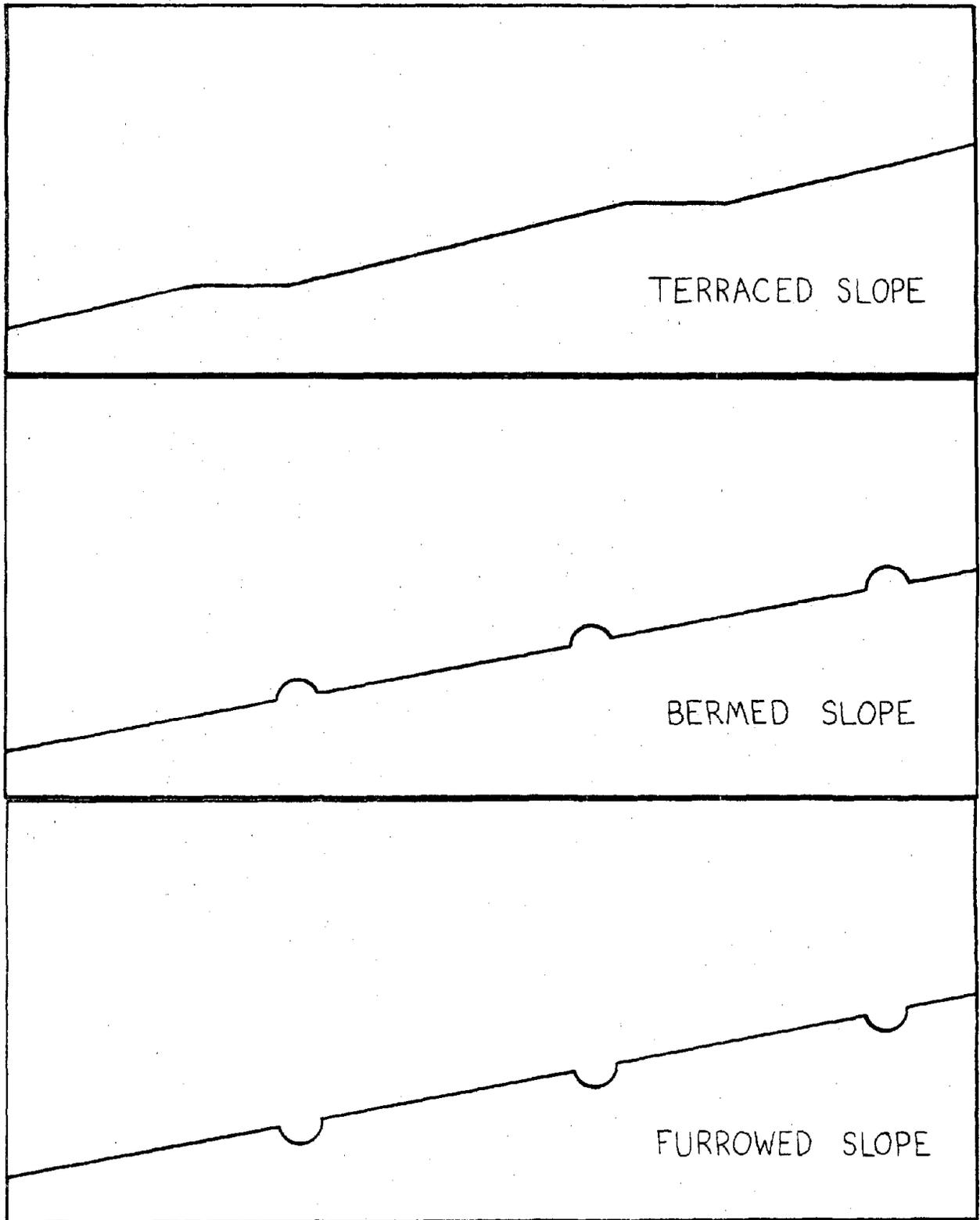


FIGURE 23. EXAMPLES OF GRADING TECHNIQUES TO HELP CONTROL EROSION ON SLOPES.



FIGURE 24. GRAVEL PIT BANK GRADED TO A GENTLE  
SLOPE ALONG THE CONTOUR

NOT REPRODUCIBLE



FIGURE 25. GRADED MATERIAL READY TO BE SEED

a minimal chance of germinating. Wind and runoff would probably move the seeds to adjacent roughened areas where they would germinate in one of the small depressions. If soil were spread over this area, the soil material would be more likely to stay in place on the roughened areas than on the smoothed areas.

### **Revegetation Practices**

Revegetating surface-mined land is perhaps one of the most critical components of the reclamation phase. Vegetation helps:

1. Stabilize the soil, thus slowing erosion
2. Improve the visual quality of the site
3. Enhance wildlife habitat
4. Increase the productivity and capability of the site.

Many gravel operations last 20 years or more, and revegetation efforts may not start until mining is completed. Even then, it may take several years for the new plants to establish themselves. For this reason, the operator should establish quick-growing grasses where needed. Quick-growing grasses will aid soil stabilization and improve the visual appearance of the site. If shrubs or trees are then planted, they can establish strong initial growth under the protection of the ground cover.

Regardless of the types of vegetation selected for planting, there are several fundamentals which should be observed:

1. Establish vegetation that suits the proposed land use.

2. Select species that are native and/or adapted to local soil and climate conditions.
3. Use vegetation that can regenerate itself and grow without continuous maintenance.
4. Establish vegetation capable of stabilizing the soil from wind and water erosion.
5. Use plants that will provide suitable wildlife habitat. Many types of wildlife will inhabit the site regardless of its intended use.

Each mine site is unique. When selecting vegetative species, the mine operator must consider local availability, planting and maintenance requirements, local soil and climate conditions, the specific reclamation plan, and many other site-specific factors. The operator may request assistance from the local Soil Conservation District or the County Extension Agent in selecting vegetation. Additionally, he can check with other operators to determine the species that grow well in the area; contact local nurseries for advice on seeds and seedlings; and consult local farmers, if possible. The operator should keep in mind that the species called for in the revegetation plan will be planted on soils containing mixed A, B, and C horizons. Consequently, plant growth response may be different from normal agricultural situations.

Some mine operators may choose to contract revegetation work to local farmers. Specialized farming equipment (harrows, cultivators, seeders, mowers, fertilizer spreaders, and irrigation equipment) may

be necessary. Sometimes, however, mining equipment can be slightly modified to perform the required tasks.

Surface Preparation. After soil has been respread, or surface materials graded to the appropriate configuration, revegetation efforts should be started. Two important procedures will help insure planting success. First, compacted soil and large soil clods should be loosened, and second, the planting surface should be roughened. Large boulders and other extraneous matter should also be removed. The time span between surface preparation and planting or seeding should be minimized. The longer an unvegetated surface is exposed, the greater the risks of erosion. Seeds or seedlings should be ready for planting when the surface preparation activities are completed.

The season of the year should also be taken into consideration when preparing the planting surface. If the ground is frozen or muddy, proper grading and soil spreading techniques are difficult to undertake, but this does not necessarily mean that wet periods must always be avoided. Taking advantage of the maximum rainfall periods can help in the establishment of new vegetation. Water is the most critical factor in establishing new plant growth. Some types of plants may require large amounts of water (i.e., large shrubs and tree seedlings), but grasses and legumes can usually get a good start with natural precipitation.

Fertilizers, Mulch, and Other Soil Additives. Frequently, respread soil or graded fill material may need help to grow plants successfully. Fertilizer (or plant nutrients), mulches (for erosion control and organic matter), lime (for acid soils), gypsum (for alkaline

soils), and other soil additives may be necessary. Table 4 lists some common soil problems and their recommended treatments.

Basic plant nutrients are nitrogen, phosphorus, and potassium (chemical symbols, N, P, and K). Fertilizers containing these nutrients can be purchased, but soil tests should first be performed to determine how much fertilizer, if any, should be added. Recommendations from the tests can be used in selecting the appropriate fertilizer.

Soils tests are not very expensive. Agricultural schools and some state agencies can perform the basic soil nutrient tests for little or no cost. They can then recommend the amount of fertilizer needed in pounds per acre, as well as the appropriate application procedures.

Fertilizer can be applied with hand-held spreaders and/or special equipment. Fertilizer can sometimes be mixed with seeds and water and applied using special tanker trucks, called hydroseeders.

The operator should investigate other types of fertilizer that may be locally available and less expensive. Farm manure and sludge from sewage treatment plants can be good alternatives to commercial fertilizers.

Mulch is applied to the soil surface to help control erosion, to conserve moisture for new vegetation, and sometimes, to supply organic matter to the soil (if the mulch is made of biodegradable organic material). Common types of mulch are straw, wood chips, peat, plastic netting, jute netting, and chemical mulches (or soil stabilizers). Generally, the cheapest are straw, hay, or wood chips, depending

**TABLE 4. COMMON SOIL PROBLEMS AND RECOMMENDED TREATMENTS**

<u>Soil Problems</u>	<u>Recommended Treatment</u>
Acid soil low pH (less than 5.5)	Apply lime in amounts determined by soil testing.
Low fertility	Add fertilizers in amounts determined by soil testing.
Rocky soil	Remove boulders and large rocks and bury beneath the surface or use as riprap.
Dry soils	Use drought-tolerant plants, mulches, organic material, mix clay soil in with sandy soils to hold water.
Wet soils	Provide good drainage and use plants that are adapted to a lot of moisture.
Dense, compacted soils	Loosen the soil, break up compacted layers with disk or cultivator type equipment.

on local supply and availability. Jute and plastic netting are expensive, as are chemical soil stabilizers.

Mulches are particularly beneficial on sloping ground, where erosion and water retention are critical factors.

Straw is available almost everywhere and is relatively inexpensive. It may be applied by hand or with special equipment. Straw covers the soil surface and protects it from the impact of raindrops and the eroding effects of flowing water. Straw can be held in place by either crimping or tacking. Crimping is accomplished by pushing some of the straw into the ground so that the soil itself holds the straw. Crimping can be done with a shovel or with a special piece of

equipment called a crimper. Tacking refers to the practice of securing the straw to the ground with wire loops, asphalt binders, chemicals, or special netting.

Straw mulch is used to shield young plant shoots from the sun and help protect them from wind. Straw also forms a shield over the soil, and helps prevent the evaporation of water held near the soil surface. As plants mature, the straw will slowly decay and become incorporated into the soil as organic matter. Soils with abundant organic matter hold water longer than soils with small amounts of organic matter.

Seeding and Planting. There are basically four types of vegetation that are suitable for revegetating a mined sand or gravel operation:

1. Grasses
2. Legumes
3. Shrubs
4. Trees.

Grasses and legumes are the least expensive, while shrubs and trees are the most expensive. The cost of shrubs and trees depends largely on their size and stage of maturity. Appendices 3 and 4 list some commonly used grasses and legumes, and Appendix 5 lists some commonly used trees.

Grasses and legumes are the most common types of plants used in vegetation. They establish quick growth and provide a complete ground cover in a short period of time. Trees and shrubs, on the other hand, grow more slowly, but their deep root systems eventually will stabilize the material more effectively. Actually, the most effective way to control erosion with vegetation is to combine plantings of grasses, legumes, shrubs, and trees.

During the premining phase, the operator should consider the following:

1. What species, or mixture of species, will grow best and be most suited to the final land use?
2. Is seed available locally, and in adequate supply?
3. How many fertile seeds per acre will be needed?
4. How deep should seeds be planted?
5. What is the best method of applying seeds (by hand, seed spreaders, drill

seeders, or mixtures of water, seed, fertilizers and mulch, called hydro-seeding)?

6. What is the best time of year to plant?
7. Is the selected grass species native to the area or adapted to local soil and climate conditions?

Legumes are plants that are frequently seeded with grasses. They are beneficial in that they assist in converting the nitrogen in the air into an essential plant nutrient. Clover and lespedeza are examples of common legumes planted with grasses (Figure 26).

Some problems may be encountered when only grasses and legumes are planted. Low-growing vegetation will protect the soil from erosion, but it could have limited potential as a wildlife habitat and is likely to be visually unattractive. Although the cost of reclamation will also increase, the addition of trees and shrubs will greatly improve both the wildlife habitat and the visual quality. Trees and shrubs could require additional maintenance, as they may need to be frequently watered and pruned.

As with grasses, trees and shrubs should be adapted to the area and suited to the proposed future land use. They should be planted in locations chosen to benefit the reclamation objectives. Correct planting procedures should always be followed. This includes preparation of the properly sized hole for planting, careful handling of the root ball, and assurance that planting is done at the proper depth. When dealing with expensive trees and shrubs, the County Extension Agent or a local nursery should be con-

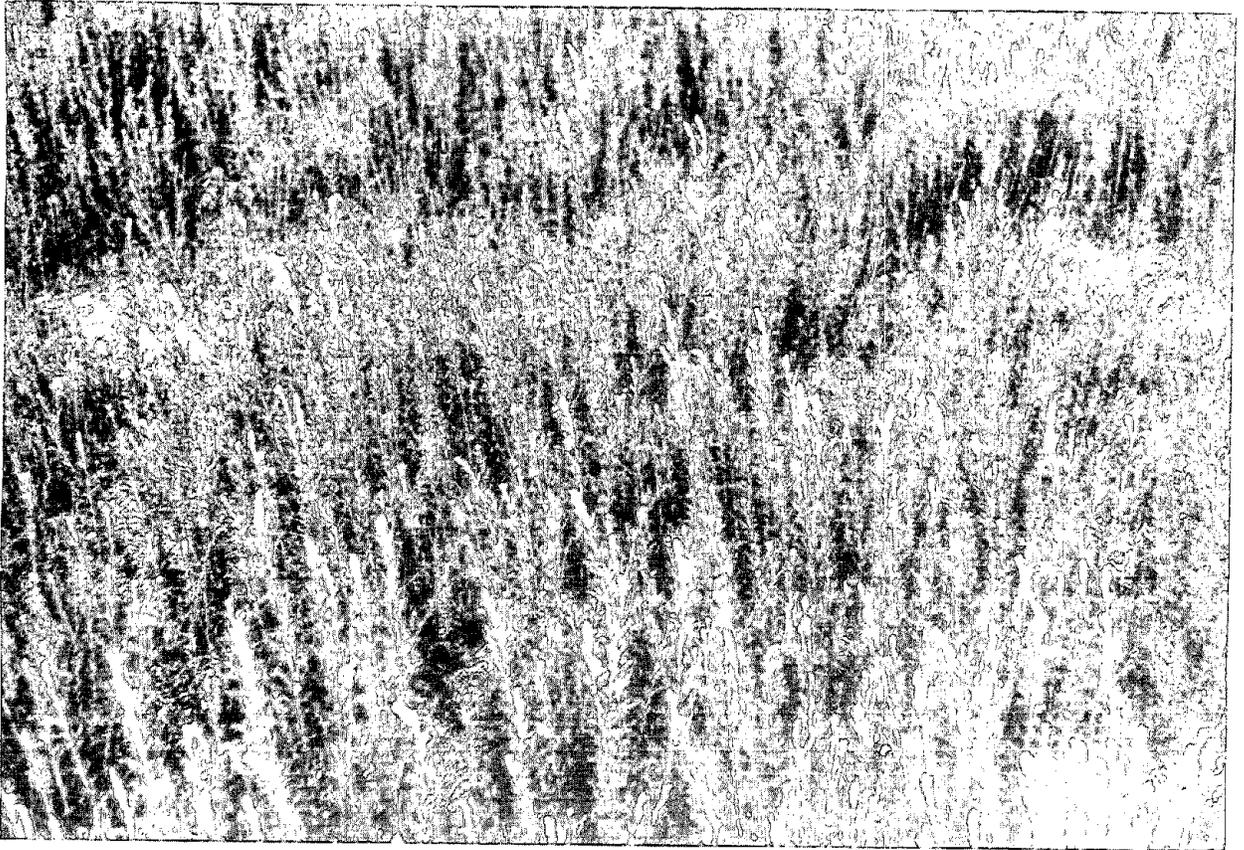


FIGURE 26. THICK GROWTH OF COMMON LESPEDEZA (A LEGUME)

sulted about planting procedures.

Experimental plantings may be conducted before significant revegetation work is started. A sample plot, containing the same soil as the area to be planted, may be used or revegetation can be accomplished in stages, with small parts of the regraded mine site being planted and evaluated. This procedure will provide an indication of what will and will not grow, as well as the planting techniques that work best.

If acid soils are encountered, the operator should use plants that can tolerate or may be adapted to such conditions. If alkaline soils are encountered, plants that can tolerate these conditions should be selected (refer to Figure 16). This concept should always be applied

whenever natural conditions are likely to affect plant growth. Clayey, sandy, or rocky soils should be seeded or planted with vegetation that grows well under existing conditions. If an area receives significant rainfall, select plants that require and use a lot of water. If the area is dry, plant drought-tolerant vegetation.

Since each sand and gravel mine has its own special conditions, the operator should check with knowledgeable individuals concerning plants most suitable for use in the particular area. Sources which may be of assistance include:

1. Soil Conservation Districts
2. Agricultural colleges

3. Local farmers
4. Local nurseries
5. County Extension Agents
6. Other sand and gravel mine operators.

#### Irrigation and Maintenance.

After seeding and planting, irrigation may be required. Additionally, occasional maintenance will be needed. In selecting the types of vegetation to be used, the operator should consider these requirements.

Low-maintenance vegetation that regenerates without difficulty, does not need large amounts of water, and is not highly susceptible to disease or pest problems. Maintenance costs money. If vegetation can maintain itself, cost savings will be realized by the operator. In an ecological sense, the operator is attempting to establish a "climax" community of vegetation. A "climax" community is one in which different types of vegetation are thriving and growing well in balance with the environment, without assistance from mankind.

The most critical vegetative requirement after planting is water. In arid or semi-arid climates, irrigation may be necessary. There are some problems with irrigation, however. It can be expensive and, in some instances, water rights may not be available to the operator. Plants can also be adversely affected by irrigation. When plants start to grow, they may become accustomed to more water than natural rainfall is able to supply. After irrigation stops, they no longer receive the extra water supply and may die. It is a good idea to irrigate the new vegetation with the same amount of water that local precipitation is able to supply. When the time comes

to cease irrigation, it should be done on a gradual basis. This procedure may help to reduce water stress problems with the plants.

Many types of grasses need to be mowed periodically, particularly in early stages. Mowing allows vegetation enough room to grow. Weed problems can also be controlled by mowing or through use of weed control chemicals. In any event, the operator should plan to prevent weeds from overgrowing the site and killing valuable vegetation.

Grasshoppers and other species, including rodents, can be harmful to newly vegetated areas. Over-grazing by domestic stock and wildlife can also be harmful. Pesticides and rodent control poisons may be effective, but many are environmentally undesirable and should only be used if absolutely required. Grazing control can be accomplished by constructing fences.

There is almost always some degree of revegetation failure. Depending on regulations and other concerns, the operator may find it necessary to reseed, refertilize, or replant some areas where revegetation efforts were unsuccessful. This is especially true if the release of the reclamation bond depends upon the success of revegetation efforts. Some seeds and fertilizer should be saved for "touch-up" planting.

Figure 27 shows an area that requires additional seeding. Figure 28 is a successfully revegetated sand and gravel mine site.

The best way for the operator to save on maintenance costs is to select low-maintenance plants, carefully plan the revegetation work, and perform revegetation activities correctly the first time.



