A Handbook for Reclaiming Sand and Gravel Pits in Minnesota

Minnesota Department of
Natural Resources
Division of Lands and Minerals
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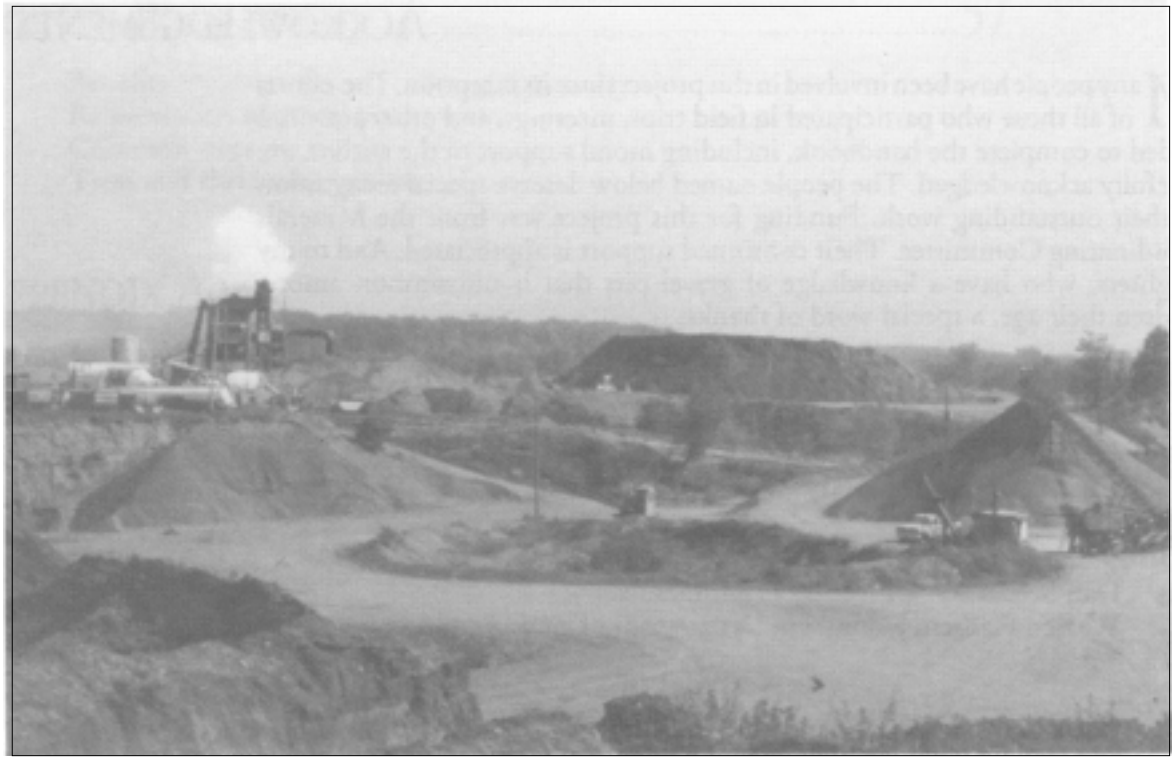

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A Handbook for Reclaiming Sand and Gravel Pits in Minnesota

by

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with updates to Appendices A, C and D - January 2003

Department of Natural Resources
Division of Lands and Minerals

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Selected references

The following websites contain information related to the topics covered herein. Many of the sites provide the most current information available and can be used to supplement material found in this publication.

www.mnplan.state.mn.us/eqb/review.html - environmental review
www.pca.state.mn.us - air and water quality permits
www.bwsr.state.mn.us - state wetlands regulation
www.maswcd.org - soil and water conservation districts
www.dnr.state.mn.us/permits/water/index.html - DNR Waters permit
www.dot.state.mn.us/environment - DOT seeding manual
www.mrr.dot.state.mn.us/geotechnical/aggregate/aggregate.asp - aggregate source information, aggregate permit requirements for counties, county pit maps
www.dnr.state.mn.us/forestry - state tree nurseries, tree care, burning permit, air photos
www.mda.state.mn.us/lis - licensed nursery stock
www.dnr.state.mn.us/ecological_services/index.html - exotic species, prairie restoration
www.dnr.state.mn.us/lands_minerals/index.html - aggregate maps, reclamation research
www.dnr.state.mn.us/wildlife/index.html - wildlife conservation
www.mnhs.org - historic preservation
www.commissions.leg.state.mn.us/aggregate.resources - Aggregate Resources Task Force