FIGURE 27. AREA IN NEED OF ADDITIONAL SEEDING  
NOT REPRODUCIBLE

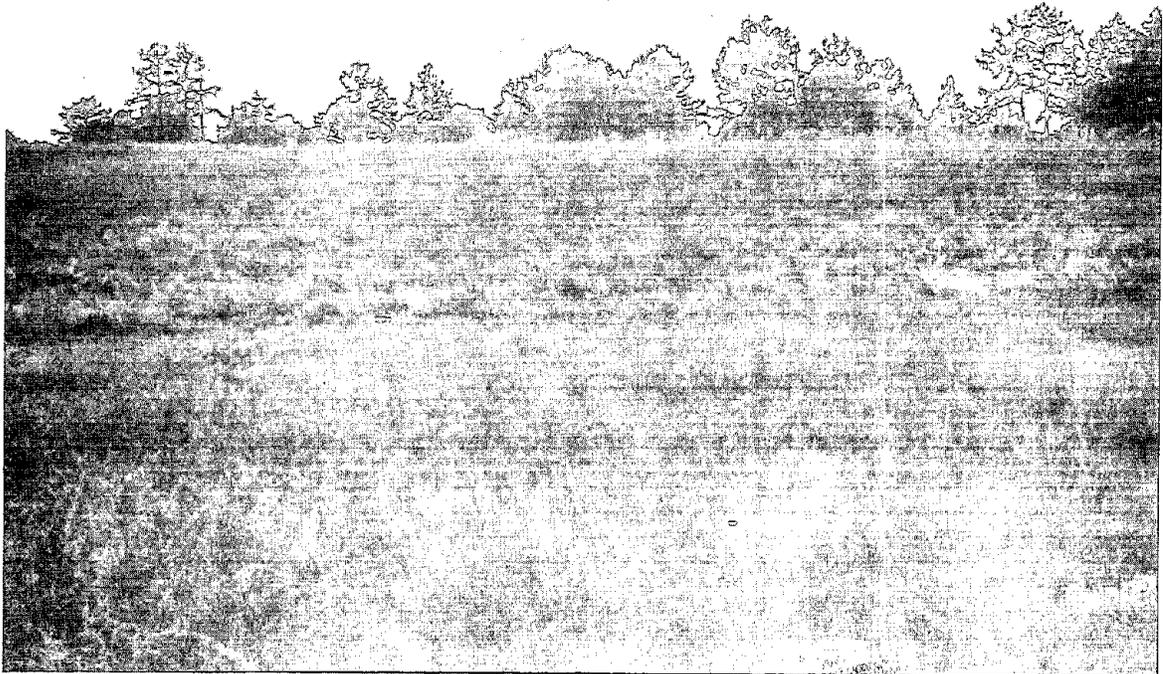


FIGURE 28. SAND AND GRAVEL MINE WHERE REVEGETATION  
EFFORTS WERE SUCCESSFUL

## Restoring Surface Drainage

Frequently, sand and gravel mining requires the alteration of streams, construction of drainage diversion ditches and dewatering trenches, construction of sediment ponds and holding ponds, and other changes which may have some effect on surface water conditions. Regulations may require the operator to develop plans for handling surface water during and after reclamation. Special permits may also be required from the U.S. Army Corps of Engineers and the appropriate state water control agency.

In the premining planning stages, the operator should determine whether changes in surface water conditions will be temporary or permanent. If the changes are temporary, the disturbed surface water may have to be restored to its original condition. If the changes are permanent, special procedures may be required to insure that the new surface water conditions will maintain water quality, control stream channel erosion and sedimentation, and provide a suitable replacement habitat for aquatic wildlife.

If a stream is diverted from its original course to keep it from interfering with mining operations, the operator should decide whether it will be left in the new channel or relocated to its original channel after mining. Either way, plans should be made to maintain the volume of stream flow and the stream gradient. This will assure that approximately the same amount of water will continue to flow downstream, and that the erosion rate will also remain constant. In many instances, stream banks may need to be riprapped and check-dams installed to control erosion and the stream gradient.

An important aspect of stream diversion is the maintenance of aquatic wildlife habitat, both stream and stream bank habitat. If the stream pooled frequently before it was diverted, it should have pools after relocation. If the stream banks were thickly vegetated and provided a special type of wildlife habitat, an attempt should be made to reestablish these conditions.

Strong emphasis is always placed on the water quality of streams. Any stream relocation program should strive to maintain or improve water quality. In some areas, if stream water quality cannot be maintained, the operator may find it necessary to develop alternate plans. Techniques such as riprapping, replanting streamside vegetation, and maintaining stream gradients all serve to help maintain water quality.

Similar concepts apply to drainage diversion ditches and dewatering trenches. If intended to be temporary, they should be filled in, planted, and stabilized during reclamation. When runoff and drainage diversion are no longer needed, they should not be left to stagnate, dry up, contribute to erosion, or reduce the visual quality of the area. The operator should backfill ditches, grade the top to the desired slope, and plant vegetation.

If some or all diversions are to be left in place, steps should be taken to stabilize channels and insure adequate water quality. Techniques similar to stream reconstruction should be used. Riprap, bank revegetation, and improvement of wildlife conditions should all be considered.

Sediment ponds, process-water holding ponds, and any other standing bodies of water used during the

mining operation must also be considered. If temporary, they should be removed and reclaimed when they are no longer needed. If permanent, they should be constructed with stability and final land utilization in mind.

The following points should be considered when designing ponds that may be left after mining:

1. Will there be enough water to keep them filled?
2. Are the pond dams and banks capable of holding the water permanently, or could erosion, leakage, and overtopping occur?
3. Can the quality of water be maintained?
4. Has wildlife habitat been considered, particularly in relation to the type of vegetation around the pond?
5. Will the pond contribute to the final land use?
6. How frequently will maintenance be required?

Temporary ponds should be dewatered, backfilled, graded, and revegetated. Reclaiming temporary ponds is as essential as reclaiming the pit area.

## **SPECIAL RECLAMATION CONSIDERATIONS**

### **Groundwater**

There always exists the potential that extraction activities could affect the elevation of water tables, change the direction and rate of groundwater flow, and reduce groundwater quality. If excavation is conducted above the seasonal high water table, significant problems

may not be encountered. In fact, depressions left after mining may hold water, and actually serve as groundwater recharge areas. However, in operations where extraction interferes with seasonal high water tables, problems could result.

Groundwater quality is rarely affected by sand and gravel mining operations. Acid drainage and toxic material problems generally do not occur. However, problems could arise if fuel, chemicals, oil, or grease are frequently spilled on the site and not attended to in regular maintenance activity. With proper handling, storage, and removal of used oil, fuel tanks, etc. during mining, groundwater pollution can likely be avoided.

In most cases, groundwater tables will restore themselves to their original elevation once mining and reclamation have been completed. This process takes time, but there is evidence that no significant long-term drops in water tables will directly result from sand and gravel mining. Excessive pumping of groundwater and droughts are far more common causes of a decline in the water table.

Initially, the level of water in the excavated mine pit is slightly below the surrounding water table, but the pit generally fills with groundwater once mining and dewatering are discontinued. Over a period of time the ponded water and the groundwater table reach the same level. Before the two water levels reach equilibrium, however, there is a slight reduction in the water table adjacent to the pit. This happens because more water can be stored in the pit area than in the adjacent undisturbed soil and rock material. When groundwater reaches a large void, such as a gravel pit, the groundwater fills the void, and is significantly reduced in the

aquifer. A gravel pit may cover a small area relative to the area occupied by an aquifer. Therefore, any problems that arise are usually confined to the immediate vicinity of the mine site. Figure 29 illustrates what could potentially occur, should the groundwater table be intercepted by extraction activities. When potential groundwater problems are evident, a professional hydrologist should be asked to address the problem.

Just as water can flow from the groundwater table, it can also flow into the water table. In dry seasons, for example, water tables may drop naturally and water ponded in a pit can actually recharge the groundwater table. In southern California, where water is relative-

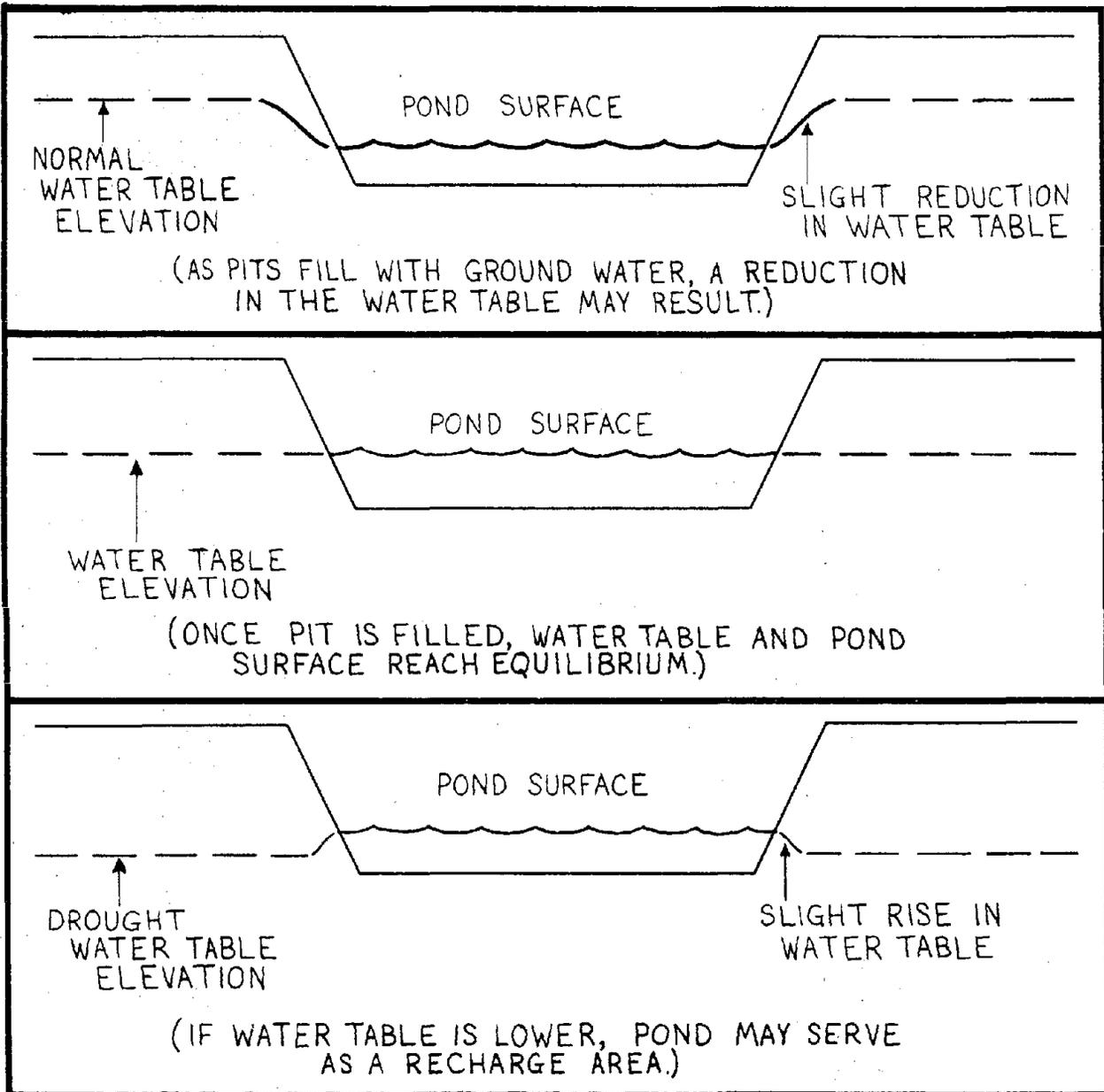


FIGURE 29. ILLUSTRATION OF THE POTENTIAL EFFECTS OF EXTRACTION ACTIVITIES ON GROUNDWATER

ly scarce, gravel pits are often used for this purpose. Operators must take care to keep the water which may flow into the water table relatively free of pollution and pollution-producing materials. Reclamation should be geared to adequately cover any toxic materials existing around pit areas, and to reduce the potential for erosion and sedimentation.

Generally, reclaimed pit areas do not alter or reduce the flow of groundwater. This does not hold true in all situations, however. For example, if a landfill is proposed for the final site use, the pit floor may have to be lined with a layer of clay to prevent groundwater movement into or out of the site. Proposed land uses, and the reclamation activities required to achieve such uses, should be carefully evaluated during the premining planning phase to determine their potential impact on groundwater resources.

### **Natural Hazards**

As discussed in Section I, areas prone to landslides and flooding could be the source of problems during the extraction phase of the mining operation.

Many sand and gravel operations are located on the floodplains of streams or rivers. Usually this is considered a viable interim use of land, because the construction of permanent structures, such as houses, is generally restricted on floodplains. Potentially, however, sand and gravel operations could change the flood characteristics of a stream, resulting in negative effects both up and downstream. Ponds could be created by floodwaters entering pit areas or by the backup of flow created by stockpiles and waste material. When a pond overflows,

or the water tops temporary dams, a surge of sediment and water can flow into the stream. On the other hand, a pit may serve as a storage area for excess water, thereby slowing discharge into the stream.

A question that needs to be addressed by an experienced hydrologist is whether the sand and gravel operation will increase, decrease, or not in any way affect the potential for flood damage. Agencies such as the U.S. Army Corps of Engineers can often provide data and maps on flood characteristics.

Natural or man-made slopes can slide under the influence of gravity. When this happens, it is referred to as a landslide. Natural slopes surrounding the mine site may be subject to landslides. This is also true of waste piles and soil stockpiles. Some important points to consider in helping prevent landslides are listed below:

1. Do not overload the top of slopes. This can increase the weight resting on top of the slope.
2. Do not underload the base of the slope. This decreases the weight resting at the bottom of the slope.
3. Do not allow water to flow on, or into, the slope.

The most common slope stability problem results from excavating the resources to the entire extent of the property boundary. This action leaves a vertical wall which can slump or slide into the pit area. If this happens, the adjacent property may be affected. The operator should remember that the steeper and wetter the slope, the greater the potential for landslides.

## **Haul Roads and Other Mine Site Facilities**

The reclamation of haul roads, access roads, preparation plant areas, office and scale house areas, and other areas disturbed by mining-related activities should be considered when preparing the reclamation plan. Excavating ground for these types of facilities can lead to just as much pollution and visual damage as the excavation of the resource pit. Many regulations require that such areas and facilities be reclaimed along with the pit area.

When mining has been concluded, the first step should be to remove structures, preparation equipment, and other salvageable materials used during the operation. Once these have been removed, the reclamation process will be very similar to that conducted on pit areas.

Junk, scrap metal, or other unsalvageable materials should not be left on the mine site. When left to be viewed by the general public, the mine site may appear as a junkyard. Also, such refuse could interfere with reclamation, contribute to water pollution, and adversely affect visual quality.

Some roads may need to be left as part of the final land use, or to provide access to the revegetated site for maintenance. Leaving a road which serves no purpose, however, is not in the best interest of successful reclamation.

## **Wildlife**

Wildlife includes birds, mammals, reptiles, amphibians, waterfowl, fish, and even the very small organisms living in stream bottoms and surface water. Wildlife habitat refers to the combination of land, water, and vegetation where wildlife

may live and propagate. Both the animals and their habitat are greatly disturbed by mining activities.

The federal government has strict regulations protecting endangered, threatened, and rare species of wildlife. The U.S. Fish and Wildlife Service maintains lists of the regulated species and it would be wise for the operator to check with this agency before mining. State fish and wildlife agencies also maintain lists of protected species. The more endangered a wildlife species, the more stringent the requirements concerning that species.

In heavily populated urban areas there may be little wildlife regulation, while in suburban or rural areas, regulatory requirements may be greater. In populated areas, however, local citizen or community groups may oppose a mining operation on the grounds that it will disrupt wildlife.

A sand and gravel mining operation can affect wildlife in several ways -- by destroying vegetation, altering the water supply, creating noise, adding human presence, and silting the water. When habitat is destroyed, various parts of the food chain are removed or driven away. All parts of the food chain are then affected.

If the mine site provides habitat for large numbers of a certain species, they could be removed. Some operators initiate plans to trap the wildlife and move them to another location. Such species may eventually migrate back to the mining site after reclamation has been completed, if reclamation provides acceptable habitat conditions.

Many reclaimed or abandoned sand and gravel mining sites become havens for wildlife. There are

numerous reports that old gravel mines in various parts of the country have some of the highest concentrations of wildlife found in the nation.

The following characteristics of sand and gravel pits combine to make good wildlife habitat. They should be remembered when planning a wildlife-related land use for the site:

1. Presence of water
2. Vegetative cover
3. Boulders, slash, slopes
4. Beaches
5. Food sources.

Many pit areas fill with water, through groundwater seepage, runoff, or both. Once a pond has been established, various wildlife species may again start to occupy the site. Fish eggs are brought in by waterfowl and other birds, mammals seek drinking water, rodents and reptiles reside in scattered piles of gravel and boulders. Eventually, a wildlife community may become established. If reclamation is directed toward the establishment of wildlife habitat, the operator should plan to provide food, cover, and water. Diversity (different and varying across the site) is also necessary in establishing good wildlife habitat.

Reclamation for wildlife habitat can be planned for a "target species" or a "diversity of species." Generally, a diversity of species is more desirable. In either case, a knowledge of wildlife needs is necessary. If a "target species" is desirable, such as duck, the grading of pond banks and the establishment of vegetation and

other cover should be carefully tailored to species needs.

When planning for wildlife, the operator should consult the appropriate state fish and wildlife agency and/or the U.S. Fish and Wildlife Service for technical assistance.

## **Waterways**

Although only about ten percent of the total construction aggregate supply comes from waterway dredging, this mining method can lead to substantial pollution problems (see Section IV). There are two types of dredging methods. One involves a shore-based dragline or shovel, and the other involves a floating dredge located in the waterway. Both excavate material from the bottom of a stream or lake. Reclamation associated with dredging activities usually focuses only on the disturbed shore area.

Streams and lake bottoms are obviously disturbed by any dredging activity. Both the habitat and the bottom-dwelling aquatic life are destroyed. The natural bed load (material carried along the bottom by the movement of the stream) deposits in the holes left by the dredging equipment. After dredging has stopped, natural processes will generally restore the bottom environment.

If the floating dredge method is used, the excavated material could be pumped ashore to a processing plant. Some dredging operations process the material onboard, with only stockpiles and loading areas onshore. Whatever the situation, any land disturbed onshore should be reclaimed. Unlike a land-based gravel mine, shore disturbances associated with dredging do not leave pits in the ground. Shore-area disturbances usually include devegetation, road construction, plant con-

struction, stockpiles, and sediment ponds to treat discharged process water (see Figure 30). Reclamation activities would generally include the removal of structures, grading stockpiles and other disturbed land areas, and revegetation. Vegetative buffer zones may be required along some streams, especially trout streams, to reduce sedimentation and to help maintain low water temperatures.

Care should be taken to restore

wildlife habitat along a disturbed shoreline. Typically, shorelines are the most important component of wildlife habitat. A major difficulty with shoreline reclamation is the longevity of dredging operations. Since the dredging operation may continue for many years, the excavated material could be constantly replenished and the shore facilities would remain in stationary use for the life of the operation, thus making revegetation impractical.



NOT REPRODUCIBLE

FIGURE 30. STREAM BANK DISTURBANCE CAUSED BY SHORE-BASED DREDGING



## SECTION IV. POLLUTION CONTROL PRACTICES

Some of the significant points addressed in this section are:

1. Control of pollution may be required by local, state, and federal laws.
2. Controlling pollution may greatly improve the mine operator's image within the community, as well as increase property value.
3. The most common pollutants resulting from the extraction of sand and gravel resources are sediment, dust, and noise. Unappealing visual features associated with the operation are generally considered a form of pollution by the public.
4. Pollution control practices should be planned, designed, and started before any extraction of the resource, and continued until complete reclamation has been achieved.
5. The most effective pollution control practice is pollution prevention.

### OVERVIEW

Soil particles carried away by wind become pollution. Sediment entering streams becomes pollution. Even noise is a form of pollution. Control of pollution on sand and gravel mines is required by most state and local laws. If properly planned and implemented, pollution controls can alleviate many community concerns and increase the value of land after mining.

Some pollution control devices can be installed before mining begins, such as sediment ponds and drainage diversions. Pollution control practices should be carried out for the life of the mining operation. Some may even be continued after reclamation. By complying with pollution performance standards, the operator will help avoid violations and potential shutdowns by the regulatory authority. Reclaiming and leaving the mine site in a stable, pollution-free condi-

tion is essential in obtaining bond release. If very sensitive environmental conditions exist at the mine site, pollution monitoring may be required after mining in order to obtain bond release.

The most common pollutants usually associated with sand and gravel mining are erosion and suspended solids (sediments) in streams, fugitive dust, and noise. Additionally, unappealing visual features associated with the mine site are often considered a form of pollution (visual pollution).

Problems resulting from these and other forms of pollution, and some practices which can be used to control them, are examined in this section.

### EROSION AND SEDIMENT

In this portion of the guide, some of the causes and problems re-

lated to erosion and sediment are discussed. Later in this section, practices for reducing erosion and trapping sediment are described. The information presented on causes of erosion can assist the operator in identifying potential sources of excessive erosion during the site analysis. Information on practices can guide the small operator in selecting appropriate erosion and sediment control measures prior to starting any extraction activities on the mining site. Although discussed as separate items in this guide, the interrelated aspects of erosion and sediment must be considered by the operator when planning control measures.