DNR fact sheets highlighting aggregate mining topics -
www.dnr.state.mn.us/lands_minerals/pubs.html

Environmental Regulations for Aggregate Mining - Fact Sheet 1
Mining Plans for Aggregate Operations - Fact Sheet 2
Reclamation at Aggregate Mining Sites - Fact Sheet 3
Using Native Prairie Species for Reclaiming Aggregate Mining Sites - Fact Sheet 4

An Overview

ECONOMICS

Sand and gravel mining is an important industry in Minnesota that contributes significantly to the state economy. Preliminary 1991 figures compiled by the United States Bureau of Mines indicate that Minnesota ranks eighth nationally in construction sand and gravel with production of 26.5 million tons at a value of $6 million. Production was reported in 77 of 87 counties by 206 companies.

Construction sand and gravel is used in concrete aggregates, concrete products, asphalt, road base, fill, snow and ice control, and other miscellaneous uses. In 1990, every person in the state consumed about 8.5 tons of sand and gravel. Sand and gravel consumption is so important to the economy that it is considered one of the most accurate measures of economic activity.

HOW MANY PITS ARE THERE?

Sand and gravel extraction is the most common form of mining in the state. Because sand and gravel is relatively inexpensive to mine but expensive to transport, most operations are located close to where the resource will be used. As a result, gravel pits have been developed in every county.

Gravel pits are a highly visible site throughout the state, especially along roads. According to a 1991 informal survey conducted by the Department of Natural Resources (DNR), there are more than 4,000 pits in Minnesota. Figure 1 shows the number of gravel pits reported for each county.

Approximately 1,500 (or 38%) of the 4,000 pits reported are active operations where noise, dust, traffic, and hours of operation are frequent concerns. These issues and final reclamation of the site are usually addressed through a county conditional land permit.

The remaining 2,500 pits (or 62%) are either permanently abandoned or intermittently active and often fall outside the regulatory authority of the counties. Problems associated with these sites include dumping, safety, unauthorized activities, and lack of reclamation.