### **Erosion**

Erosion is a natural geologic process that can be accelerated when vegetation is removed and land is disturbed by mining activities. Erosion can best be defined as the detachment and movement of material from one place to another. The major agents of erosion are water, wind, and gravity. Of the three, running water is the most significant. The amount of water erosion, and its impact upon an area, are influenced by four conditions:

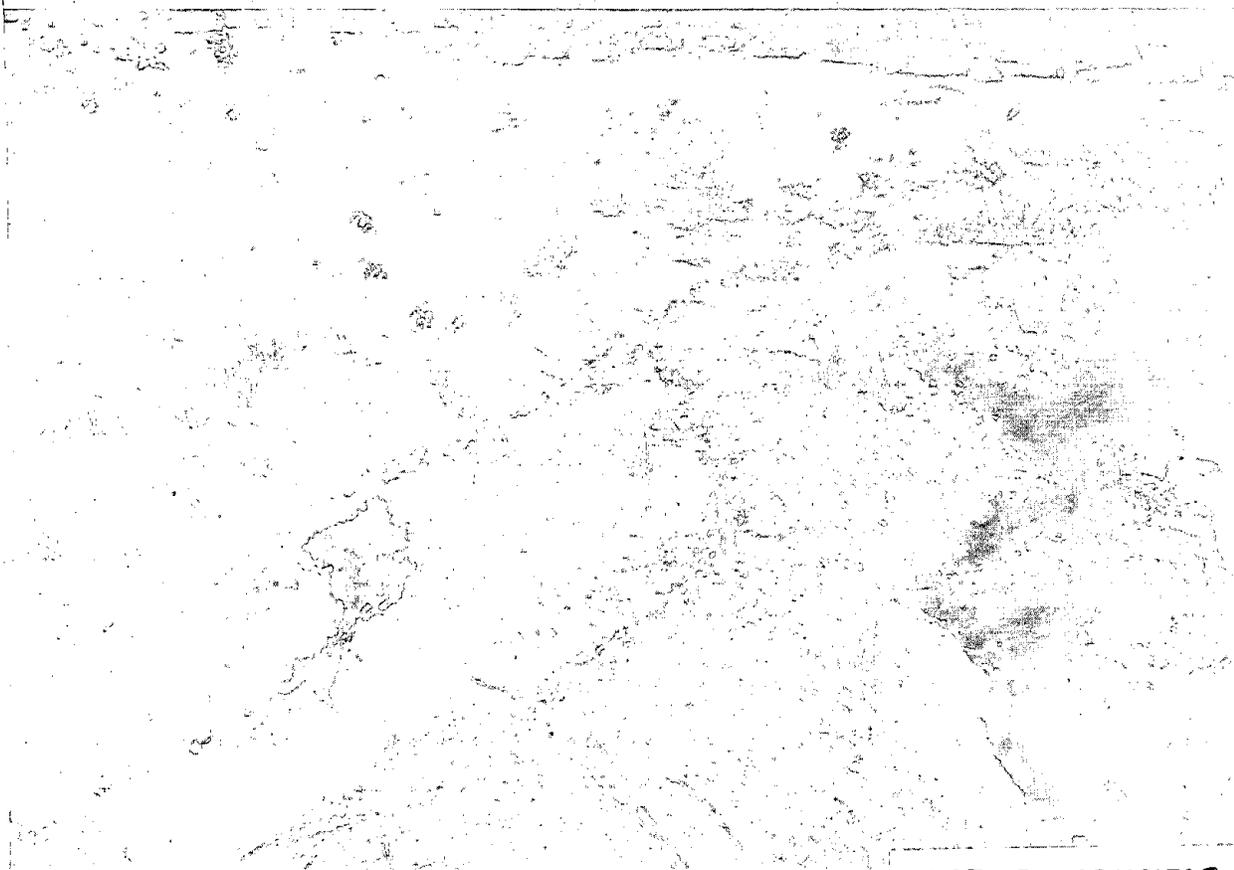
1. Climate
2. Soil
3. Vegetation
4. Topography.

Although not as significant as water, wind can also lead to erosion problems on sand and gravel mine sites. Under natural vegetative soil conditions, wind erosion takes place at a slow geologic rate. During mining, however, the erosive action of wind can be accelerated.

An important factor of the water erosion process is the "balance between infiltration and runoff." Runoff is the amount and rate of water that flows over the land surface and eventually enters streams. During the early stages of a rainfall event, much of the water seeps (infiltrates) into the soil. Vegetation not only helps the soil hold more water, but also binds the soil particles together, protecting the soil surface from erosion. During a heavy rainfall, the soil can become saturated to the point that water no longer infiltrates. Excessive runoff can then occur. When the vegetation is removed and soils are disturbed, the infiltration and runoff balance is altered, and runoff usually increases. Increased runoff, flowing over land void of vegetation, leads to accelerated erosion. Figure 31 shows an example of the effects of accelerated erosion.

Sand and gravel mining requires both vegetation removal and soil and earth moving. Furthermore, slopes are sometimes created where flat or gently sloping ground previously existed. All of these factors increase the potential for accelerated erosion. The operator must be aware of these factors, anticipate potential sources, and plan to reduce erosion to the extent possible.

Areas in and around the active extraction pit are subject to extensive erosion action. Unpaved haul and access roads are vulnerable, and areas cleared for preparation of plants and other mine site structures are also susceptible to erosion. Stockpiles of soil, waste fines, and other material can be easily eroded due to steep slope angles and the presence of fine-grained material. Outlets from drainage ditches and dewatering



**NOT REPRODUCIBLE**

**FIGURE 31. EXAMPLE OF ACCELERATED EROSION**

trenches are also subject to erosion due to the concentration and velocity of large water volumes.

The erosion of soil, either in place or from a soil stockpile, presents a dual problem. Not only is there a potential for a sediment problem, but the soil itself is being lost. Soil is a valuable material resource. Allowing it to erode away is similar to building a subdivision on an unmined gravel deposit. In both cases, an irreplaceable resource is lost.

### **Sediment**

The formation of sediment and resulting sedimentation are the most common pollution problems associated with sand and gravel mining. Water, running over exposed soil and rock,

creates sediment. The term sediment refers to the solid fragments, grains, and particles detached and moved from exposed soil and rock by the water erosion process. When sediment enters natural drainage ways, it becomes a form of pollution (suspended solids). The depositing of sediment materials is a process called sedimentation. Solid particles stay suspended since they are small and lightweight, and can be carried by the energy of a flowing stream. Sedimentation occurs when the stream loses the energy required to carry the suspended solids.

It is important to remember that streams carry a natural sediment load. Mining activities can serve to increase the stream sediment load by creating an unnatural

condition, thus leading to potential sedimentation problems. If an operator can reduce the potential for erosion and sedimentation, the potential for pollution can also be reduced.

Not every mining operation creates sediment problems and mining is not the only cause of erosion and sedimentation. Construction and farming activities also contribute to the problems. Examples of problems associated with excessive sediment are listed below:

1. Sediment muddies water and is visually unappealing.
2. Sediment can be deposited in stream channels, clog flow, change the stream course, and possibly change flooding characteristics.
3. When a stream enters a lake, reservoir, or other body of water, flow velocity is reduced to the point where suspended solids are deposited. As a result, water-holding capacities can be reduced, and navigation can ultimately be disrupted.
4. During floods, sediment can be deposited on farmland and other valuable lowland property.
5. Suspended sediment and/or resulting sedimentation impact fish and other aquatic life forms.
6. Suspended sediment could prevent the use of the water for domestic purposes, increase water treatment costs, and damage pipes, pumps, and

other water distribution systems.

7. Sediment could potentially carry other pollutants, such as pesticides and bacteria clinging to sediment particles carried downstream.

## **EROSION AND SEDIMENT CONTROL PRACTICES**

### **Controlling Erosion**

There are three basic practices which the sand and gravel operator can use to reduce the impacts of erosion:

1. Disturb the least amount of land possible
2. Leave disturbed land areas exposed only for the period of time required to extract the resource
3. Re-establish vegetation promptly.

Supporting measures which can be used include diverting runoff away from exposed areas, and reducing the speed (velocity) of runoff where possible. More expensive, but equally effective supporting measures include paving, riprapping, graveling, and/or mulching areas highly susceptible to erosion.

If the mine site is large enough, the operation could be planned and conducted in stages (see "Mining and Reclamation Plans," Section I). In this mining method, extraction occurs on a portion of the site while other portions remain undisturbed. After the resource is removed, reclamation can be started on the first portion, while extraction is started on an adjacent portion of the site. This approach may

not be applicable to all small operations, but it is an example of a means to minimize the amount of acreage disturbed and exposed at any one time.

Reducing the amount of time that soils are left void of vegetation can reduce the amount of erosion occurring during an excessive rainfall event. The operator should also plan to avoid disturbing vegetation and soil for weeks before extraction activities are to be conducted. Extraction should be completed as quickly as feasible in order to reclaim and stabilize potential sources of erosion in a timely fashion.

Establishing quick-growing species of vegetation on exposed soil or soil material is one of the best erosion control practices. Vegetation protects soil from the impact of raindrops, slows runoff, encourages water retention in the soil, and filters some of the sediment carried by runoff. Vegetation can be used to stabilize soil stockpiles and regraded areas, and to serve as a buffer along haul roads. Grasses and legumes, planted in combination, are recognized as the best types of vegetation to use in establishing a quick ground cover. Annual grasses, which will eventually die, can also be used to provide a temporary cover. Resulting temporary growth is referred to as a "cover crop," and used to protect exposed areas until long-lived vegetative species are established.

The operator should remember that a few scattered shrubs or trees will not provide adequate cover, or protect the ground surface as well as grasses. By the same token, areas reclaimed exclusively with grasses may not be visually attractive and could limit wildlife potential.

Runoff diversion can be accomplished with diversion ditches. The primary purpose of this measure is to keep water from flowing over exposed areas. There is no way to divert all rainfall and runoff away from erosion-prone areas but, by diverting the runoff to other locations, some erosion can be reduced. It is advisable to construct drainage diversion ditches before extraction activities begin in order to immediately reduce erosion potential.

Slowing the velocity of runoff and stream flow reduces the energy of the running water and, therefore, reduces its erosion potential. Runoff velocity can be slowed primarily by reducing slope steepness, but other measures can be used. Check dams and controlled gradients in diversion ditches and streams will help reduce the flow velocity. Along with decreasing slope steepness, decreasing the length of slopes will be beneficial. The creation of long steep slopes should be avoided where possible. Such slopes enable runoff to gain speed and increased momentum, two factors which can increase the erosion potential of the water.

On areas that are especially prone to erosion, non-vegetative controls can also be used. Haul roads can be paved, graveled, or oiled to help seal the surface and reduce erosion. Stream and diversion channels can be lined with riprap, and steep slopes can be mulched (e.g. straw or jute netting) to support vegetation. These measures can be expensive, but in critical areas, their costs may be justifiable.

Unpaved haul and access roads are highly susceptible to erosion. When considering the location of haul roads, operators should avoid steep slopes, if at all possible.

Additionally, road gradient should be minimized.

The following points should be considered when designing and constructing haul roads:

1. Cuts and fills should be stabilized by properly compacting fill material and revegetating the disturbed cuts.
2. Drainage ditches should be constructed along the roads, and a vegetative buffer zone established beside the drainage ditch and away from the road.
3. The road surface should be sloped with a high point in the middle so that drainage flows off the road, not along it.
4. A safety berm should be constructed outside the drainage ditch to control water overflow.

By controlling erosion at its source, the operator can minimize sediment pollution, conserve valuable soil material, and reduce water treatment costs. Water treatment in this case refers primarily to sediment ponds used to retain mine drainage long enough to allow sediment to deposit. Controlling erosion at its source can also save money by possibly reducing the number and size of sediment ponds that may be required by the regulatory authority, and by reducing the number of times that sediment ponds have to be cleaned.

### **Controlling Sediment**

Regardless of the efforts undertaken by the mine operator to

prevent and control erosion, some sediment will be generated during the mining operation. Methods to control and reduce the impacts of sediment are presented below.

Trapping Sediment from Land-Based Mines. Assuring that drainage leaving the mine site meets regulatory environmental standards for water quality will help the operator avoid pollution violations.

Trapping sediment before it enters natural drainageways is a practice which will assist in conforming to such standards. The operator must remember, however, that he will never be able to trap and retain all sediment generated by extraction activities. Sediment on the mine site can be trapped in several ways:

1. Berms, benches, and contour furrows (ditches) can be constructed on slopes. These slow down runoff and enable some sediment to deposit (see Section III).
2. Vegetation, especially dense grasses, can be used as a filter to assist in removing some sediment from flowing water.
3. Sediment ponds can be constructed and used to retain drainage for a certain period of time, and enable a significant amount of sediment to be deposited.

Of the three methods, sediment ponds are most commonly used. The theory behind all the methods, however, is basically the same. Running water has energy to carry sediment particles. If the speed of the water is reduced, so is the energy. Without the necessary energy, the sediment particles can no longer be carried and will start to deposit.

Therefore, any method that slows down the drainage will also help to retain some sediment on the mine site.

Vegetative establishment and slope grading (e.g. benches or furrows) are reclamation-type activities, but they also serve pollution control functions. Typically, sloping cannot be done until the mining operation is well progressed. But erosion and sedimentation can begin with the first ground disturbance.

Diversion of runoff and construction of sediment ponds generally take place before mining starts. Vegetative filters, if well planned, can also be installed at key locations on the mining site before extraction activities start. Natural vegetation, when possible, can also be used as buffers or filters.

Slope grading and vegetation are discussed in Section III. Since sediment ponds are the most commonly used techniques for trapping sediment, they are the primary topic of discussion in this portion of the guide.

Sediment ponds can be called by various names, including silt ponds, settling ponds/basins, settling lagoons, holding ponds, or detention basins. Regardless of what they are called, the function is the same. They retain all or part of the surface drainage from the mine site for a certain length of time, and enable significant amounts of sediment to settle to the bottom of the pond. Sediment ponds should be constructed in the early stages of the operation. The operator must select the location of the structures carefully, to allow retention of drainage, and yet to be out of the way of the extraction activities. These structures and surrounding berms

must be designed to hold a specified amount of water safely. In some areas, the State Water Engineer, or a person of similar authority, must approve the location and design of sediment ponds, dams, and berms.

A sediment pond will not be effective if mine drainage is allowed to bypass and directly enter off-site drainageways. The operation should be planned to allow all mine site runoff and natural drainage to enter one or more sediment ponds. The locations selected for the ponds, therefore, should be suitable to receive the concentrated, diverted drainage. The excavation pit or another part of the property can be used for pond locations. Usually, requirements are that they be located within the approved permitted area.

The size and specific design of a sediment pond depends on the volume of water it is expected to hold, and the amount of sediment anticipated. Generally, a pond is designed to hold runoff resulting from a major storm event. This is a safety precaution, insuring that an unusual rainfall event does not overtop the dam. Professional hydrologists and civil engineers may be used to design the sediment pond using criteria based on historic and anticipated storm runoff data. Operators should check with the regulatory authority to determine the type of personnel qualified to design and build such structures.

Allowing for extra height on the dam and berms provides an added safety measure should the water level become higher than calculated. This "freeboard" may also be required by local or state regulations.

Certain problems that could occur with sediment ponds can often be avoided through proper design.

Since the function of a sediment pond is to retain water long enough for sediment to deposit, anything that speeds up the flow of water into and out of the pond is a negative factor. For example, if the distance between the inlet and outlet of the pond is too short, the retention time may not be long enough. Not only is the size of the pond important, its relative dimensions are also important. Typically, sediment ponds should be longer than they are wide. Otherwise, water may enter the pond at a high velocity, flow through quickly, and discharge before a significant amount of sediment has had time to deposit. This potential problem can often be avoided by constructing obstacles or small barriers (called "baffles") in the flow path of the water. Baffles slow water velocity to allow for proper discharging.

The design of the pond discharge, or outflow mechanism, is critical. The discharge pipe can be constructed through, or under, the dam. If constructed through the dam, it should be high enough to allow water to pond, but low enough to allow discharge before overflow occurs. A problem associated with discharge pipes, when constructed through dams, is erosion around the pipe. Resulting erosion could possibly weaken the dam. To avoid this problem, a riser pipe could be installed in the pond, rising vertically from the bottom. When water rises to a certain height in the pond, it can flow down the riser and horizontally out of the discharge pipe. Eroding of the dam around the discharge pipe can often be prevented using this approach.

When water starts to flow down the riser pipe, a swirling motion may occur in the pond (like water draining out of a bathtub). This motion does not allow the pipe to

perform properly, and can be avoided by building fins at the top of the riser pipe. These fins are called "anti-vortex devices." These devices will reduce the swirling effect and allow the water to flow to capacity.

Outside the sediment pond (downstream from it) there will be a flow of discharged water. Once again, this flowing water can cause erosion, pick up sediment, and erase the work of the sediment pond. Placing riprap or gravel around the point of discharge will help control erosion at this point. It may be necessary to riprap the discharge channel farther downstream, at least until the water reaches a stable, natural water body.

Many sand and gravel operations are located in floodplains. In some cases, the sediment pond may be located close to a stream. This could create problems if the stream floods and "washes-out" the pond, or if overflow and seepage from the pond enters the stream.

To assist in controlling flood and overflow problems, a large berm could be constructed between the stream and the sediment pond. The height and construction specifications of this berm should be determined from storm records, flood data, and other hydrologic information. Since some floodplains fall under the jurisdiction of the U.S. Army Corps of Engineers, they may have to approve these construction plans. Some state agencies may also be required to approve floodplain construction. Additionally, some states may have dam and reservoir safety statutes, laws, or regulations with which the operator must comply.

In some instances, water from the sediment pond could leak through

the berm or seep into the material directly beneath the pond, and find its way into the stream. This is unlikely, unless a crack or other conduit opens up between the sediment pond and the stream. If the berm is constructed of materials that have been adequately compacted, seepage should be minimal. Also, when water does seep through earth or fill material, any sediment in the water tends to be filtered. Water escaping the pond in this fashion will generally be low in sediment. The bottom of a sediment pond is usually covered with a layer of clay material. This type of bottom layer helps to seal the pond against leakage. Sediment usually does not enter groundwater unless there are direct openings to the groundwater table. The percolation of water through soil or rock material will also help filter sediment.

Sediment deposition can be improved with the use of certain chemicals. These chemicals will cling to sediment particles and, in effect, make them heavier. The heavier particles sink more rapidly. Some chemicals will also help to neutralize electrical charges and assist in speeding up the settling process. Clay particles can remain suspended for a long time. This is due to similar electrical charges (on the clay particles and in the water) that repel each other and keep the particles moving. Chemical settling agents, called "flocculants," modify these charges and allow particles to come together and deposit. Use of these chemicals can be expensive, and may not necessarily increase the sediment pond's effectiveness.

If the sediment pond is functioning adequately, the bottom will fill up with fine-grained material. When this buildup becomes too large, the pond will become ineffective.

Sediment occupies space that water could occupy, and the additional sediment entering the pond will not be provided with sufficient settling space. Ponds should be inspected frequently, and when one-half full, accumulated sediment should be removed. Some disposal suggestions are discussed in Section III.

Sediment Control in Dredged Waterways. Dredging sand and gravel from waterways stirs bottom sediments and suspends them in water. Onshore processing of the dredged material also contributes suspended sediment to nearby streams or lakes (see Figure 32). Naturally, if the dredged material is processed on-board, significant quantities of sediment will be discharged.

Sediment caused by dredging and on-board materials processing is extremely difficult to control since the sediment is introduced directly into the body of water (see Figure 33). When using these procedures, there is virtually no way to prevent sediment from entering the waterway. The problem becomes one of removing suspended particles that are already in the water.

As with land-based operations, sedimentation can be partially controlled by slowing down the flow of water, and/or treating with chemical flocculants. These methods have been tried, but have proved mostly unsuccessful. Another possibility for waterway sediment control is the use of silt or sediment curtains. These curtains consist of filter-type material and are placed downstream from the operation or arranged in a circle around the operation. The curtain can then act to filter some of the sediment.