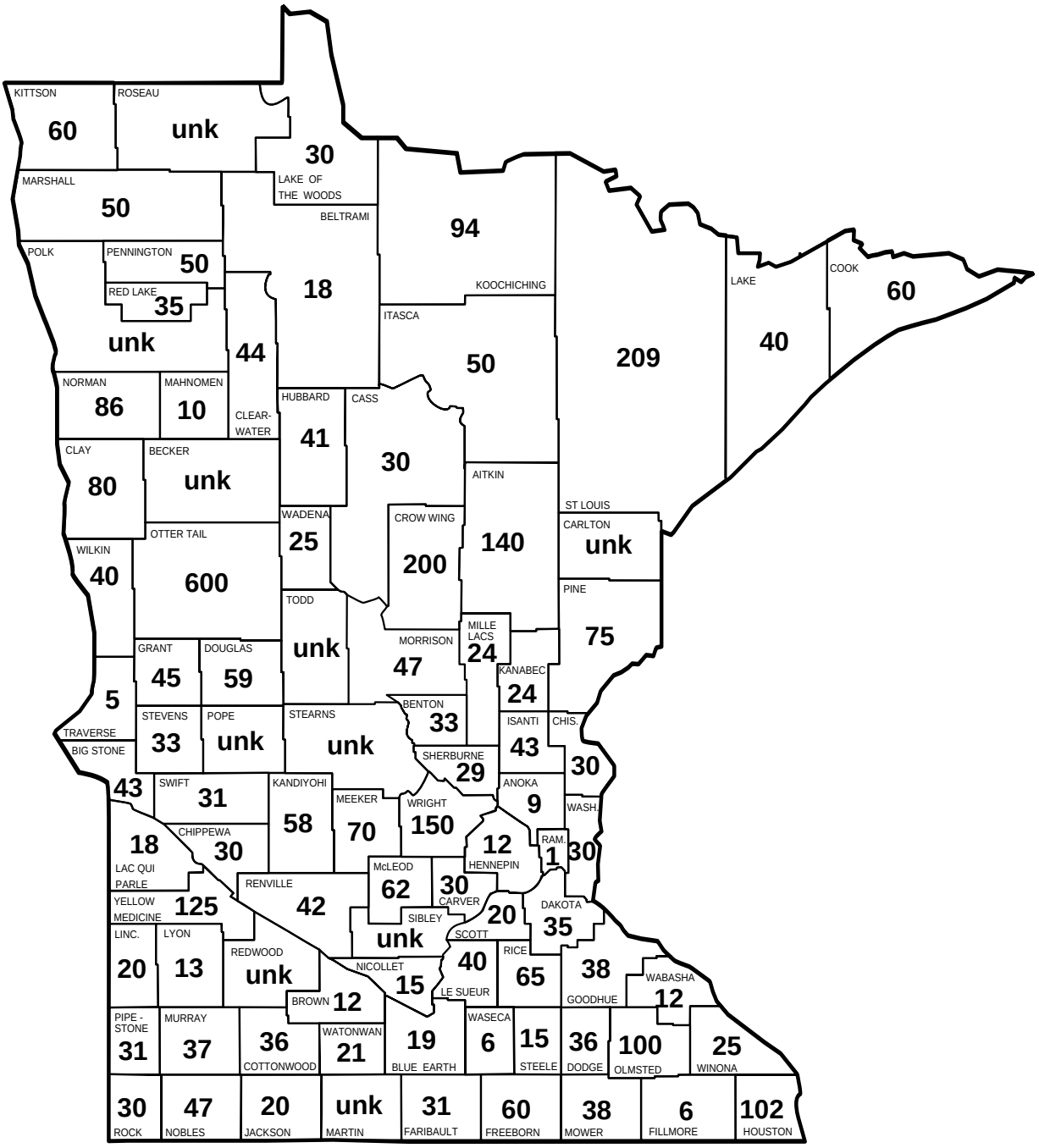


Figure 1. Number of gravel pits estimated for each county from a 1991 survey.

THE NEED FOR RECLAMATION

In the past, reclamation of sand and gravel mining areas has not been a major environmental concern to the public. Although the area disturbed by a single mining operation generally is small, the combined acreage nationwide is substantial. Nearly one million acres were affected by sand and gravel mining in the U.S. in a recent 40-year period. Less than a third of these acres were reclaimed.

In Minnesota, sand and gravel mining is increasingly viewed as a temporary use to be followed by another land use that is compatible with the surrounding landscape. The need to reclaim gravel pits and the demand for technical information on the subject was the motivation for this handbook.

The benefits of reclamation are widely recognized. When a pit is progressively reclaimed during active mining, problems like those mentioned above can be minimized. Operator costs can also be reduced if reclamation is accomplished as part of a mining plan. Some operators have already realized the public relations benefits gained from reclamation.

Numerous examples are found throughout the state of depleted gravel pits that have been successfully reclaimed to agricultural and forestry uses, fish and wildlife habitat, recreation areas, or urban building sites. In some cases, reclamation has been so successful that the pits are no longer recognizable as former mining areas. Other pits can be found where natural revegetation has successfully occurred unassisted. Obviously, there is not a need to reclaim every one of the 2,500 abandoned or intermittently used pits in the state. Many have value in their present condition.

However, the problems associated with unreclaimed pits can be substantial. Some pits are a threat to public safety due to dangerous vertical pit walls or deep water. Others are a concern because of erosion and possible pollution of downstream receiving waters. Still other pits become arenas for off-road vehicle use, illegal dumping, trespass, and unauthorized activities like target shooting. When these situations arise near populated areas, they often conflict with surrounding land uses. For troublesome pits that are the scene of reoccurring misuse, the only reasonable and permanent solution may be reclamation.

Since 1987, the DNR and the Minnesota Department of Transportation (MnDOT) together with local government and the aggregate industry have

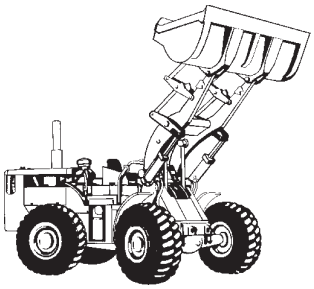
been working on gravel pit issues, especially those dealing with reclamation. This group first came together at the request of then Governor Perpich who felt that gravel pit reclamation was a problem that needed the attention of a task force.

The findings of the task force are summarized in a 1989 DNR report entitled "A Review of Regulations Regarding the Reclamation of Sand and Gravel Pits in Minnesota". Recommendations in the task force final report led to the production of this volume, "A Handbook for Reclaiming Sand and Gravel Pits in Minnesota".

About this handbook

This handbook was compiled by the DNR from information collected in literature searches, surveys, discussions with operators and county officials, field trips to gravel mining sites, and the input of an advisory committee composed of representatives from industry, local government, and state agencies.

The purpose of the handbook is to provide technical information to landowners, county officials, and operators on reclaiming sand and gravel pits. It is intended to serve as a general reference in the development of site specific mining and reclamation plans.



Throughout this volume, sand and gravel means a surficial geologic deposit of unconsolidated material that is mined using shovels, draglines, loaders, trucks, and other similar equipment. Borrow pits could also be included in this definition.

The handbook does not consider reclamation of pits or quarries associated with the production of crushed stone, industrial sand, or dimension stone. These mineral commodities are usually extracted from the earth using hard rock mining methods. Although some of the information described herein may be applicable to other types of mining operations, this handbook was prepared primarily for sand and gravel operations.

The handbook will be of the greatest value in planning for future operations. It will also have some application for operations that are currently active. It will, however, be of limited value for abandoned pits because the methods described within are most cost-effective to implement during active operations.

Contents

The handbook contains general information on environmental regulations applicable to sand and gravel mining, development of site-specific mining plans, reclamation guidelines, wildlife habitat, and forest plantings. Although

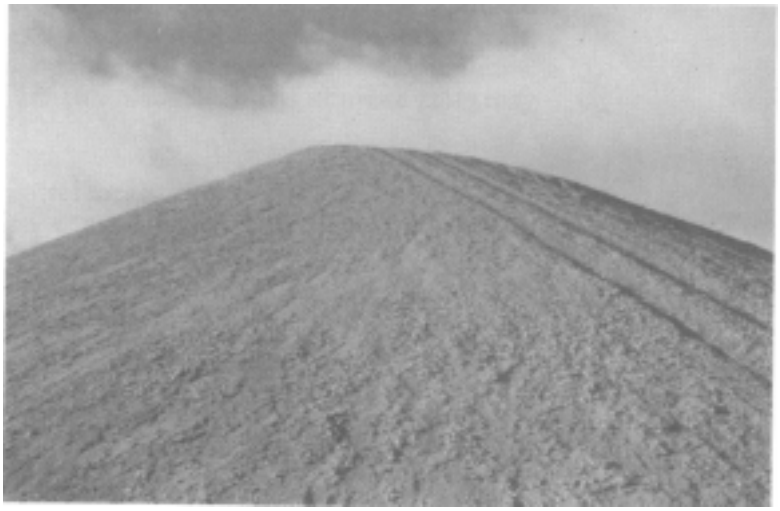
there are a variety of appropriate end uses for gravel pits ranging from agriculture to residential and industrial development, space limits the discussion to these topics. The handbook contains four appendices. Appendix A is a list of environmental permits that may apply to sand and gravel mining and a directory of governmental agencies to contact for more information.

A model permit application is contained in Appendix B. The permit application can be used by local government in its role as the primary regulatory authority for sand and gravel mining.

Appendix C identifies sources of maps, air photos, soils information, and plant materials. Information from these sources may be useful in the preparation of a mining plan or in actual on-site reclamation.

Numerous references were collected on sand and gravel pit reclamation for the preparation of this handbook. A list of selected references is found in Appendix D. These references are housed in the DNR Lands and Minerals Division office at the address indicated in the appendix. Also on file is a complete set of Minnesota county ordinances dealing with extractive uses.

Copies of the handbook were initially distributed to the Aggregate Ready Mix Association, Asphalt Pavement Association, county zoning administrators, county engineers, MnDOT district offices, DNR regional offices, Minnesota Pollution Control Agency (PCA) field offices and other interested parties. Additional copies may be obtained from the DNR Lands and Minerals Division at the address shown on the inside front cover.



Environmental Regulations

ENVIRONMENTAL CONCERNS

This chapter discusses environmental concerns commonly associated with the development of sand and gravel operations. These concerns are usually addressed through a variety of federal, state, and local permits. Because environmental regulations will continue to evolve, operators should keep informed to avoid excessive mitigation costs or possible penalties.