Stream flow can be slowed down and temporarily stagnated by dikes or baffles. These structures pro-



FIGURE 32. SEDIMENT-LADEN WASTEWATER BEING DISCHARGED FROM AN ONSHORE PROCESSING PLANT

trude from the shoreline and form small dams. When water backs up behind them, some of the sediment deposits to the bottom. This process can also be helped by the addition of chemical flocculants. The operator should carefully consider the use of these techniques. Dike construction and the use of chemical flocculants are expensive and are not always effective. The operator must also remember that whenever chemicals are introduced to a water source, the potential exists for additional pollution problems.

Sediment curtains are expensive and require constant maintenance. When the filter material becomes clogged, it will no longer function effectively. Periodically, the curtain has to be removed and cleaned.

Sediment control methods for use in waterway dredging are more theoretical than practical. When cost is compared to effectiveness, they may not prove to be worthwhile. There is also evidence that much of the sediment load may deposit naturally before it is carried very far downstream. Very fine-grained clay material can, however, stay in suspension for a longer period of time, and thus be carried many miles downstream.

Onshore processing of dredged materials allows for the use of more effective sediment control measures. Wastewater flow can be diverted to a sediment pond to allow settling before it is returned to the stream. Since significant amounts of sediment are usually generated in this



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FIGURE 33. DREDGING STIRS SEDIMENT IN WATERWAYS

type of operation, the sediment pond may have to be large, thus requiring frequent cleaning. Since the sediment pond would most likely be located in a floodplain or other low-lying area, protection from flooding and overflowing may also be required. Large berms can be constructed around the pond to prevent settled sediment from being washed into the stream during high-water periods.

Most waterway dredging and floodplain construction on larger streams and rivers comes under the jurisdiction of the U.S. Army Corps of Engineers (by authority of the Rivers and Harbors Act of 1899). The operator should determine legal requirements prior to any excavation or construction in the areas.

Recycling Process Wastewater.  
Another source of sediment associated with a sand and gravel mine site is water used to process (clean) the resource. This water is used at both permanent and temporary on-site preparation plants. After processing, the water contains a large amount of fine-grained sediment.

Large amounts of water are needed to process the raw material. In regions with arid climates, where water rights are allocated, it may be difficult to obtain an adequate volume of water for such use. Recycling (i.e., reusing) process water will not only reduce the consumptive use of water, but also help to control the sediment problem.

Regardless of the supply situation, the operator should conserve water. Recycling process water can save up to 90 percent of the water required to run an operation. In many cases, a small holding pond can serve the purpose, with initial and replacement water being supplied by groundwater or stream flow. Operations that excavate below the water table can utilize ponded water for processing (see Figure 34). Recycling process water will enable the operator to contain most water on-site and minimize flow into surrounding streams. This, in itself, is a valid pollution control technique. In fact, the U.S. Environmental Protection Agency has determined that recycling process water is the "best available control technology" for maintaining water quality on sand and gravel mines.

Fine-grained waste products are flushed from the resource with the process water. When discharged water flows to a holding pond, the sediment is allowed to deposit. An intake pipe will draw water that has been partially cleared of sediment. Holding ponds act like sediment ponds, except there is no discharge to off-site surface drainage. As with sediment ponds, holding ponds should be cleaned periodically to prevent sediment buildup and clogging of pipes and pumps.

Some water may flow off conveyors and stockpiles in the preparation plant area. To keep this water from flowing into streams, small holding ponds can be used (see Figure 35). The volume of flow is usually so small that no outlet will be required. Water will evaporate and seep into the ground, generally at the rate supplied.

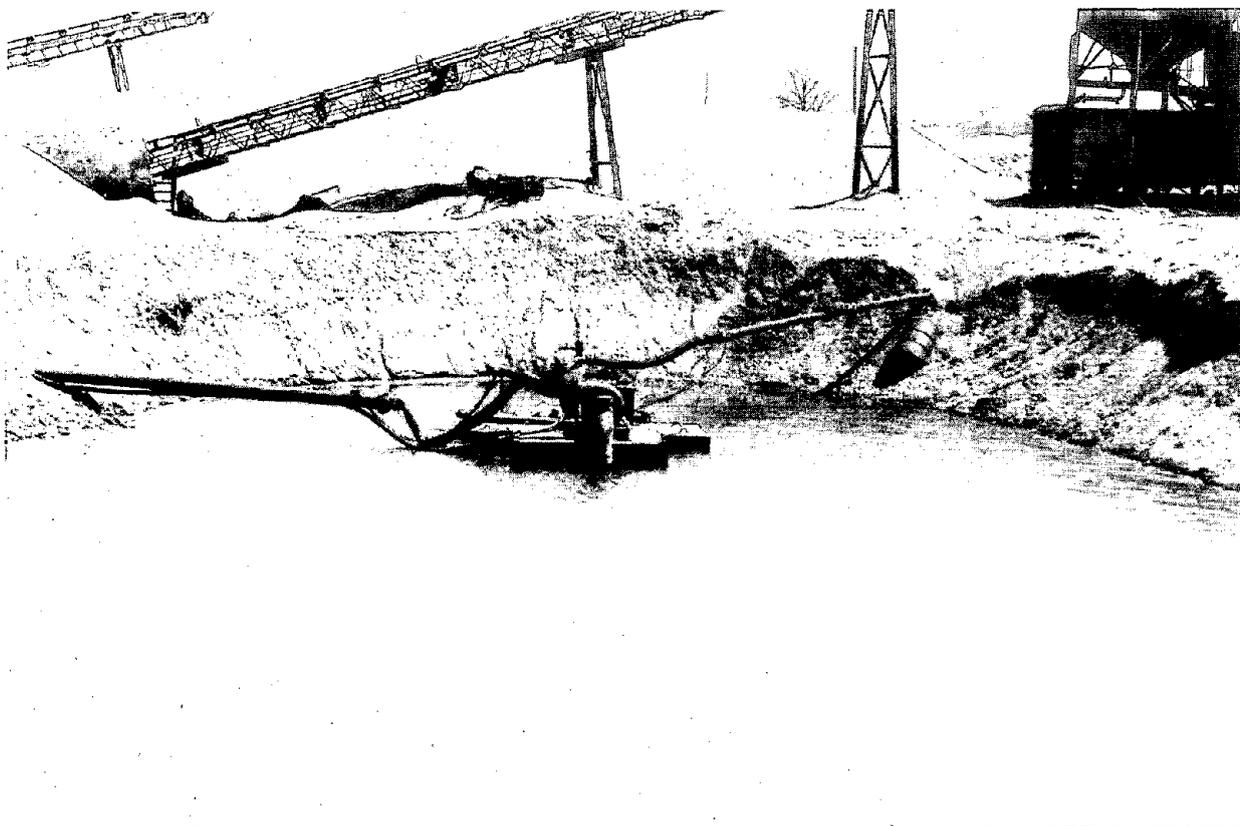
Measuring Sediment. It may be essential either before, during, or after mining to measure the sediment

load in affected bodies of water. This can be done in several ways, with some methods being more accurate (and more costly) than others.

A common method involves the degree of visibility through the water (turbidity). The turbidity of sediment-laden water refers to its cloudiness. In most cases, if an individual can easily see through the water, it is not considered very turbid. If the water is extremely muddy, and light will not pass through, the water is considered highly turbid. Turbidity is measured in Jackson Candle Units (JCU's). High JCU measurements indicate significant amounts of sediment in the water. This testing method provides a relative measurement of sediment. It does not measure exact amounts. Turbidity analyses are, however, quicker and cheaper than obtaining laboratory measurements of the exact volume of sediment.

To more accurately determine sediment loads, the use of laboratory equipment and procedures is necessary. A water sample of known volume is collected and separated from the sediment by filtering it through fine mesh paper. The filter paper is weighed, allowing the exact weight of the sediment to be determined. Weight is usually specified in milligrams per liter (mg/l). This method can be used to determine if sediment loads meet standards for acceptable water quality, and if sediment control practices are properly functioning.

Many regulations require that water discharged from a sand and gravel mine site contain no more than a specified amount of sediment, measured in milligrams per liter. This is one reason why premining monitoring of the water can be important. For example, suppose sedi-



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FIGURE 34. PONDED GROUNDWATER CAN BE USED FOR PROCESSING RAW MATERIALS

ment in a stream measured 120 mg/l prior to resource extraction while regulations allow only 70 mg/l as the maximum. The operator could then argue that the regulations are requiring cleaner water than exists under natural conditions. Thus, if subsequent measurements taken during mining were over regulatory limits, a pollution violation might be avoided.

### STREAM FLOW VOLUME

When mining occurs in or near streams, there is always the potential for decreasing the flow of water. This can happen if:

1. A stream is intercepted by the excavation and a pond is created, thereby hold-

ing water and not allowing it to flow downstream

2. Water is pumped from the stream for use in the washing and separating process
3. The mine site changes the watershed characteristics (i.e. runoff percolates into the ground rather than flowing to streams).

Decreasing flow can cause water rights problems and lead to other complaints from downstream water users. In some cases, the sand and gravel operator may be required to supply additional water to affected downstream users, or the operation could eventually be halted by the



FIGURE 35. HOLDING PONDS CAN BE USED TO CATCH FLOW FROM STOCK-PILES AND PREPARATION AREAS

regulatory authority.

To avoid such problems, the operator should determine stream flow rates before mining, and predict the effects of the mine on flow conditions.

Some practices which can be used to help maintain stream flow are:

1. Diverting streams around the mine site, if possible, so flow will not be dammed or ponded
2. Directing runoff from the mine site into a sediment pond for treatment, and then discharging the treated water into the

stream normally receiving the runoff

3. Maintaining the normal balance between infiltration and runoff to the greatest extent possible
4. Recycling water as much as possible.

Pit dewatering (pumping groundwater out of the pit area and into the surface drainage) can increase stream flow. This action usually causes no problems in a small sand and gravel operation, but the volume of water pumped and the capacity of the stream channel should be considered in order to avoid potential problems. Controlled pumping can keep the outflow constant, and help to minimize downstream problems.

## GROUNDWATER

Groundwater is basically rainfall or other surface water that has percolated underground to be stored in the gravel deposit, in the material below, or both. If groundwater is located near the surface, such as in a swamp or a river bottom, the entire thickness of the gravel deposit will be wet.

Rock or earth material (such as gravel deposits) that hold water are called aquifers. The elevation at which groundwater is encountered below the surface is called the water table. Aquifers that hold water above the water table are called perched aquifers. In general, gravel deposits make good aquifers, but this situation is very dependent on regional characteristics. In humid Eastern climates, water tables can be close to the surface and, therefore, gravel deposits could serve as aquifers. In arid Western climates, water tables can be deeper and gravel deposits may or may not serve as aquifers. An aquifer recharge, or recharge area, is the area where surface water seeps underground to become part of the water table. Water-table levels vary with the seasons of the year. Figure 36 shows some possible positions of water tables relative to a gravel deposit. Operators should determine aquifer and other groundwater characteristics during the site analysis (Section I).

Sand and gravel mining operations can have both positive and negative effects on groundwater. Negative effects can include:

1. Dropping the water table and drying up nearby wells
2. Removing water from the groundwater system permanently, particularly if

excavated pits are dewatered during extraction activities

3. Loss of groundwater due to evaporation, particularly in areas where pits are filled with groundwater.

Sand and gravel mining rarely pollutes groundwater systems, but can decrease the amount of groundwater, as well as lower the water table.

A positive effect includes the creation of ponds when groundwater fills the excavated pits after mining. Such ponds can often be used for recreational or wildlife purposes.

## FUGITIVE DUST

Fugitive dust is a term used to describe fine-grained earth material that has been detached by wind and carried across or off the mine site. Fugitive dust can be considered a pollutant since, potentially, it can cause respiratory problems, settle on neighboring property, cars, clothes, etc., and affect vegetation and wildlife on or near the mine site. A main component of fugitive dust is the chemical element silica (Si), the known cause of a respiratory problem identified as silicosis. Any methods proposed to control fugitive dust will be beneficial and the operator should note planned dust control procedures in his permit application.

Monitoring of fugitive dust, before and during extraction, may be required by the regulatory authority. The amount of fugitive dust measured before mining (called baseline or background fugitive dust levels) is compared with amounts generated and measured during extraction. This procedure enables

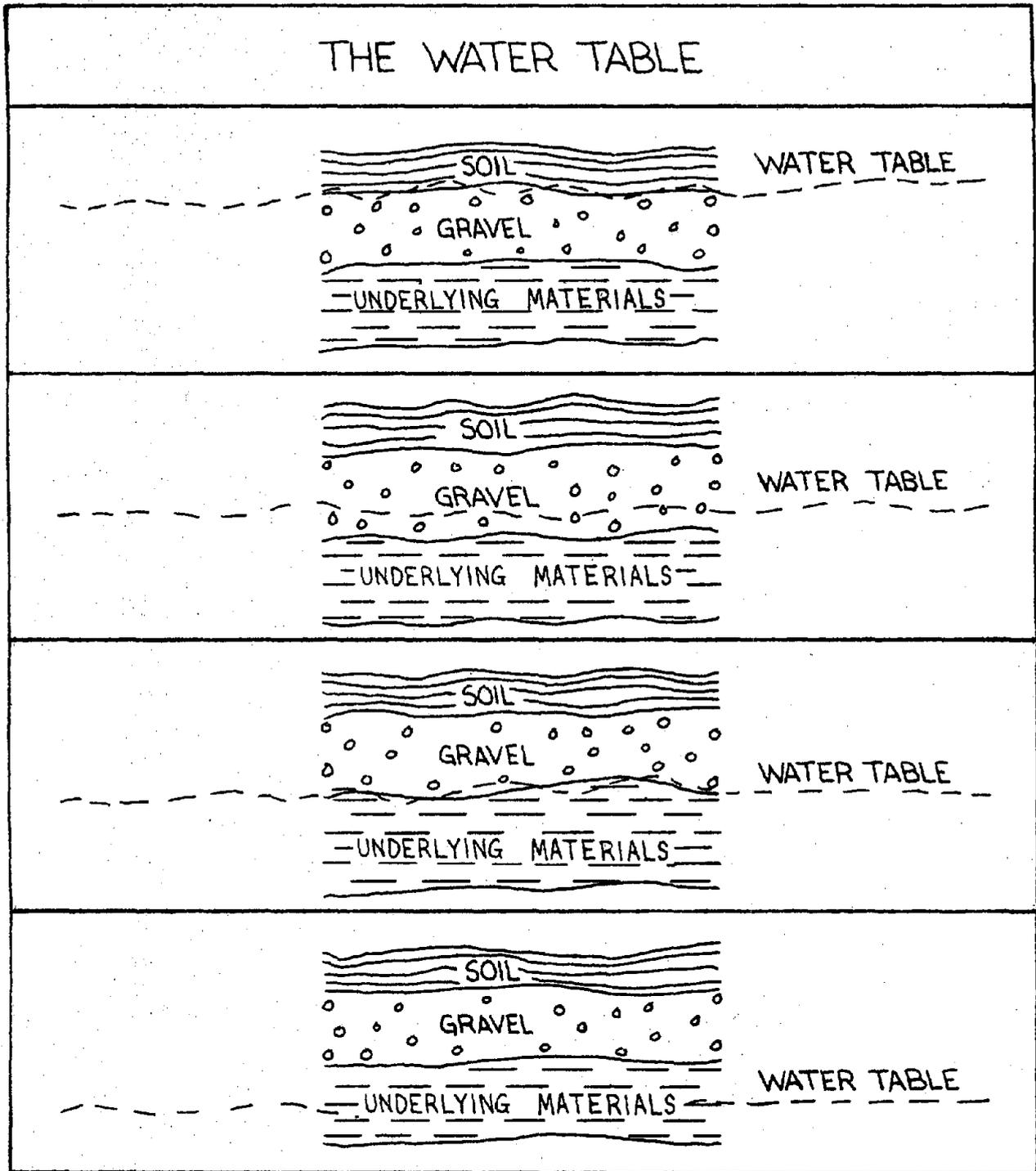


FIGURE 36. SOME POSSIBLE POSITIONS OF WATER TABLES RELATIVE TO GRAVEL DEPOSITS

the regulatory authority to determine if the operation is contributing to air pollution.

Fugitive dust can be generated in a number of ways. The most significant amounts are probably gener-

ated by haul trucks travelling on unpaved roads. Other contributors include excavating and loading equipment, crushers and other preparation machinery, and wind erosion on land void of vegetation. Any activity which exposes fine-grained

material to wind will generate fugitive dust. Two basic approaches can be used to control fugitive dust:

1. Avoid exposing bare ground to wind.
2. If bare ground must be exposed, try to protect it from wind.

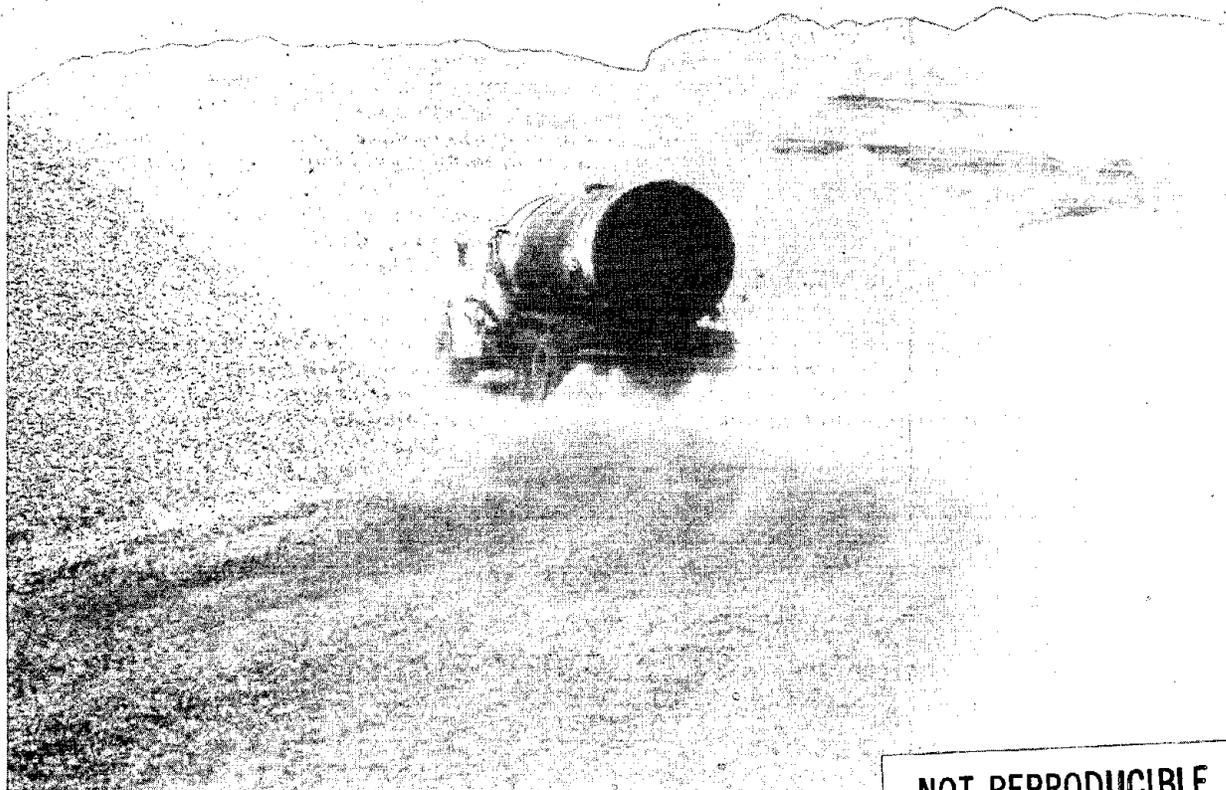
Some practices and procedures which the small sand and gravel mine operator can use to control fugitive dust include:

1. Not removing vegetation until necessary and then trying to limit the time such areas will be exposed.
2. Reducing mining activities on windy days, or when a temperature inversion could trap dust and cause stagnation.
3. Attempting to establish quick-growing grasses and legumes on exposed ground as soon as possible. Plants protect soil and earth material from wind erosion. This technique is particularly useful on areas that will be unused for an extended period of time (such as six months or more). This practice, for example, would be very helpful to control dust along haul road embankments.
4. Identifying all dust-producing sources during planning to devise adequate controls, particularly for preparation areas. Spray bars can be used in conjunction with crushers and conveyors,

and stockpiles can be wetted.