Site appearance

The appearance of a sand and gravel operation is an important concern to surrounding residents. The more visible a mining operation is to the public, the greater the need for a neat site appearance. Similarly, the less compatible the mining operation is with adjacent land uses, the greater the need for effective screening.

For most settings, mining and processing facilities should be designed to be as inconspicuous to the public as possible. Much of the operation can often be screened by trees and vegetation or by construction of earthen berms. An aesthetically pleasing site appearance can create a positive impression.

Erosion and sediment control

Erosion and sediment deposition are concerns for some sand and gravel operations. Erosion normally proceeds at a slow rate, but when protective vegetative cover is removed and underlying soil exposed, the rate is greatly accelerated. Disturbed land may experience erosion rates as much as 1,000 times that of undisturbed land. The greater the distance and slope, the more difficult erosion is to control. Increasing volume and velocity of runoff waters also contributes to the severity of erosion.

Damage from sedimentation caused by erosion is costly in both economic and environmental terms. Sediment deposition can destroy fish spawning beds, reduce storage volume in reservoirs, clog streams, and may carry toxic chemicals. Impacts from sediment deposition are cumulative and the ultimate costs may not be evident for years.

Mine planning and use of erosion control measures can minimize impacts from erosion and sedimentation. Erosion control plans should be developed in advance of land disturbance.

Reclamation

Like many other industries, sand and gravel mining suffers from its own history. In the past, former mining areas were operated and abandoned in a manner that is no longer acceptable. Today, the public expects that sand and gravel mining areas will be reclaimed to an appropriate end use. Reclamation and good conservation practices including sloping, seeding, and erosion control should

be part of a mining plan that is developed before operations begin.

Air quality

Air quality is an increasing concern across the county as witnessed by new laws. For sand and gravel operators, air emissions are from two sources. Plant-generated dust arises from drilling, crushing, conveying, screening, and stockpiling materials. It can be controlled through wet dust suppression, dry dust collection techniques or a combination of the two.

Fugitive dust is generated from blasting operations, haul roads, and stockpile storage areas. It is caused by natural occurrences like wind in addition to mining activities like truck hauling. For sand and gravel mining operations, fugitive dust typically is the largest contributor to overall dust at a site. Control of fugitive dust can be accomplished by use of water trucks, windbreaks, enforcement of on-site speed limits, strategic placement of stockpiles, and the use of protective vegetative cover in open areas.

Water resources

Protecting water quality is important in situations where the water table is intersected by mining. In operations where pumping for dewatering or gravel washing will occur, the impact these activities may have on water levels in surrounding wells is a concern. Pollution and sediment deposition in surface waters receiving discharge from the mining area are also a concern. Possible pollution of the groundwater from accidental spills of chemicals such as solvents or fuels and leaking of underground storage tanks is a further concern.

Wetlands

A heightened public awareness of the ecological significance of wetlands has led to concern over the rapid rate at which wetlands are presently being destroyed. Sand and gravel mining is an activity that may impact wetlands.

Wetlands are defined in the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soil conditions".

The federal manual is currently the standard by which all federal agencies delineate wetlands. It establishes three indicators for wetland identification:

wetland vegetation, wetland hydrology, and wetland soils. These three indicators must all be present in a single location before that site is classified as a wetland.

In addition to federal efforts, several states including Minnesota have been active in wetlands protection. Under current requirements, for every acre of wetland impacted by sand and gravel mining, at least one and sometimes more than one acre of new wetland must be created. Wetlands laws like other environmental regulations will continue to evolve and operators should keep informed.

Operating issues

Operating issues such as blasting, noise, traffic, public safety, and hours of operation are local concerns frequently associated with sand and gravel operations. These concerns are addressed in county conditional land use permits and are beyond the scope of this handbook.

ENVIRONMENTAL REVIEW

The Minnesota Environmental Policy Act of 1973 established a formal process for reviewing the environmental impacts of major development projects. Environmental review may be required for new gravel mining operations or for expansion of existing gravel mining operations.

The process operates according to rules adopted by the Environmental Quality Board (EQB), but actual review is carried out by a local governmental unit or by a state agency referred to as the Responsible Governmental Unit (RGU). Depending on the type and size of a project, the review can take the form of an Environmental Assessment Worksheet (EAW) or an Environmental Impact Statement (EIS).

An EAW is a short questionnaire about the project, the purpose of which is to determine if a project has potential for significant environmental effects. The RGU prepares the EAW. If an EAW results in a determination that an EIS is necessary, the RGU would also prepare an EIS.

According to current EQB rules, preparation of an EAW is mandatory for development of a facility for the extraction or mining of sand, gravel, stone, or other nonmetallic minerals, which will excavate 40 or more acres of land to a mean depth of ten feet or more during its existence. An EIS is mandatory for sand and gravel operations exceeding 160 acres in size. The complete project size including anticipated expansions is to be used in evaluating the need for an EAW or an EIS. The designated RGU for sand and gravel projects is the local unit of government, most often the city or county where the project is located.

An EAW can also be prepared in response to a citizen petition, as a condition for a conditional land use permit, or at the discretion of the project proposer.

Since 1990,EAWs have been prepared for more than a dozen sand and gravel mining operations in Minnesota.

ENVIRONMENTAL PERMITS

Appendix A is a list of governmental agencies that have regulatory authority for certain sand and gravel mining activities in Minnesota. At the state level, environmental permits may be required from the DNR and the Pollution Control Agency, among others. Federal agencies like the Army Corps of Engineers have regulatory authority for sand and gravel operations impacting wetlands.

In addition to state and federal permits, Minnesota adopted new shoreland management regulations in 1989 that require specific zoning and performance standards for mining within a shoreland. The area subject to floodplain or shoreland regulation is defined in local zoning ordinances. More recently, the Minnesota Wetlands Conservation Act of 1991 mandated tighter control and mitigation of impacts to wetlands.

Currently, the most extensive review of sand and gravel operations takes place at the local level of government. Minnesota has 87 counties, 1,792 townships, and 853 cities. Each county, township, and city has the authority to regulate sand and gravel mining through zoning ordinances and land use planning.

Although the treatment of sand and gravel mining varies from one county to the next, many communities in Minnesota effectively regulate extractive uses through regulation and land use planning. An excellent example is the comprehensive gravel mining plan developed for the city of Maple Grove in Hennepin County. Maple Grove recognized that sand and gravel mining is typically a local industry, serving local markets from a stable location for a long period of time. Providing gravel at a reasonable cost to the community can best be assured by reasonable local regulation that discourages the irresponsible operator and rewards the conscientious.

Local land use planning can also provide important opportunities for protecting sand and gravel reserves for future extraction to benefit both producers and consumers alike. Sand and gravel is a finite resource that is often lost because the location and value of the resource was not recognized prior to placement of buildings, roads, and other structures on the deposits.

Appendix B contains a model permit application for use by local government in its role as the primary regulatory authority for sand and gravel mining. The purpose of the model permit

application is to encourage the preparation of mining plans through the use of a standard form. It was compiled based on review of local ordinances pertaining to gravel mining in Minnesota and throughout the U.S. and Canada. The permit application, which can be used in conjunction with existing county ordinances, addresses active mining issues while focusing on reclamation. Use of the permit application in part or in whole by local government is strictly voluntary.

RESPONSIBLE PARTY

The party responsible for preparing a mining plan, obtaining the necessary environmental permits, and reclaiming the site is often a clouded question. Landowners repeatedly lease the same tract of land for gravel mining with the result being that a single pit may be mined by several different lessees over a relatively long period of time. To further compound matters, a lessee sometimes subcontracts gravel mining to yet another party--a sand and gravel operator.

For many sand and gravel pits, responsibilities of the landowner, the lessee(s) and the operator(s) that worked in the pit are not clear. Responsibilities of all parties should be explicitly described in the leasing agreement, the mining plan, and in any required permits before mining begins. These responsibilities should be commonly understood by all parties. Without a common understanding, the burden for reclaiming the entire pit may unfairly fall to the last operator.

There can also be confusion over who should hold required permits. The landowner, the lessee(s), the operator(s) or some combination are all possible permittees. For sites where several operators may work out of the same pit at different times, the landowner has a role in directing mining activities according to a comprehensive mining plan. In these cases, the local regulatory authority may wish to consider the landowner as joint permittee with the operator.