5. Controlling the weight and speed limit of haul trucks. The amount of dust generated by a truck depends on the weight of the vehicle and the speed at which it travels.
6. Wetting haul roads frequently. Water, or water mixed with chemical dust suppressants (such as calcium chloride) can be used. The dust suppressants are mixed with spray water and coat grains of dust, thus decreasing wind detachment. Water spray trucks can be used to wet haul roads, as well as preparation plant areas (see Figure 37).
7. Preparation of haul roads. They can be paved, oiled, or graveled. Asphalt, road oil, or gravel covers small dust grains and helps prevent their detachment by truck tires. When using oil to control dust, the operator should remember that excessive use of oil can sometimes lead to surface and groundwater pollution.

Fugitive dust can be measured in several ways. The use of "high-volume air samplers" which provide for the intake of air and dust particle samples are the most expensive. Once a sample has been collected, the dust can be filtered and weighed. Fugitive dust is usually measured in<sub>3</sub> milligrams per cubic meter (mg/m<sup>3</sup>). A less expensive method is the "visual opacity" measurement. This method measures the degree of visibility through a dust



**NOT REPRODUCIBLE**

**FIGURE 37. WATER SPRAY TRUCK WETTING HAUL ROADS**

cloud and is reported in percent opacity. For example, 20 percent visual opacity means that an individual can see only 80 percent of what could be seen if the dust were not there. The instrument used in this method is a small telescope-like device that the operator may look through to measure the thickness of a dust cloud. A third method is known as the "water bucket" measurement. A tub or bucket of water is placed near the mine site. Dust falls into the water and settles to the bottom of the bucket. At a predetermined time, the water is removed and the dust residue is weighed. This provides a rough indication of the amount of fugitive dust generated.

Some state agencies may require the operator to obtain an air qual-

ity permit. The general intent of such permits is to prevent "significant deterioration" of air quality. To obtain such a permit, the operator must often prove that the operation will not result in air pollution greater than that which exists prior to mining. To convince agencies that dust will be controlled, the operator must often demonstrate that appropriate control methods have been considered in planning for extraction and reclamation.

Fugitive dust is generated primarily from three sources: 1) the excavation area, 2) the preparation plant area, and 3) unpaved haul and access roads. The most troublesome source is unpaved haul and access roads. Special attention to the control of dust from haul and access roads will help keep air pollution problems at a minimum.

## NOISE

Noise can be defined as unwanted sound. Sand and gravel mines create noise which may be irritating to people living in the vicinity. Typical noise producers at sand and gravel mine sites are:

1. Crushers
2. Haul trucks and other heavy hauling/earth-moving equipment
3. Back-up sirens on heavy equipment
4. Asphalt batch plants.

Noise from haul trucks can be heard both on- and off-site. Other noises are made on-site and can occasionally be heard off-site in surrounding neighborhoods.

Regulations sometimes require that a "background" noise study be conducted, and that noise generated during the operation be monitored. Results from a background study are used to determine how much noise is present without the sand and gravel operation. Monitoring during extraction helps to determine if increased noise is caused by the operation.

Noise is measured with a decibel meter and is reported in units called decibels (dB). The farther away measurements are taken from the source of noise, the lower the decibel level. Decibel levels indicate the loudness of noise. The higher the decibel reading, the louder the noise. Figure 38 provides examples of common decibel levels for different sources of noise.

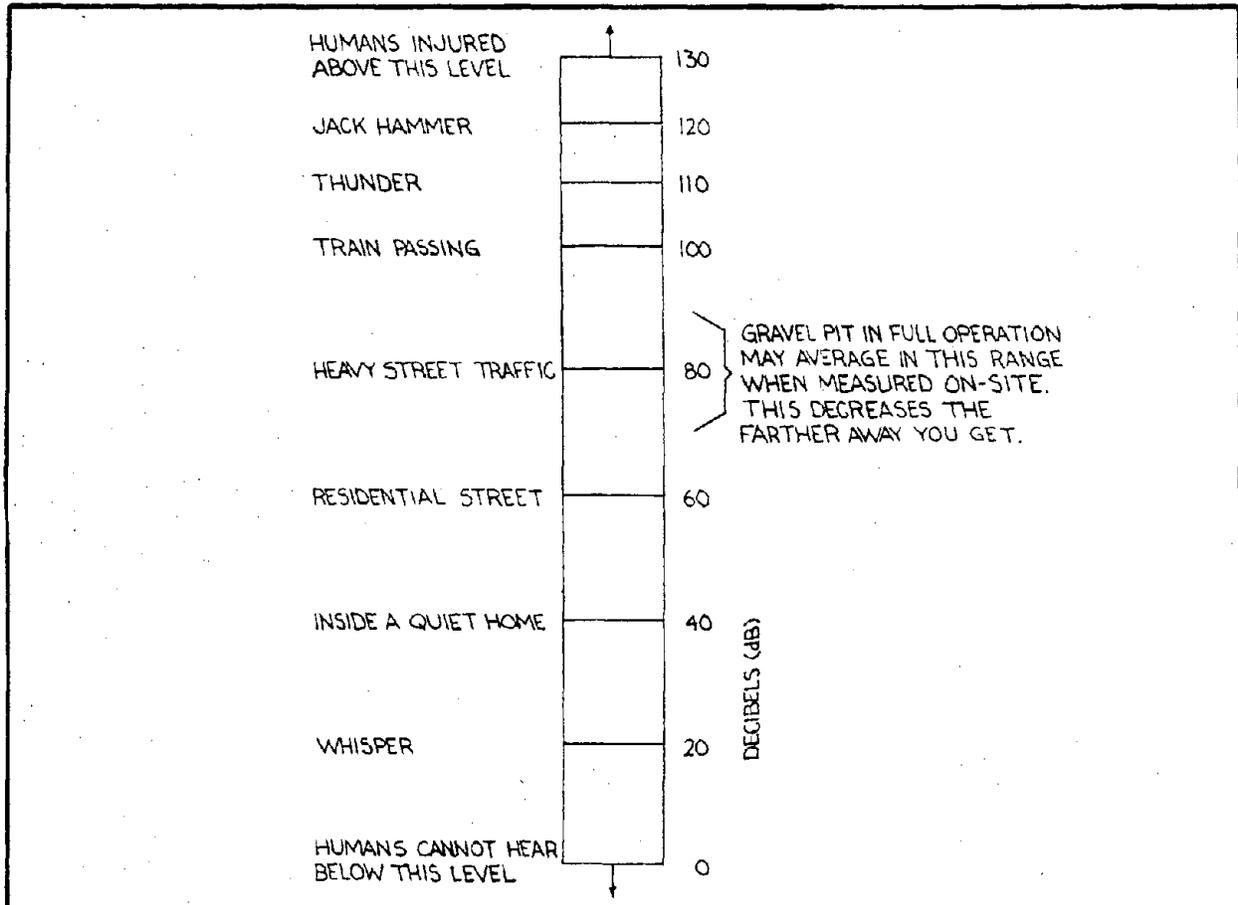


FIGURE 38: THE DECIBEL SCALE AND SOME ASSOCIATED NOISES

Usually, local noise ordinances (if there are any) require new land uses or developments to operate within the normal background noise levels of that area. Therefore, a sand and gravel operation in a residential area may have to be quieter than one located in an industrial area. The operator should check with local regulatory authorities for noise ordinances which may apply to his operation.

There is little doubt that a sand and gravel operation will create some additional noise. There are some practices, however, that can be used to reduce the amount of noise leaving the mine site. These practices do not apply to occupational noise hazards that are regulated by the Occupational Safety and Health Administration (OSHA), but apply to noise covered mainly by local ordinances. The following noise abatement techniques should be considered when developing extraction and reclamation plans. The operator's intentions to practice such techniques should be clearly conveyed to the regulatory authority.

1. Tune engines and install and maintain good mufflers or baffles on equipment. This practice controls noise at the source. Also, try to avoid hauling through residential areas.
2. Limit hours of operation so as not to disturb residents when they are most likely to be home. Typically, hours such as 6:00 A.M. to 6:00 P.M. Monday through Friday are acceptable. Attempt to limit weekend work to maintenance and repairs.
3. Locate preparation plants away from densely populated areas, if possible.

4. Install topographic berms and vegetative buffers to help reduce noise levels. A topographic berm is a graded pile of waste material constructed along the border of the excavation pit. It can prevent people from seeing the pit, and can help reduce the effects of noise. A vegetative berm is made up of vegetation (shrubs and/or trees) planted around the active pit or mine site. It will also prevent people from seeing in, and may help to reduce noise levels. Topographic berms are considered better at reducing noise levels than vegetative berms.
5. Consider wind directions. The direction of prevailing winds may affect the distance noise is carried. By determining wind direction, the operator may be able to reduce the effects of noise in certain directions.

There are several factors which influence community attitudes towards noise. They include:

1. Type of noise. Is it low-frequency noise, or high-frequency noise? Is it continuous, or short and intermittent noise? Generally, loud high-frequency noise (like back-up sirens) which lasts only a short time is the most bothersome. Low-frequency noise that is continuous (like the hum of a conveyor or a bulldozer engine) is often viewed as less of a problem.

2. Amount of normal background noise. Is the area usually noisy? If so, problems may be small. If normal noise levels are usually low, however, residents may complain about additional noise created by the mining operation.
3. Time of day. Noise is more tolerable to residents in the daytime than at night or during weekends.
4. Initial effects of noise. At first, residents may object to additional noise, but later, they may not notice.

Noise usually has three main sources. First is the steady noise of crushers, screening and washing operations, conveyors, etc. Second is the noise resulting from the off-site transportation of the sand and gravel resources. Third is the noise associated with excavating the raw sand and gravel (shovels, draglines, dozers, loaders, etc.). Noise levels are generally influenced by atmospheric conditions, berms, trees, buildings and other barriers, and the nature of the noise itself. High-pitched, intermittent noises tend to travel farther than constant, low-frequency noises. Some regulations may establish maximum decibel levels allowed for noise as measured at the property boundary of the mine site.

## **VISUAL APPEARANCE**

The topography and geometry of the proposed mining site are important considerations in planning and implementing techniques designed to enhance the visual appearance of the operation.

The site will generally have some characteristics that will enable the operator to partially screen it from view. The operator usually has enough flexibility to design the site layout in a manner that takes advantage of any visual screening features already present. It is always better and cheaper to use natural conditions to screen the site than it is to build artificial screens.

Through "line-of-sight" studies conducted during the premining planning phase, the most and least visual portions of the site can often be identified. Preparation plants, stockpiles, and other highly visible components of the operation can, if possible, be located in low-visibility areas. Topographic lows should be considered for use in locating high-profile structures and stockpiles. The operator must take care, however, to control drainage when using such areas.

If trees or other thick vegetation is present, they could be left in place and used to naturally screen site features. Topographic highs, such as berms, mounds, and ridges, can be used in a similar manner. It may be cheaper to leave gravel resources in place for visual screening purposes, than to construct artificial berms. This alternative would have to be carefully analyzed by the operator, but using existing features to screen the site, instead of relying totally on artificial screening methods, is often cost-effective. The "no-screening" alternative, if selected by the operator, may impede his chances for permit or rezoning approvals, or may lead to citizen complaints during the mining operation.

Frequently, some visual screening of sand and gravel operations is required by regulations (e.g. zoning

ordinances), or by community pressure. Even if natural screening features are considered in designing the site layout, artificial screens may still be required in some areas. In determining the locations and types of visual screens to use, the operator should consider the following points:

1. Where will screens be required?
2. What type of visual screen will be most cost-effective?
3. Can a visual screen be used for other purposes, such as wind breaks (to control fugitive dust), or noise buffers?
4. Will visual screening structures be removed after mining, or can they be left in place?

There are a number of visual screening techniques which can be used at small sand and gravel mines. One feature these techniques have in common is that they replace the view of the sand and gravel operation with a view of something else.

The most commonly used visual screening structures are:

1. Berms (mounds created with fill material, waste fines, overburden, etc.)
2. Vegetation
3. Berms planted with vegetation
4. Fences or walls.

A frequently used visual screening technique is the earth berm. Essentially, any material

available on the site, or left after processing, can be piled along roads and around the perimeter of the site. The height at which the berm should be constructed depends on the eye-level of the viewers, and the size of the object(s) to be hidden. Frequently, berms (as well as other screening structures) are constructed at least as high as the eye level of passing motorists or pedestrians.

Figure 39 shows a small berm which has been constructed to screen a small sand pit from the view of motorists. The berm material is sand. The length and height of the berm are matched to the size of the pit and the eye level of drivers. The vegetation along the berm is natural and was not destroyed during berm construction. When possible, it is beneficial to combine existing site features with visual screen construction. In this situation, shrubs along the road add extra screening to the sand berm.

An unvegetated, fill-material berm may present some problems. The berm itself may be as unattractive to observers as extraction activities, or the stockpile it was designed to hide. Another problem may arise through erosion of the earth material used to construct the berm. Generally, the establishment of vegetation on the berms will help to control both problems.

Vegetation is attractive and makes an excellent visual buffer. Vegetation can be used alone, or it can be planted on a berm. Either way, it is important to plant large, fast-growing, bushy (leafy) shrubs and trees. Grasses on a berm are a definite improvement over an unvegetated berm, but most grasses do not grow very high, and, by themselves, provide little cover. Of course, trees and shrubs are more expensive, but they will afford a more effective and attractive screening.



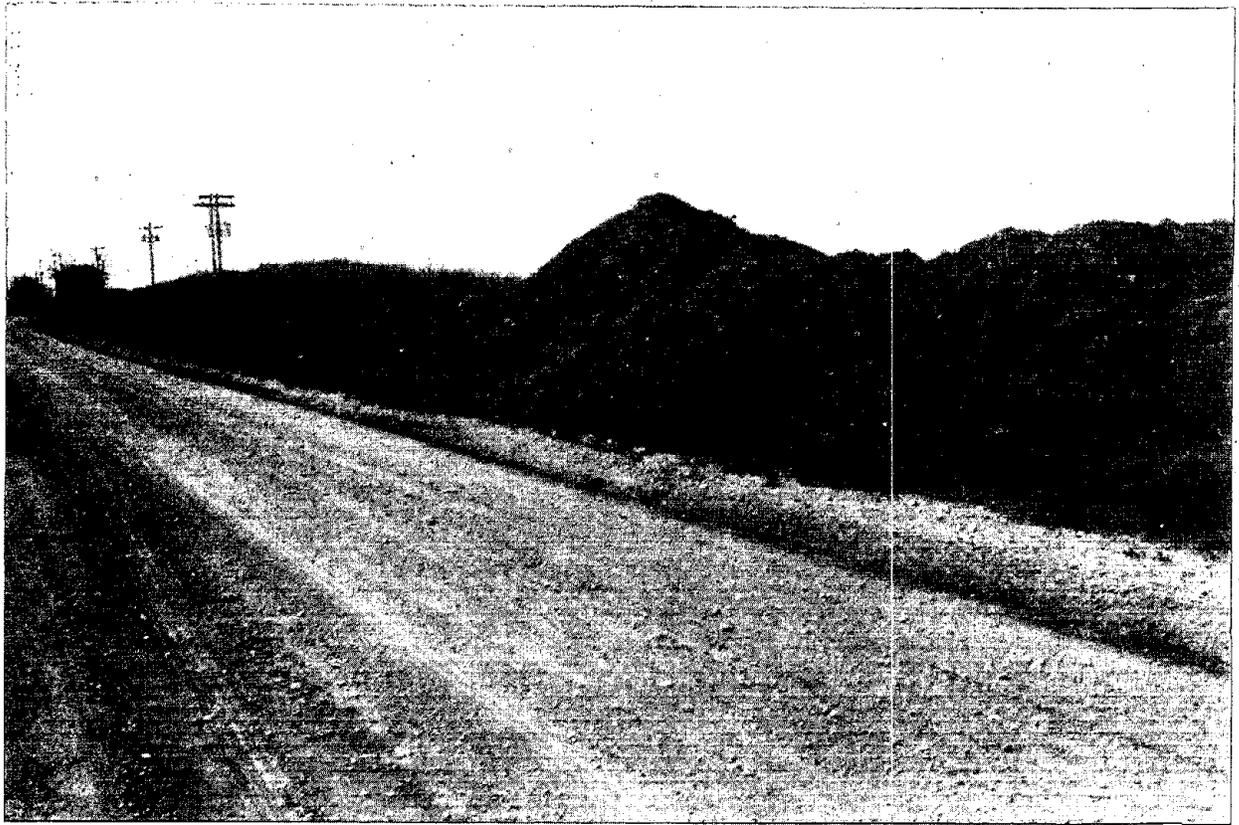
NOT REPRODUCIBLE

FIGURE 39. SMALL VISUAL BERM CONSTRUCTED BETWEEN ROAD AND SAND PIT

Waste fines, overburden, and other fill materials are usually present on a sand and gravel mine site and can readily be used for constructing visual berms. Planting grasses on these berms is done more for erosion control than visual appearances, but the grasses do add to the overall image.

The berm shown in Figure 40 screens a relatively small operation from a lightly travelled road. The berm is high enough to screen the mine site from people driving by, and it is no longer than the mine pit area. The size and expense of the berm is compatible with the value of the resource deposit, and the visual sensitivity of the area. A wall, or expensive trees and shrubs may not be practical or necessary in this type of situation.

Figure 41 illustrates another vegetated visual berm. The chain-link fence is a safety measure, but vines growing up the fence (in the center of the photograph) will provide excellent visual screening. This berm is intended for long-term use and will not reach maximum effectiveness until the trees and shrubs mature. Vegetation on this berm adds to the visual appeal of the area and, after several more years of growth, may add to property values. The proximity of this residential area to the gravel operation is one reason why the berm, fence, and vegetation were used. This level of protection and visual screening would probably not be necessary or required in non-residential areas, or in areas where the visual sensitivity is low.



**NOT REPRODUCIBLE**

FIGURE 40. EXAMPLE OF A SMALL, PARTIALLY VEGETATED BERM

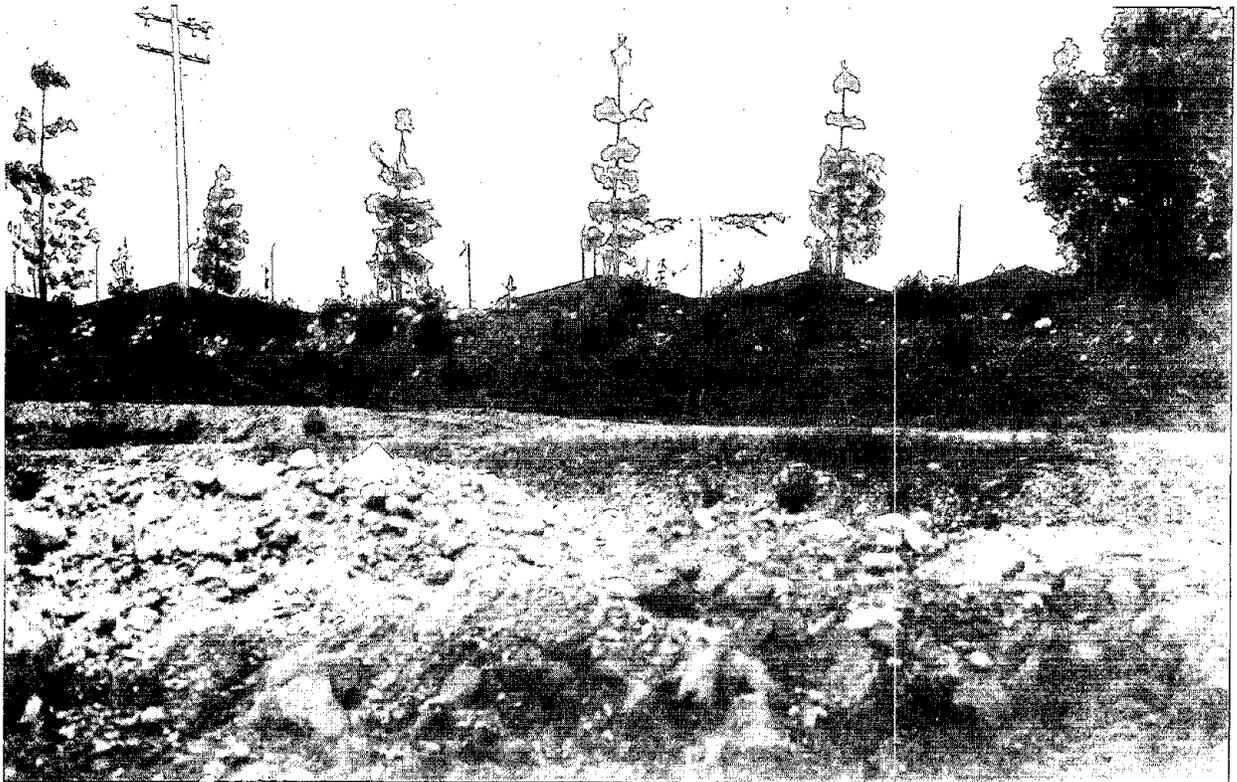


FIGURE 41. VEGETATED BERM USED IN CONJUNCTION WITH FENCE  
TO VISUALLY SCREEN AN OPERATION

If vegetation alone is to be used by the operator to screen the mine site, it becomes even more critical to use large, leafy varieties that will substantially block vision during all seasons. Figure 42 shows another example of a vegetative visual screen. The terrain is relatively flat, and the conveyor rises to a height well above average grade. In this situation, a wall or fence probably would not work, and a berm could be difficult to build because of space limitations (note the distance between the line of trees and the edge of the active pit). The technique used here was to establish a vegetative screen of tall trees. There are some important points about this situation. First, extraction is a large, long-term operation (not necessarily applicable to all small sand and gravel opera-

tions), justifying the cost of the trees and the length of time it took them to grow and mature. Secondly, the shape of the trees is well adapted to this particular site. Since the area used for the visual screen is narrow, and the object to be screened is relatively tall, the tall trees were most appropriate. Also, since they are narrow trees, they were planted close together to completely block vision.