As for permitting, local regulations vary from county to county. Even within a county, regulations may not apply equally to all gravel mining situations. For example, a local permit may not be required for mobile gravel operators working on short-term road construction projects. A series of unregulated gravel mining activities in one location can inadvertantly lead to a large mining area that will be more costly to reclaim and for which there is no clear responsible party.

The Mining Plan

PURPOSE

The purpose of a mining plan is to ensure that mining will proceed in an environmentally sound manner and that the area will be left in a safe, nonpolluting condition that has some future land value. A mining plan may also address concerns like view, hours of operation, noise, dust, and traffic.

Many of the 2,500 abandoned or intermittently active pits in Minnesota were mined over a long period of time by multiple operators for a variety of gravel products without the benefit of a mining plan. Often, the resulting landscape is characterized by randomly located piles of rock and stripping material sometimes resting on useable gravel reserves, an absence of the original topsoil, steep slopes that are unsafe and eroding, lack of a suitable vegetative cover, and scattered garbage from illegal dumping.

Reclaiming such a landscape can be a costly endeavor. Earth and equipment must be handled a second time to construct final landforms. In droughty sites with no topsoil, establishing vegetation can be difficult. Not only are the costs higher, but the results are often disappointing compared to what might have been accomplished if reclamation had been a planned activity.

BENEFITS

Benefits that come from a mining plan are early identification of environmental concerns, efficient removal of the gravel resource, and cost-effective reclamation. With planning, materials are placed in the appropriate location during stripping operations. Areas requiring fill material are identified. Final landforms are constructed during active mining. Other benefits that may be realized from a mining plan are:

- Appropriate location of roads, berms, screens, and processing facilities.
- Proper placement of stored materials to avoid double handling.
- Efficient use of equipment for cost-effective construction of final landforms.
- Best use of available fill material.
- Use of progressive reclamation.
- Reduced operating costs.
- Good public relations within the community.

WHAT IS A MINING PLAN?

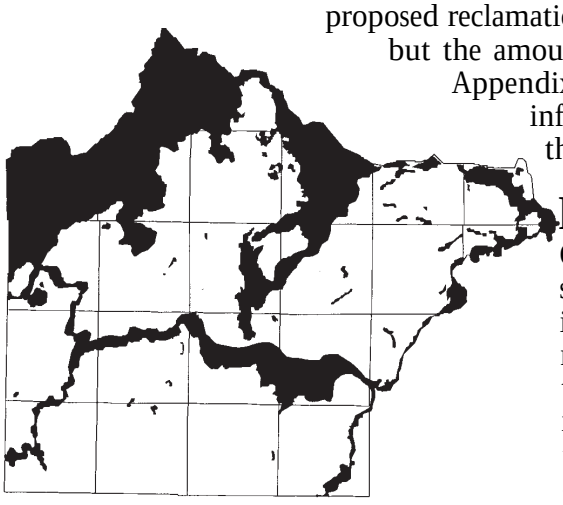
A mining plan is a combination of maps and written information that describe every aspect of the proposed operation from inventory of the gravel resource to post mining management of the site. The mining plan describes activities to be conducted at the mine site over the life of the operation. A mining plan is prepared before mining begins, often as a requirement for an environmental permit.

A mining plan is geared to the size and scope of the project. For small projects, the plan may be quite simple while a larger operation may require a more elaborate plan. All sand and gravel operations share similarities but no two are exactly alike. A mining plan must be site-specific and tailored to the unique setting of the proposed operation.

Because the sand and gravel industry fluctuates dramatically with economic conditions, there must be flexibility within the mining plan to accommodate unanticipated changes in the market that affect mining activities. A mining plan ensures that activities move forward according to a general concept that includes reclamation of the site. Mining plans can be updated at regular intervals (such as annual reporting) to reflect changes in operating plans.

INFORMATION INCLUDED IN A MINING PLAN

The information needed to prepare a mining plan generally includes: an inventory of the gravel resource; an assessment of premining conditions; a description of mining methods; a discussion on the staging of operations; and proposed reclamation. This information is needed for all mining plans, but the amount of detail depends on the scope of the proposal. Appendix C identifies sources of maps, air photos, soils information, and plant materials that may be useful in the preparation of a mining plan.