The important concepts displayed in this figure are:

1. Select the best visual screening technique(s) for the specific circumstances involved.
2. Should vegetation be selected as the screening

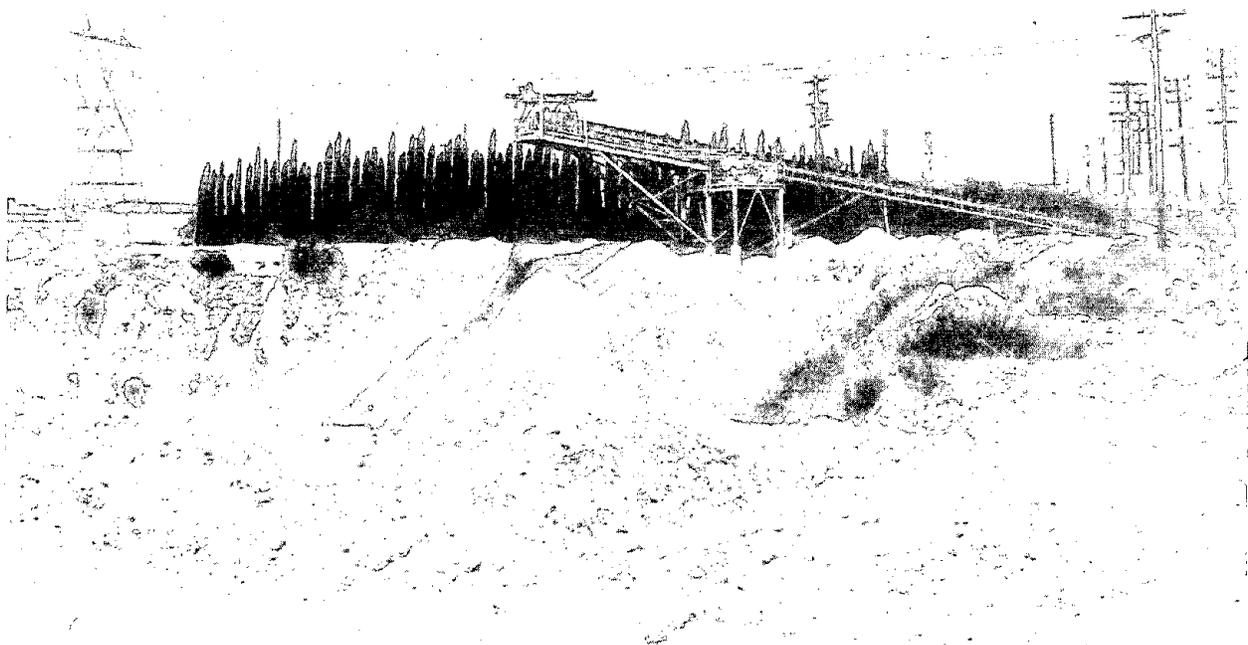


FIGURE 42. EXAMPLE OF TREES USED FOR SCREENING

device, use plants that are tall enough and wide enough to block vision. Also, plant them close together to form an effective screen.

Fences or walls can also be used to screen the mine site. The expense can be large but, depending on individual site conditions and community attitudes, this type of screening may be justified. Walls can be used in conjunction with vegetative screens.

If the mine site is located in a residential area or along a heavily travelled road where berms would be considered out of place, then a fence or wall may be appropriate.

Figures 43 and 44 show the effectiveness of a cement block wall

as a visual screen. The road in Figure 43 is a heavily travelled route. The mountain view was considered very sensitive to development, but the gravel deposit was very thick and of high quality. As a compromise, the operator constructed this wall to block the view of the operation from the road. The high cost of the wall is well warranted when considered in relation to the value of the sand and gravel deposit. As with all sand and gravel operations, the value of the natural resource must be balanced with the costs of reclamation, pollution control, and reduction of community impacts. This type of wall probably would not be constructed around a short-term mining operation. Walls are fairly permanent structures, and are more suited to long-term operations, perhaps 20 years or more.

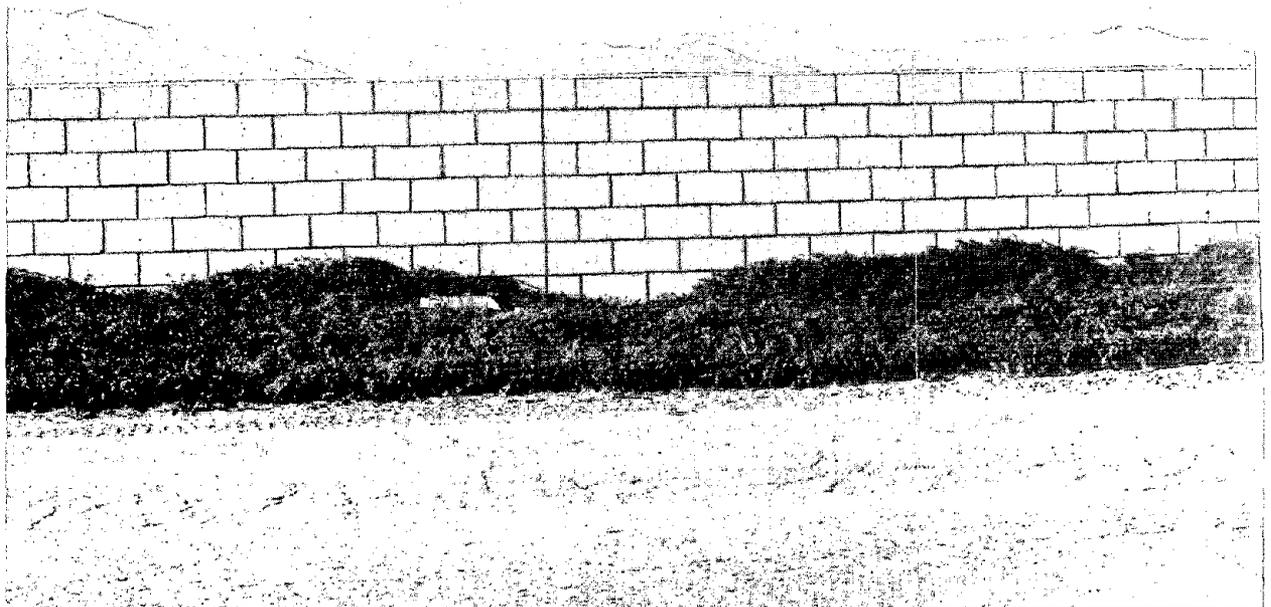
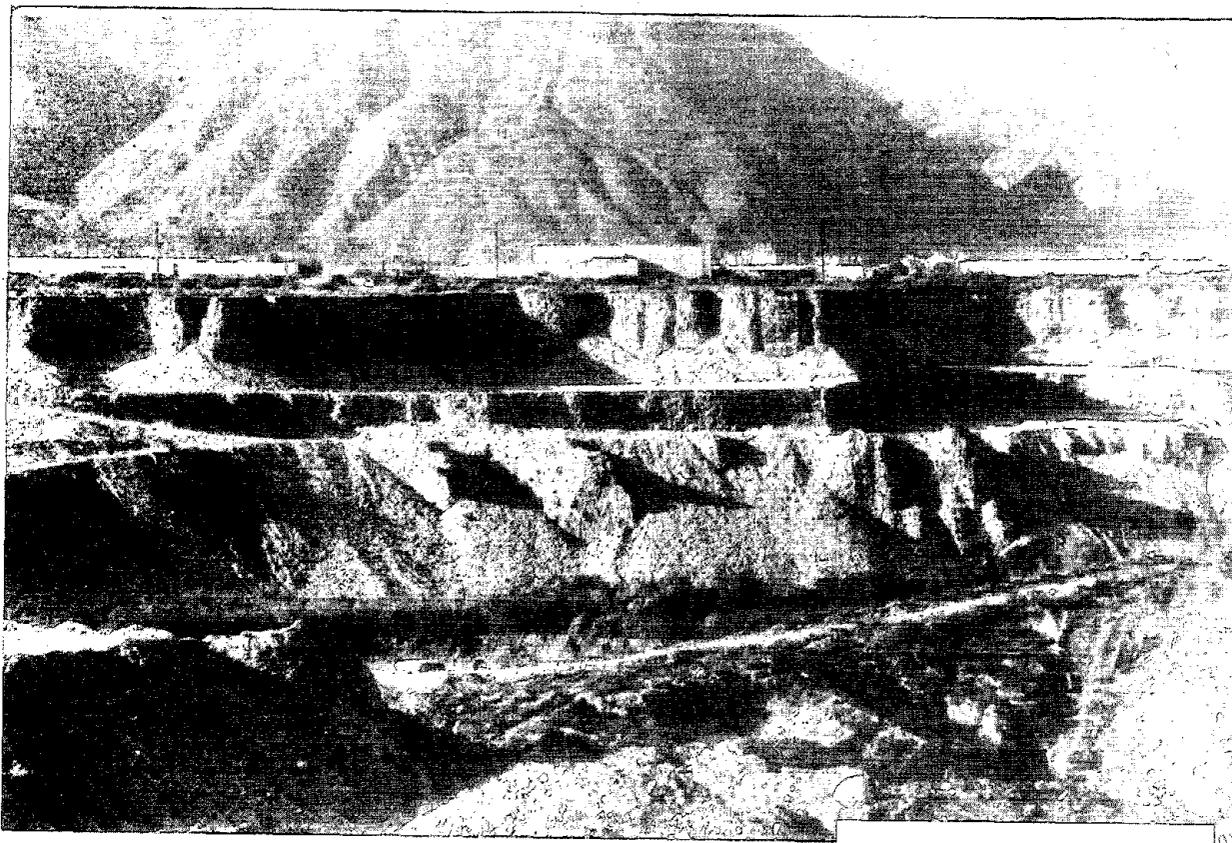


FIGURE 43. CEMENT BLOCK WALL USED TO SCREEN A LARGE GRAVEL OPERATION



NOT REPRODUCIBLE

FIGURE 44. GRAVEL OPERATION SCREENED BY THE WALL SHOWN IN FIGURE 43

Effective visual screening structures and site layout are influenced by the characteristics of the surrounding area. Visual quality is often judged by how well the land development "blends" in with surrounding conditions.

Some of the visual techniques and practices discussed in this section are very expensive and not always necessary. Most sand and gravel operators, however, have had to deal with such problems at some point during their operations. The issue is very sensitive with the general public, especially in heavily populated areas.

#### **FUEL, OIL, AND CHEMICAL STORAGE AREAS**

On-site storage of fuel, oil, grease, or chemicals should be handled as a potential pollution source. Leaky drums or improper handling techniques may allow seepage into surface and ground waters. In selecting the location of storage areas, the operator should attempt to: 1) avoid areas close to streams or near the groundwater table, and 2) keep storage areas away from excavation activities and areas used for extensive vehicular movement.

Riprap or other barriers can be placed around storage areas to pro-

vide warning to the driver of a vehicle that he is nearing fuel tanks.

During routine refueling and maintenance, care should be taken to avoid spillage. Leaky engines and transmissions should be repaired to prevent the discharge of oil.

Operators should also attempt to properly handle trash and other items, such as junk equipment and

old unused structures, in order to maintain a clean mining site. This action can help to eliminate potential pollution sources, as well as enhance the visual appearance of the site.

Table 5 lists those items which should be considered by the operator when preparing a pollution control plan.

**TABLE 5. ITEMS TO CONSIDER IN POLLUTION CONTROL PLANNING**

<ul style="list-style-type: none"> <li>● DRAINAGE AND SEDIMENT CONTROL STRUCTURES               <ul style="list-style-type: none"> <li>A. Plan View (Locations)</li> <li>B. Cross-Sections of Structures</li> <li>C. Design Computations</li> <li>D. Maintenance:                   <ul style="list-style-type: none"> <li>1. Requirements</li> <li>2. Schedule</li> </ul> </li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● NOISE, DUST AND VIBRATION               <ul style="list-style-type: none"> <li>A. Blasting Plan and Practices</li> <li>B. Barrier Devices</li> <li>C. Equipment Maintenance</li> <li>D. Other Control Measures</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>● WASTE DISPOSAL METHODS               <ul style="list-style-type: none"> <li>A. Timber, Brush, Etc.</li> <li>B. Toxic Materials</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● MONITORING PROGRAM               <ul style="list-style-type: none"> <li>A. Parameters</li> <li>B. Monitoring Points (Location)</li> <li>C. Frequency</li> <li>D. Analytical Procedures</li> <li>E. Quality Control Procedures</li> <li>F. Reporting Procedures</li> <li>G. Maintenance:                   <ul style="list-style-type: none"> <li>1. Requirements</li> <li>2. Schedule</li> </ul> </li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>● EROSION PREVENTION               <ul style="list-style-type: none"> <li>A. Vegetative Practices</li> <li>B. Surface Soil Stabilization Practices</li> <li>C. Grading and Contouring Practices</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● OTHER PROTECTIVE MEASURES               <ul style="list-style-type: none"> <li>A. Unique Physical and Cultural Resources</li> <li>B. Removal of Pollution Control Structures and Devices</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>● MINE DRAINAGE TREATMENT               <ul style="list-style-type: none"> <li>A. Type</li> <li>B. Volume</li> <li>C. Treatment Procedures</li> <li>D. Equipment and Techniques to be Used</li> </ul> </li> </ul>	

## GLOSSARY

Acid Soil	Generally considered soil that has a pH of less than 6.6 and is acidic throughout all or most of the plant root zone. Precisely, a soil with a pH value less than 7.0
Adapted Species of Vegetation	Plants that will grow and survive in geologic areas where the soil and climate are different from that of their native areas.
Alkaline Soil	Generally considered soil that has a pH of greater than 7.5 and is alkaline throughout all or most of the plant root zone. Precisely, any soil layer having a pH value greater than 7.0.
Aquatic Wildlife	Fish, waterfowl, amphibians, water plants, aquatic insects, and other organisms that live in or on the bottom of lakes, streams, and other water bodies.
Aquifer	Rock or other earth material that can store and transmit water.
Aquifer Recharge	The process, area, or earth material that supplies water to an aquifer.
Archaeological Site	Area with evidence of the pre-recorded history of mankind.
Attractive Nuisance	Legal term defining a dangerous area or thing that people find appealing.
Baseline Conditions	The natural state of the environment (i.e., water, air, vegetation, wildlife, etc.) before disturbance by mining.
Berm	A constructed mound or pile of earth material rising above the normal level of the land.
Climax Vegetation	Different species of vegetation growing, thriving, and reproducing naturally, without assistance from mankind.

Compatible Land Use	Land use which does not conflict with surrounding land uses, or interfere with or negatively affect surrounding land uses.
Comprehensive Land Use Plan	Document consisting of maps and text compiled by local, or sometimes state government agencies, which guide and recommend land development in certain areas.
Concurrent Mining and Reclamation	The process of simultaneously mining <u>and</u> reclaiming land.
Consumptive Use of Water	Taking water from surface or ground-water supplies without replacing it.
Contour Furrows	Ditches paralleling the contour of a slope, rather than running up and down the slope.
Cost-Effective	A method or technique used to conduct a required job at the least cost. Not necessarily the cheapest, but yielding the most for the money.
Cover Crop	Generally, grasses used for short-term erosion control, usually no longer than one year.
Cultural Resources	Archaeological sites, historic sites, scenic sites, and areas of scientific significance, such as fossil localities.
Decibel	The unit of measurement for noise.
Drainage Diversion	A ditch, channel, culvert, etc., used to divert surface runoff or streams away from the area of active mining.
Dust Suppressants	Chemicals or techniques used to control fugitive dust.
Endangered Species	Fish and/or wildlife considered on the verge of becoming extinct.
Environmental Impact Assessment (EIA)	An assessment of the impacts which mining could have on the environment. Prepared by the <u>operator</u> , not by a government agency.

Environmental Impact Statement (EIS)	A statement on the potential impacts an activity could have on the environment. Prepared by the <u>government</u> , not by the operator.
Erosion	The detachment and movement of earth and rock material by the forces of wind, water, or ice and gravity.
Flocculant	A chemical used to speed up the settling of sediment.
Grading Along the Contours	The technique of grading earth material along a slope, rather than up and down a slope.
Groundwater	The part of the total water supply that is found beneath the earth's surface.
Gully Erosion	A type of erosion that creates long, narrow valleys or ditches on slopes often void of vegetation.
Historic Site	Area with evidence of the recorded history of mankind.
Impermeable	Material that is not capable of allowing water to pass through easily.
Infiltration	The process of water seeping into and through earth and rock material.
In-Progress Reclamation	Reclaiming mined land before all mining has been completed. Similar to "concurrent mining and reclamation."
Interim Land Use	A temporary use of land for a purpose other than the final application.
Introduced Vegetation	Species of vegetation that are not native to the geographic area in which they are planted.
Land Use	Utilization of land, i.e., agriculture, recreation, wildlife habitat, etc.
Land Use Capability	The extent to which a parcel of land may support one or more uses.

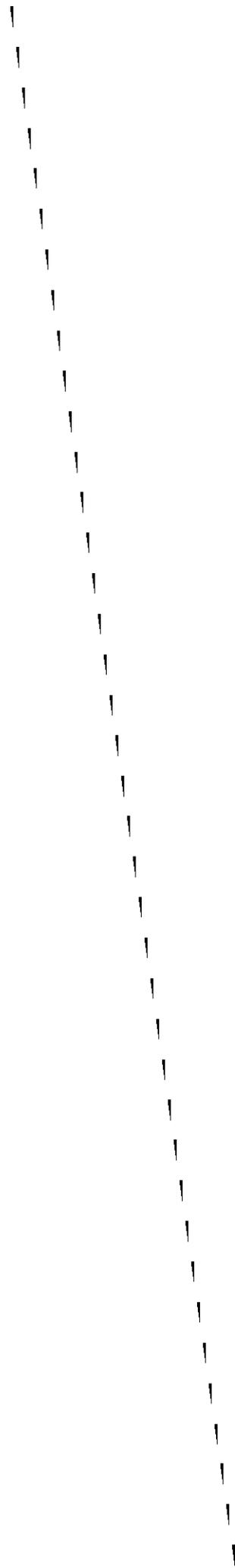
Leachate	Water-bearing foreign substance picked up through contact with something containing a foreign substance.
Legumes	Plants that are capable of assisting in the conversion of nitrogen (N) to an essential plant nutrient.
Microtopography	Small-scale relief on a soil or re-graded surface, mounds and depressions of no more than a few inches.
Mulch	Organic or non-organic material placed on soil to help control erosion and retain moisture.
Multiple Sequential Land Use	The use of a parcel of land for several different purposes over a period of time.
Native Vegetation	Species of vegetation that grow and thrive in geologic areas where the soil and climate are suited to natural propagation.
Overburden (Waste Material)	Earth or rock material lying above or between the sand and gravel deposit that is not marketable. Often considered waste material.
Performance Bond	Cash or cash-equivalent provided by the mine operator to guarantee that reclamation will be accomplished in accordance with approved permit provisions.
pH	A measure of the hydrogen ion (H <sup>+</sup> ) activity in soil or water. Measured from 1 to 14, with 1 being most acidic, and 14 being most alkaline.
Post-Mining Land Use (Land Use After Mining)	The use of land or property after mining has been completed.
Quality of Life	A subjective term describing the general condition of a neighborhood or community, and pertaining to things like noise levels, visual appearance, air and water quality, traffic, safety, and property values.

Rare Species	Species of wildlife not frequently found in certain geographic areas.
Reclamation	The process of restoring disturbed land to a beneficial, productive, stable, and non-polluted condition, which is capable of supporting one or more land uses.
Recycling Process Water	Saving for reuse water used in processing raw materials (e.g., washing and separating).
Regrading	Shaping and grading mined property to a gently sloping stable land configuration.
Revegetation	Seeding or replanting vegetation on land disturbed by mining activities.
Runoff	Rainwater or other form of precipitation that flows across the surface of the land.
Sediment	Particles of earth and rock material that have been eroded.
Sedimentation	The deposition of sediment (earth and rock particles) on the bottom of lakes, streams, or other bodies of water or parcels of land.
Sediment Pond	A pond used to retain water for a certain time period to allow eroded material to settle.
Scarify	Roughening the surface of soil or graded material prior to planting or seeding.
Sheet Erosion	A type of erosion where running water flows evenly over the surface and removes layers or "sheets" of earth material.
Site Analysis	The study of environmental characteristics and conditions existing at a mine site prior to any disturbance.
Soil	Unconsolidated, surface material containing organic materials and capable of supporting vegetation.

Soil Fertility	The amount of essential plant nutrients required by soil, including, among others, nitrogen (N), potassium (K), and phosphorus (P).
Soil Horizon	The horizontal layers usually occurring in soils and other underlying material.
Soil Respreding	The spreading of soil that has been salvaged from the mine site.
Surface Water	That part of the total water supply that is present on the earth's surface, including streams, lakes, reservoirs, etc.
Suspended Solids	Sediment which is "floating" in water.
Threatened Species	Species of fish and wildlife on the verge of being "endangered."
Topography	The contour or geometry of the earth's surface, usually displayed by lines on a map connecting points of equal elevation (contour lines).
Topsoil	The uppermost soil horizon, containing the largest amount of organic material and generally best suited to plant growth.
Turbidity	A "muddiness" or "cloudiness" of water caused by the presence of sediment.
Visual Screening	Blocking the view of a sand and gravel operation with walls, vegetation, or berms.
Visual Sensitivity	Generally, public reaction to the visual aspects of the mining operation in relation to the community scene; an assessment of the degree to which the operation is not pleasing to the eye.
Volunteer Vegetation	Species of vegetation that grow naturally, without assistance from mankind.
Water Table	The elevation below the earth's surface at which groundwater is encountered.

Wildlife Habitat

The combination of food, vegetation, (cover), and water that will support wildlife populations.



# APPENDIX 1

## FEDERAL AGENCIES THAT MAY HAVE SOME CONTROL OVER SAND AND GRAVEL MINING OR COULD PROVIDE INFORMATION

Federal Agencies	Types of Controls	Types of Information
<ul style="list-style-type: none"> <li>o Army Corps of Engineers</li> <li>o Bureau of Indian Affairs</li> <li>o Bureau of Land Management</li> <li>o Bureau of Mines</li> </ul>	<p>Public waterways, dams, and reservoirs, dredging</p> <p>Indian lands</p> <p>Significant amounts of federal land</p> <p>N.A.</p>	<p>Permit, water quality and quantity; floodplain use</p> <p>Permits, other data for Indian lands</p> <p>Maps, land statistics, surveying and topographic control</p> <p>Research, demonstration, and development on various types of mining; mineral statistics; monitoring techniques</p>
<ul style="list-style-type: none"> <li>o Bureau of Outdoor Recreation</li> <li>o Environmental Protection Agency</li> </ul>	<p>Federal recreation areas</p> <p>Air and water quality, NPDES permits</p>	<p>Recreation data - recreational land use planning and design</p> <p>Permit compilation, a variety of environmental quality data</p>
<ul style="list-style-type: none"> <li>o Fish and Wildlife Service</li> <li>o Forest Service</li> <li>o Geological Survey</li> </ul>	<p>Federal fish and wildlife lands</p> <p>National forest lands</p> <p>N.A.</p>	<p>Wildlife data; habitat restoration; endangered species</p> <p>Vegetation; reclamation techniques; water data; erosion and sediment monitoring techniques</p> <p>Geologic data and maps, reserve estimates, topographic maps, aerial photographs</p>

APPENDIX 1 (CONTINUED)

Federal Agencies	Types of Controls	Types of Information
<ul style="list-style-type: none"> <li>o National Park Service</li> <li>o Soil Conservation Service</li> </ul>	<p>National Parks</p> <p>N.A.</p>	<p>User data - recreation planning</p> <p>Soil data and maps; soil surveys; water quality; construction guidelines; erosion and sediment; monitoring procedures and calculations</p>

# APPENDIX 2

## SUMMARY OF STATE LAWS

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
ALABAMA	YES	Alabama Department of Industrial Relations 204 Industrial Relations Bldg. Montgomery, AL 36130 Tel: (205) 832-3628	Office of the Director Alabama Environmental Health Administration Room 328 State Office Bldg. Montgomery, AL 36130 Tel: (205) 832-3176
ALASKA	NO	Land Management Officer Division of Land Alaska Department of Natural Resources 323 East 4th Avenue Anchorage, AK 99510 Tel: (907) 279-5577	Land Use Supervisor Division of Terrestrial Programs Alaska Department of Environmental Conservation Pouch 0 Juneau, AK 99811 Tel: (907) 465-2635
ARIZONA	NO	Arizona State Land Department 1627 West Adams Phoenix, AZ 85007 Tel: (602) 271-4628	State Clearing House Office of Economic Planning and Development 1700 West Washington St. Mail Room 505 Phoenix, AZ 85007 Tel: (602) 271-5004

APPENDIX 2 (CONTINUED)

Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
YES	<p>Arkansas Department of Pollution Control and Ecology            8001 National Drive            Little Rock, AR 72709            Tel: (501) 371-1701</p>	<p>Arkansas Public Service Commission            State Capitol Bldg.            Little Rock, AR 72201            Tel: (501) 371-2051</p>
YES*	<p>State Mining and Geology Board            State Department of Conservation            Room 1341            1416 9th Street            Sacramento, CA 95814            Tel: (916) 445-1825</p>	<p>Secretary            California Resource Agency            Room 1311            1416 9th Street            Sacramento, CA 95814            Tel: (916) 445-9134</p>
YES*	<p>Division of Mined Land Reclamation            State Department of Natural Resources            Room 723            1313 Sherman Street            Denver, CO 80203            Tel: (303) 892-3567</p>	<p>Director            Division of Planning            State Department of Local Affairs            Room 520            Centennial Bldg.            Denver, CO 80203            Tel: (303) 892-2351</p>

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
CONNECTICUT	NO	Local Controls Only	<p>Director            Division of Planning and Coordination            State Department of Environmental Protection            State Office Bldg.            165 Capitol Avenue            Hartford, CT 06115            Tel: (203) 566-4202</p>
DELAWARE	NO	Local Controls Only	<p>State Office of Management, Budget, and Planning            Executive Department            Townsend Bldg.            Federal Street            Dover, DE 19901            Tel: (302) 678-4271</p>
FLORIDA	YES	<p>Bureau of Geology            Florida Department of Natural Resources            903 West Tennessee Street            Tallahassee, FL 32304            Tel: (904) 448-2479</p>	<p>Office of Environmental Services            Florida Game and Freshwater Fish Commission            Bryant Bldg.            1620 South Meridian            Tallahassee, FL 32304            Tel: (904) 488-6661</p>

APPENDIX 2 (CONTINUED)

Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
YES	<p>State GEORGIA</p> <p>Bureau of Land Reclamation Georgia Department of Natural Resources Box 233 Macon, GA 31201 Tel: (912) 744-3346</p>	<p>State Office of Planning and Budget 270 Washington St., SW. Atlanta, GA 30334 Tel: (404) 656-3861</p>
YES	<p>State IDAHO</p> <p>Idaho Department of Lands State House Boise, ID 83727 Tel: (208) 384-3617</p>	<p>Division of Environment Idaho Department of Health and Welfare State Offices--State House Boise, ID 83720 Tel: (208) 384-2393</p>
YES*	<p>State ILLINOIS</p> <p>Division of Land Reclamation Illinois Department of Mines and Minerals 704 State Office Bldg. Springfield, IL 62706 Tel: (217) 782-4970</p>	<p>Director Illinois State Clearing-house Governor's Bureau of Budget 3rd Floor Lincoln Tower Plaza 524 South 2d Street Springfield, IL 62706 Tel: (217) 782-3105</p>

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
INDIANA	NO	Division of Reclamation Indiana Department of Natural Resources 613 State Office 100 State Office Indianapolis, IN 46204 Tel: (317) 633-6244	Coordinator of Environmental Programs Agency of the Indiana Board of Health 1330 West Michigan Street Indianapolis, IN 46206 Tel: (317) 633-8467
IOWA	YES	Division of Mines and Minerals Iowa Department of Soil Conservation Grimes State Office Bldg. Des Moines, IA 50319 Tel: (515) 281-5774	Iowa Department of Environmental Quality 3920 Delaware Avenue Box 3326 Des Moines, IA 50316
KANSAS	NO	Legal Department State Corporation Commission 4th Floor State Office Bldg. Topeka, KS 66612 Tel: (913) 296-3361	State Department of Health and Environment State House Topeka, KS 66620 Tel: (913) 862-9360

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
KENTUCKY	YES	<p>Division of Reclamation            State Department of Natural Resources and Environmental Protection            6th Floor            Capitol Plaza Tower            Frankfort, KY 40601            Tel: (502) 564-6940</p>	<p>Office of Planning and Research            Secretary's Office of the State Department of Natural Resources and Environmental Protection            6th Floor            Capitol Plaza Tower            Frankfort, KY 40601            Tel: (502) 564-7320</p>
LOUISIANA	NO	<p>Division of Oil and Gas            State Department of Conservation            Box 44275            Baton Rouge, LA 70804            Tel: (504) 389-5161</p>	<p>Director            Office of Wetlands            State Wildlife and Fisheries Department            400 Royal Street            New Orleans, LA 70130            Tel: (504) 568-5665</p>
MAINE	YES	<p>Bureau of Land Quality            State Department of Environmental Protection            State House            Augusta, ME 04333            Tel: (207) 289-2111</p>	<p>Commissioner            State Department of Environmental Protection            State House            Augusta, ME 04333            Tel: (207) 289-2111</p>

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
MARYLAND	YES*	Tower Plant and Siting Administration Maryland Department of Natural Resources Tawes State Office Bldg. Annapolis, MD 21401 Tel: (301) 269-2261	Clearinghouse Department of State Planning 301 West Preston Street Baltimore, MD 21201 Tel: (301) 383-2467
MASSACHUSETTS	NO	Local Controls Only	Executive Office of Environmental Affairs 100 Cambridge Street Boston, MA 02202 Tel: (617) 727-5830
MICHIGAN	NO	Division of Geology Michigan Department of Natural Resources Stevens T. Mason Bldg. Box 30028 Lansing, MI 48909 Tel: (517) 373-1256	Environmental Review Board Bureau of Special Boards and Commissions Michigan Department of Management and Budget 1st Floor Stevens T. Mason Bldg. Box 30026 Lansing, MI 48909 Tel: (517) 373-6491

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
MINNESOTA	NO**	<p>Division of Minerals                      Minnesota Department of Natural Resources                      345 Centennial Bldg.                      St. Paul, MN 55155                      Tel: (612) 296-4807</p>	<p>Director for Environmental Planning                      State Planning Agency                      Capitol Square                      550 Cedar Street                      St. Paul, MN 55101                      Tel: (612) 296-8254</p>
MISSISSIPPI	YES	<p>Mississippi Geologic, Economic, and Topographic Survey                      Box 4915                      Jackson, MS 39216                      Tel: (601) 354-6228</p>	<p>Project Review Manager                      Office of the Governor                      Box 139                      Jackson, MS 39205                      Tel: (601) 354-7787</p>
MISSOURI	YES	<p>Land Reclamation Commission                      Division of Environmental Quality                      Missouri Department of Natural Resources                      Box 1368                      Jefferson City, MO 65101                      Tel: (314) 751-3241</p>	<p>Division of Budget and Planning                      Office of Administration                      Room B-9                      Capitol Bldg.                      Box 509                      Jefferson City, MO 65101                      Tel: (314) 751-3925</p>

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
MONTANA	YES	Montana Department of State Lands Capitol Station Helena, MT 59601 Tel: (406) 449-2074	Executive Director Environmental Quality Council Capitol Station Box 215 Helena, MT 59601 Tel: (406) 449-3742
NEBRASKA	NO	Local Controls Only	Comprehensive Planning Coordinator Office of Planning and Programming Box 94601 State Capitol Lincoln, NE 68509 Tel: (402) 471-2414
NEVADA	NO	Local Controls Only	Division of Environmental Protection Nevada Department of Conservation of Natural Resources 201 South Fall Carson City, NV 89710 Tel: (702) 885-4670

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
NEW HAMPSHIRE	NO	Division of Forests and Lands State Department of Natural Resources Box 856 State House Annex Concord, NH 03301 Tel: (603) 271-2214	Office of Comprehensive Planning Office of the Governor State House Annex Concord, NH 03301 Tel: (603) 271-2155
NEW JERSEY	NO	Local Controls Only	Office of Environmental Review State Department of Environmental Protection Box 139 Trenton, NJ 08625 Tel: (609) 292-2662
NEW MEXICO	NO	New Mexico Surface Coal Mining Commission c/o New Mexico Bureau of Mines and Mineral Resources Campus Station Socorro, NM 87801 Tel: (505) 835-5420	State Planning Officer State Planning Office 505 Don Gaspar Greer Bldg. Santa Fe, NM 87502 Tel: (505) 827-2073

APPENDIX 2 (CONTINUED)

Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
NEW YORK	<p>YES*</p> <p>Bureau of Mineral Resources New York State Environmental Commission Room 404A 50 Wolf Road Albany, NY 12233 Tel: (518) 457-7480</p>	<p>Director, Division of Environmental Analysis New York Department of Environmental Conservation Room 414 50 Wolf Road Albany, NY 12233 Tel: (518) 475-2233</p>
NORTH CAROLINA	<p>YES</p> <p>Land Quality Section State Department of Natural and Economic Resources Box 27687 Raleigh, NC 27611 Tel: (919) 733-4574</p>	<p>Division of Environmental Assessment State Department of Natural Resources and Community Development Box 27687 Raleigh, NC 27611 Tel: (919) 733-2955</p>
NORTH DAKOTA	<p>NO</p> <p>Division of Reclamation and Siting State Public Service Commission State Capitol Bldg. Bismarck, ND 58505 Tel: (701) 224-2400</p>	<p>Division of Water Supply and Pollution Control North Dakota Department of Health 1200 Missouri Avenue Missouri Office Bldg. Bismarck, ND 58505 Tel: (701) 224-2386</p>

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
OHIO	YES*	Division of Reclamation Ohio Department of Natural Resources Fountain Square Columbus, OH 43224 Tel: (614) 466-4850	Division of Environmental Assessment Office of Planning Coordination Ohio Environmental Protection Agency 361 Board Street Columbus, OH 43215
OKLAHOMA	YES	Oklahoma Department of Mines and Mining 117 Capitol Bldg. Oklahoma City, OK 73105 Tel: (405) 521-3859	State, Oklahoma Department of Economic and Community Affairs 5500 North Western Oklahoma City, OK 73118 Tel: (405) 840-2811
OREGON	YES*	Division of Mined Land Reclamation Department of Geology and Mineral Industry Box 1028 Albany, OR 97231 Tel: (503) 928-2386	Assistant to the Governor for Natural Resources Office of the Governor Room 160 State Capitol Bldg. Salem, OR 97310 Tel: (503) 378-3109

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
PENNSYLVANIA	YES	<p>Bureau of Surface Mine Reclamation                      State Department of Environmental Resources                      7th Floor                      Fulton Bldg.                      Harrisburg, PA 17120                      Tel: (717) 787-5103</p>	<p>Chief of the Division of Policy Planning and Project Revision                      Bureau of Environmental Planning                      State Department of Environmental Resources                      Room 813                      Executive Office Bldg.                      2nd Street &amp; Chestnut                      Harrisburg, PA 17120                      Tel: (717) 783-1334</p>
RHODE ISLAND	NO	<p>Local Controls Only</p>	<p>Statewide Planning Program                      State Department of Administration                      265 Melrose Street                      Providence, RI 02907                      Tel: (401) 277-2656</p>
SOUTH CAROLINA	YES	<p>Land Resources Conservation Commission                      State Department of Mining Reclamation                      Box 11708                      Columbia, SC 29211                      Tel: (803) 758-2823</p>	<p>Grants and Contracts Review Unit                      State Auditor's Office                      Box 11333                      Room 214                      Wade Hampton Office Bldg.                      Columbia, SC 29211                      Tel: (803) 758-3160</p>

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
SOUTH DAKOTA	YES	<p>State Conservation Commission            South Dakota Department of Agriculture            Room 322            Siguard Anderson Bldg.            Pierre, SD 57501            Tel: (605) 224-3258</p>	<p>South Dakota Department of Environmental Protection            Room 406            Foss Bldg.            Pierre, SD 57501            Tel: (605) 224-3351</p>
TENNESSEE	YES	<p>Division of Surface Mining            State Department of Conservation            2611 West End Avenue            Nashville, TN 37203            Tel: (615) 741-1046</p>	<p>Office of Urban and Federal Affairs            Tennessee Office of the Governor            108 Parkway Tower            Nashville, TN 37219            Tel: (615) 741-2714</p>
TEXAS	NO**	<p>Water Quality Board of Texas            Stephen F. Austin Bldg.            Austin, TX 78711            Tel: (512) 475-4252</p>	<p>Director            Budget and Planning Office            Office of the Governor            411 West 13th Street            Austin, TX 78704            Tel: (512) 475-2427</p>

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
UTAH	YES	Division of Oil, Gas, and Mining Utah Department of Natural Resources 1588 West North Temple Salt Lake City, UT 84116 Tel: (801) 533-5771	Environmental Coordinator State Planning Office Room 118 State Capitol Bldg. Salt Lake City, UT 84114 Tel: (801) 533-5245
VERMONT	YES	State Environmental Board Agency of Environmental Conservation State Office Bldg. Montpelier, VT 05602 Tel: (802) 828-3309	State Environmental Board Agency of Environmental Conservation State Office Bldg. Montpelier, VT 05602 Tel: (802) 828-3309
VIRGINIA	YES*	Division of Mined Land Reclamation Virginia Department of Conservation and Economic Development Drawer U Bigstone Gap, VA 24219 Tel: (703) 523-2925	Environmental Impact Coordinator Council on the Environment Room 903 9th Street Office Bldg. Richmond, VA 23219 Tel: (804) 786-4500

APPENDIX 2 (CONTINUED)

State	Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May Be Able to Provide Environmental Data
WASHINGTON	YES*	<p>Division of Geology and Earth Resources                      Washington Department of Natural Resources                      Olympia, WA 98504                      Tel: (206) 753-6183</p>	<p>Washington Department of Ecology                      St. Martin's College                      Olympia, WA 98504                      Tel: (206) 753-6890</p>
WEST VIRGINIA	YES	<p>Reclamation Division                      West Virginia Department of Natural Resources                      Room 322                      1800 Washington St. East                      Charleston, WV 25305                      Tel: (304) 348-2754</p>	<p>Division of Research and Statistics                      West Virginia Department of Natural Resources                      1800 Washington St. East                      Charleston, WV 25305                      Tel: (304) 348-2754</p>
WISCONSIN	NO**	<p>Mine Reclamation Section                      Bureau of Water Regulation and Zoning                      Wisconsin Department of Natural Resources                      Box 7921                      Madison, WI 53707                      Tel: (608) 266-2050</p>	<p>Bureau of Environmental Impact                      Department of Natural Resources                      Box 7921                      Madison, WI 53701                      Tel: (608) 266-2121</p>

APPENDIX 2 (CONTINUED)

Does State Have Law Controlling Sand and Gravel Mining?	State Agency to Contact Regarding Laws or Other Controls in Sand & Gravel Mining	State Agencies Which May be Able to Provide Environmental Data
WYOMING	YES Division of Land Quality Wyoming Department of Environmental Quality Hathaway Bldg. Cheyenne, WY 82002 Tel: (307) 777-7756	State Planning Coordinator's Office Office of the Governor 2320 Capitol Avenue Cheyenne, WY 82002 Tel: (307) 777-7574

NOTES ON SUMMARY OF STATE LAWS

\*Both State and local controls are commonly present.

\*\*State law controlling sand and gravel mining is under consideration by State legislature.



## APPENDIX 3

### GRASSES COMMONLY USED FOR RECLAMATION

NAME OF GRASS	USEFUL INFORMATION
Bahiagrass (perennial)	<ul style="list-style-type: none"> <li>• Warm, dry season grass</li> <li>• Grows well in southern, humid climates</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 4.5 - 7.5</li> <li>• Grows tall with good root system</li> <li>• Low maintenance, can stand wide range of soils</li> </ul>
Barley (annual)	<ul style="list-style-type: none"> <li>• Cool season grass (provides winter cover)</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 5.5 - 7.8</li> </ul>
Bermuda Grass (perennial)	<ul style="list-style-type: none"> <li>• Warm, dry season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soils</li> <li>• Likes soil pH from 4.5 - 7.5</li> <li>• Grows well in southern humid climates</li> </ul>
Canada Bluegrass (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Grows well in northern humid climates</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 4.5 - 7.5</li> <li>• Can be used where soils are dry or low in nutrients</li> <li>• Shallow root system</li> </ul>
Kentucky Bluegrass (perennial)	<ul style="list-style-type: none"> <li>• Cool season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.5 - 7.0</li> <li>• Germinates and grows slowly</li> <li>• Grows well in northern humid climates</li> <li>• Needs a lot of water and fertilizer</li> </ul>

APPENDIX 3 (CONTINUED)

NAME OF GRASS	USEFUL INFORMATION
Big Bluestem (perennial)	<ul style="list-style-type: none"> <li>• Warm season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes pH from 5.0 - 7.5</li> <li>• Deep root system, provides good erosion control</li> <li>• Grows well in southern humid climates</li> </ul>
Little Bluestem (perennial)	<ul style="list-style-type: none"> <li>• Warm season grass</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 6.0 - 8.0</li> <li>• Dense roots provide good erosion control</li> <li>• Grows in clumps up to 3 ft tall</li> <li>• Grows well in southern humid climates</li> </ul>
Field Bromegrass (annual)	<ul style="list-style-type: none"> <li>• Cool season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 6.0 - 7.0</li> <li>• Provides winter ground cover with good root system</li> <li>• Grows rapidly and is easy to establish</li> </ul>
Smooth Bromegrass (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.5 - 8.0</li> <li>• Grows tall and forms sod</li> <li>• Drought and heat tolerant</li> <li>• Grows well in northern humid climates</li> </ul>
Buffalograss (perennial)	<ul style="list-style-type: none"> <li>• Warm season grass</li> <li>• Suitable for moderately and poorly drained soils</li> <li>• Likes soil pH from 6.5 - 8.0</li> <li>• Drought tolerant and can withstand over-grazing</li> <li>• Can tolerate alkaline soils but not sandy soils</li> <li>• Grows well in northern and southern dry climates</li> </ul>

APPENDIX 3 (CONTINUED)

NAME OF GRASS	USEFUL INFORMATION
Reed Canarygrass (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Can tolerate wide range of soil drainage conditions</li> <li>• Likes soil pH from 5.0 - 7.5</li> <li>• Will grow in wet areas and can emerge through 6 ft of sediment cover</li> </ul>
Deertongue (perennial)	<ul style="list-style-type: none"> <li>• Warm, dry season grass</li> <li>• Can tolerate wide range of soil drainage conditions</li> <li>• Likes soil pH from 3.8 - 5.0</li> <li>• Very acid soil tolerant plant</li> <li>• Drought resistant</li> <li>• Seed rarely available commercially</li> </ul>
Creeping Red Fescue (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.0 - 7.5</li> <li>• Grows well in cold weather but establishes slowly</li> <li>• Grows well in northern humid climates</li> </ul>
Tall Fescue (perennial)	<ul style="list-style-type: none"> <li>• Cool season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.0 - 8.0</li> <li>• Drought resistant</li> <li>• Provides good fall and winter pasture</li> </ul>
Blue Grama (perennial)	<ul style="list-style-type: none"> <li>• Warm, dry season plant</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 6.0 - 8.5</li> <li>• Sod forming with extensive root system</li> <li>• Grows well in northern and southern dry climates</li> </ul>
Sideoats Grama (perennial)	<ul style="list-style-type: none"> <li>• Warm season grass</li> <li>• Likes well-drained soil</li> <li>• Likes sod pH 6.0 - 7.5</li> <li>• Grows in bunches, good for controlling wind erosion</li> </ul>

APPENDIX 3 (CONTINUED)

NAME OF GRASS	USEFUL INFORMATION
Indian Grass (perennial)	<ul style="list-style-type: none"> <li>• Warm season grass</li> <li>• Likes moderately drained soil</li> <li>• Likes soil pH from 5.5 - 7.5</li> <li>• Provides quick ground cover</li> </ul>
Sand Lovegrass (perennial)	<ul style="list-style-type: none"> <li>• Warm season grass</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 6.0 - 7.5</li> <li>• Can grow on sandy soils and is good for grazing</li> </ul>
Weeping Lovegrass (perennial)	<ul style="list-style-type: none"> <li>• Warm, dry season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 4.5 - 8.0</li> <li>• Provides early, quick ground cover</li> <li>• Can grow on low-fertility soils and has a good root system</li> <li>• Grows well in southern dry climates</li> </ul>
Foxtail Millet (annual)	<ul style="list-style-type: none"> <li>• Warm, dry season grass</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 4.5 - 7.0</li> <li>• Cannot tolerate drought</li> </ul>
Oats (annual)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 5.5 - 7.0</li> <li>• Good winter cover, needs lots of nitrogen for good growth</li> </ul>
Tall Oatgrass (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 5.0 - 7.5</li> <li>• Grows in bunches, matures in early spring, short-lived</li> </ul>
Orchardgrass (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soils</li> <li>• Grows tall and matures early</li> </ul>

APPENDIX 3 (CONTINUED)

NAME OF GRASS	USEFUL INFORMATION
Redtop (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Can tolerate wide range of soil drainage conditions</li> <li>• Likes soil pH from 4.0 - 7.5</li> <li>• Can withstand drought</li> <li>• Can tolerate wide range of soil conditions</li> <li>• Grows fast but lasts only 2-3 years</li> <li>• Grows well in northern humid climates</li> </ul>
Winter Rye (annual)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Likes well-drained soil</li> <li>• Likes soil pH from 5.5 - 7.5</li> <li>• Good temporary cover for winter</li> <li>• Good root system</li> </ul>
Annual Ryegrass (annual)	<ul style="list-style-type: none"> <li>• Cool season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.5 - 7.5</li> <li>• Good temporary ground cover</li> <li>• Grows quickly</li> </ul>
Perennial Ryegrass (perennial)	<ul style="list-style-type: none"> <li>• Cool season grass</li> <li>• Likes well-drained soil but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.5 - 7.5</li> <li>• Grows in bunches, short lived (3 or 4 years)</li> <li>• Grows well in northern and southern humid climates</li> </ul>
Prairie Sandseed (perennial)	<ul style="list-style-type: none"> <li>• Warm, dry season grass</li> <li>• Likes well-drained soil</li> <li>• Likes soil pH from 6.0 - 8.0</li> <li>• Drought tolerant, grows tall</li> </ul>
Sudangrass (annual)	<ul style="list-style-type: none"> <li>• Warm, dry season grass</li> <li>• Likes well-drained soil but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.5 - 7.5</li> <li>• Summer temporary cover</li> <li>• Drought tolerant</li> <li>• Grows well in southern humid climates</li> </ul>

APPENDIX 3 (CONTINUED)

NAME OF GRASS	USEFUL INFORMATION
Switchgrass (perennial)	<ul style="list-style-type: none"> <li>• Warm season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.0 - 7.5</li> <li>• Tolerates acid and low-fertility soils</li> </ul>
Timothy (perennial)	<ul style="list-style-type: none"> <li>• Cool season grass</li> <li>• Can tolerate wide range of soil drainage conditions</li> <li>• Likes soil pH from 4.5 - 8.0</li> <li>• Shallow root system</li> <li>• Grows well with alfalfa and clover</li> </ul>
Winter Wheat (annual)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.0 - 7.0</li> </ul>
Tall Wheatgrass (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Can tolerate wide range of soil drainage conditions</li> <li>• Likes soil pH from 6.0 - 8.0</li> <li>• Sod forming</li> <li>• Can tolerate alkaline and salty soils</li> </ul>
Western Wheatgrass (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season grass</li> <li>• Can tolerate wide range of soil drainage conditions</li> <li>• Likes soil pH from 4.5 - 7.0</li> <li>• Sod forming</li> <li>• Germinates slowly but spreads rapidly</li> <li>• Grows well in northern dry climates</li> </ul>

## APPENDIX 4

### LEGUMES COMMONLY USED FOR RECLAMATION

NAME OF LEGUME	USEFUL INFORMATION
Alfalfa (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season legume</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 6.5 - 7.5</li> <li>• Needs high-fertility soils</li> </ul>
Alsike Clover (perennial)	<ul style="list-style-type: none"> <li>• Cool season legume</li> <li>• Can tolerate a wide range of soil drainage conditions</li> <li>• Dies after two years</li> </ul>
Red Clover (perennial)	<ul style="list-style-type: none"> <li>• Cool season legume</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 6.0 - 7.0</li> <li>• Seeds in early spring</li> </ul>
White Clover (perennial)	<ul style="list-style-type: none"> <li>• Cool season legume</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 6.0 - 7.0</li> </ul>
Flatpea (perennial)	<ul style="list-style-type: none"> <li>• Cool, dry season legume</li> <li>• Likes well-drained soils but can tolerate moderately drained soil</li> <li>• Likes soil pH from 5.0 - 6.0</li> <li>• Provides good cover but seeds are toxic to grazing animals</li> </ul>
Common Lespedeza (annual)	<ul style="list-style-type: none"> <li>• Warm season legume</li> <li>• Likes well-drained soils</li> <li>• Likes soil pH from 5.0 - 6.0</li> <li>• Grows low to ground and is acid soil tolerant</li> </ul>
Korean Lespedeza	<ul style="list-style-type: none"> <li>• Warm, dry season legume</li> <li>• Likes well-drained soils but can tolerate moderately drained soils</li> <li>• Likes soil pH from 5.0 - 7.0</li> </ul>

APPENDIX 4 (CONTINUED)

NAME OF LEGUME	USEFUL INFORMATION
Cicer Milkvetch (perennial)	<ul style="list-style-type: none"> <li>● Dry season legume</li> <li>● Likes well-drained soils but can tolerate moderately drained soils</li> <li>● Likes soil pH from 5.0 - 6.0</li> <li>● Grows low to ground and is drought tolerant</li> </ul>
White Sweetclover (biennial)	<ul style="list-style-type: none"> <li>● Cool, dry season legume</li> <li>● Likes well-drained soil</li> <li>● Likes soil pH from 6.0 - 8.0</li> <li>● Grows tall and requires high pH soil</li> </ul>
Yellow Sweetclover (biennial)	<ul style="list-style-type: none"> <li>● Cool, dry season legume</li> <li>● Likes well-drained soil</li> <li>● Likes soil pH from 6.0 - 8.0</li> <li>● Grows tall and requires high pH soil</li> </ul>
Birdsfoot Trefoil (perennial)	<ul style="list-style-type: none"> <li>● Cool, dry season legume</li> <li>● Likes well-drained soils but can tolerate moderately drained soil</li> <li>● Likes soil pH from 5.0 - 7.5</li> <li>● Can tolerate acid soil</li> </ul>
Crown Vetch (perennial)	<ul style="list-style-type: none"> <li>● Cool, dry season legume</li> <li>● Likes well-drained soils</li> <li>● Likes soil pH from 5.5 - 7.5</li> <li>● Drought tolerant and winter hardy</li> <li>● Good for erosion control</li> </ul>
Hairy Vetch (annual)	<ul style="list-style-type: none"> <li>● Cool, dry season legume</li> <li>● Likes well-drained soils</li> <li>● Likes soil pH from 5.0 - 7.5</li> <li>● Good winter cover</li> </ul>

## APPENDIX 5

### SHRUBS AND TREES COMMONLY USED FOR RECLAMATION

NAME	USEFUL INFORMATION
<u>SHRUBS</u>	
Amur Honeysuckle	<ul style="list-style-type: none"> <li>● Good for wildlife</li> <li>● More adaptability and vigor as plants mature</li> </ul>
Antelope Bitterbush	<ul style="list-style-type: none"> <li>● Best adapted to sand or gravelly slopes in West</li> <li>● Good for wildlife</li> </ul>
Apache Plume	<ul style="list-style-type: none"> <li>● Adapted to gravelly soils in West</li> <li>● Good for erosion control</li> <li>● Can withstand excessive silting</li> </ul>
Autumn-Olive	<ul style="list-style-type: none"> <li>● Nitrogen fixer</li> <li>● Good for wildlife</li> </ul>
Bristly Locust	<ul style="list-style-type: none"> <li>● Extremely vigorous</li> <li>● Excellent on flat areas and out-slopes</li> <li>● Good for erosion control</li> </ul>
Fourwing Saltbush	<ul style="list-style-type: none"> <li>● Well adapted to sandy or gravelly soils in West</li> <li>● Good for wildlife</li> </ul>
Japanese Fleeceflower	<ul style="list-style-type: none"> <li>● Grows well on many sites, especially moist areas</li> <li>● Excellent leaf litter and canopy protection</li> </ul>
Mountain Mahogany	<ul style="list-style-type: none"> <li>● Good browse for wildlife</li> <li>● Grows well on dry, rocky mountain slopes</li> </ul>
Silky Dogwood	<ul style="list-style-type: none"> <li>● Grows best on neutral soil pH</li> <li>● Good for wildlife</li> <li>● Poor surface protection</li> </ul>

APPENDIX 5 (CONTINUED)

NAME	USEFUL INFORMATION
<u>SHRUBS (Con't)</u>	
Tatarian Honeysuckle	<ul style="list-style-type: none"> <li>● Grows up to 12 feet tall</li> <li>● Does well on well-drained soils</li> </ul>
Winterfat	<ul style="list-style-type: none"> <li>● Grows on dry sand or shallow clay soils in West</li> <li>● Excellent for wildlife</li> </ul>
<u>TREES, CONIFERS</u>	
Austrian Pine	<ul style="list-style-type: none"> <li>● Can be planted on all slopes</li> <li>● Plant in blocks or bands</li> </ul>
Eastern Red Cedar	<ul style="list-style-type: none"> <li>● Grows best on dry, sandy soils</li> <li>● Does well with black locust</li> </ul>
Japanese Larch	<ul style="list-style-type: none"> <li>● Plant on unlevelled, noncompacted spoil</li> <li>● Provides good litter</li> </ul>
Loblolly Pine	<ul style="list-style-type: none"> <li>● Rapid early growth</li> <li>● Grows best in South</li> <li>● Susceptible to ice and snow damage</li> </ul>
Mugho Pine	<ul style="list-style-type: none"> <li>● Develops slowly</li> <li>● Low growing</li> <li>● Good wildlife cover</li> </ul>
Pitch Pine	<ul style="list-style-type: none"> <li>● Deep rooted</li> <li>● Acid tolerant</li> <li>● Can survive fire injury</li> </ul>
Red Pine	<ul style="list-style-type: none"> <li>● Light ground cover</li> <li>● Plant on all slopes</li> </ul>
Rocky Mountain Juniper	<ul style="list-style-type: none"> <li>● Good for wildlife</li> <li>● Will survive in very rough, dry, and poor soils</li> </ul>
Virginia Pine	<ul style="list-style-type: none"> <li>● Tolerant of acid spoil</li> <li>● Good for wildlife</li> <li>● Slow development</li> </ul>

APPENDIX 5 (CONTINUED)

NAME	USEFUL INFORMATION
<u>TREES, HARDWOOD</u>	
Black Locust	<ul style="list-style-type: none"> <li>o Wide range of adaption</li> <li>o Rapid growth</li> <li>o Can be direct seeded</li> </ul>
Cottonwood	<ul style="list-style-type: none"> <li>o Desirable for large-scale planting</li> <li>o Good cover</li> <li>o Rapid growth</li> </ul>
European Black Alder	<ul style="list-style-type: none"> <li>o Wide range of adaption</li> <li>o Nitrogen fixing, non-legume</li> <li>o Rapid growing</li> <li>o Can survive low pH</li> </ul>
Hybrid Poplar	<ul style="list-style-type: none"> <li>o Rapid growing</li> <li>o Can survive low pH</li> <li>o Good for screening</li> <li>o Cannot withstand grass competition</li> </ul>



## APPENDIX 6

### ADDITIONAL READINGS

#### SECTION I. PLANNING FOR RECLAMATION AND POLLUTION CONTROL

Bauer, A.M. "Simultaneous Excavation and Rehabilitation of Sand and Gravel Sites." National Sand and Gravel Association, Silver Spring, Maryland, 1965, 60 pp.

Erosion and Sediment Control: Surface Mining in the Eastern U.S., Volume I: "Planning," EPA-625/3-76-006. U.S. Environmental Protection Agency, October 1976, 102 pp.

Integrated Mined Area Reclamation and Land Use Planning, Volume 3A, A Case Study of Surface Mining and Reclamation Planning: South Boulder Creek Park Project, Sand and Gravel Operations, Boulder, Colorado. Argonne National Laboratory, Argonne, Illinois, 1977, 90 pp.

Pugliese, J.M., D.E. Swanson, W.H. Engelmann, and T.R. Bun. "Quarrying Near Urban Areas: An Aid to Premine Planning." U.S. Bureau of Mines Information Circular 8804. 1979, 50 pp.

#### SECTION II. COMMUNITY RELATIONS: BEFORE, DURING, AND AFTER MINING

Sheridan, J.J. "Urbanization and Its Impact on the Mineral Aggregates Industry in the Denver, Colorado, Area." U.S. Bureau of Mines Information Circular 8329. 1967.

Working Paper III of the Panel on Construction Minerals. Prepared for the Committee on Surface Mining and Reclamation (COSMAR), National Academy of Sciences, Washington, D.C., 1979.

Baxter, John G. "Site Planning for Sand and Gravel Operations, Project No. 4." National Sand and Gravel Association and University of Illinois, Silver Spring, Maryland, 1969, 45 pp.

#### SECTION III. RECLAMATION AND LAND USE PRACTICES

Jensen, David R. "Selecting Land Use for Sand and Gravel Sites." National Sand and Gravel Association and University of Illinois, Silver Spring, Maryland, 1967, 66 pp.

Schellie, Kenneth L., and David A. Rogies. "Site Utilization and Rehabilitation Practices for Sand and Gravel Operations." National Sand and Gravel Association, Silver Spring, Maryland, 1963, 80 pp.

APPENDIX 6 (CONTINUED)

Johnson, Craig. "Practical Operating Procedures for Progressive Rehabilitation of Sand and Gravel Sites." National Sand and Gravel Association and University of Illinois, Silver Spring, Maryland, 1966, 75 pp.

SECTION IV. POLLUTION CONTROL PRACTICES

"Evaluation of Dust and Noise Conditions at Typical Sand and Gravel Plants." A study conducted for the National Sand and Gravel Association, by Industrial Hygiene Foundation of America, Inc., Washington, D.C., 1961, 23 pp.

Gatley, W.S., and E.E. Frye. "Regulation of Noise in Urban Areas: A Manual Prepared for Public Officials, Managers, and Environmental Engineers," 2nd ed. University of Missouri at Rolla, Rolla, Missouri, 1972, 380 pp.

"Surface Mining and Our Environment: A Special Report to the Nation," second printing. U.S. Department of the Interior, Washington, D.C., 1967, 124 pp.

Newport, B.D., and J.E. Moyer. "State of the Art: Sand and Gravel Industry," EPA-660/2-74-066. U.S. Environmental Protection Agency, Washington, D.C., 1974, 40 pp.