Potential Aggregate Resources

Resource inventory

Obtaining information about the type, depth, and shape of the gravel deposit through a resource inventory is important to the preparation of a mining plan. The most complete inventory data comes from drilling or test pitting. Drilling logs and test pits provide information not only about the extent and quality of the gravel but also about the thickness of the material overlying the deposit (known as overburden) and the depth to groudwater.

This infmation is useful because the shape of the deposit will determine the layout of the mine and sequence for development. Depth to groundwater will influence whether wet or dry mining methods should be used.

Knowledge of the gravel resource is also necessary to determine the economic feasibility of the mining proposal. The thickness of the overburden and the quality of the gravel resource combined with factors like haul distance are all economic considerations.

Assessment of premining conditions

An assessment of premining conditions will contain a variety of information unique to each proposal. Typical information that might be found in a premining assessment includes: direction of flow in surface waters; depth to and direction of groundwater flow; identification of wetlands on or near the mine site; access to the site by new or existing roads; previous excavations; existing vegetation; current use of the area by wildlife; location of buildings and other structures; proximity of occupied dwellings; proximity to floodplains and shoreland areas; surrounding land uses; and occurrences of other natural features.

An assessment of premining conditions is useful in identifying and mitigating environmental problems and public concerns associated with the proposal. For example, if occupied dwellings are found near the proposed site, the mine can be designed to include berms and vegetated buffers to reduce noise levels and limit view. There may be an opportunity to use existing vegetation and topography for screening as well.

Those same occupied dwellings might depend on shallow sandpoint wells for domestic water supply. Sandpoint wells, typically found in areas where sand and gravel is mined, are especially vulnerable to interference from nearby pumping. Assessment of premining conditions and prediction of possible impacts could prevent a situation where mine dewatering or gravel washing operations must cease pending resolution of a dispute over water levels.

Description of mining methods

A description of mining methods is a broad discussion that addresses how the gravel will be mined. The following list of questions indicates the kind of information sought in a description of mining methods. The list is not exhaustive, nor will every question apply to all mining operations.

- What is the gravel being used for?
- How will the gravel be mined?
- What are the proposed seasons of operation?
- What are the proposed hours of operation?
- How will gravel be transported from the site?
- What is the proposed route of transport and ultimate destination of the gravel?
- What screening techniques will be used?
- How will topsoil be reserved?
- What methods will be used to store or dispose of brush, stripping material, and overburden?
- What methods will be used to dispose of oversize (i.e., boulders) and undersize (i.e., fine sand) material?
- What erosion control measures will be used?
- How will dust be controlled?
- Where will gravel reserves be stockpiled at the site?
- Will mining intersect the groundwater table?
- Will the mining area be dewatered?
- Will water be discharged from the site?
- Will groundwater flow be altered?
- Will any protected waters or wetlands be altered?
- What processing methods will be used?
- Where will processing facilities be located?
- What are the proposed hours for the processing facilities?
- Will washing operations require water appropriations?
- How will chemical substances be stored on the site?
- How will access be controlled?
- Where will fences, gates and signs be located?
- How many people will be employed at the site?
- What type of office facilities will be provided?
- What equipment will be stored on site and where will it be located?
- What environmental permits are required for operation?

Staging of operations

Staging of operations refers to the sequence of mining. Some mining operations will remove the gravel in several discreet stages. For others, the gravel deposit will be mined all at once in one stage. Again, a list of questions best describes the information sought in a discussion on staging of operations.

- What is the projected life of the operation?
- Will the deposit be mined continuously until depletion?
- Will mining occur in stages over several years?
- Will stages be reclaimed as soon as mining is completed?
- Will the deposit be mined by a single operator or by multiple operators?
- What methods will be used at the cessation of seasonal operations to stabilize slopes from erosion?
- If the site will become inactive at the close of current operations for an unspecified period of time, what interim reclamation measures will be completed?
- If there will be subsequent operators at the site, are their responsibilities clearly defined in terms of interim and final reclamation?
- Will final reclamation require post mining management?

Proposed Reclamation

Proposed reclamation as contained in a mining plan describes a concept for the final end use of the site. Reclamation end uses are quite variable and may range from basic slope stabilization to wildlife habitat, or even lakeshore residential development. With a concept in mind, mining activities like clearing, stripping, stockpiling, and landform construction are directed towards final reclamation.

The proposed schedule for reclamation will determine the amount of detail needed in the mining plan. For short-term operations that will be conducting reclamation in the near future, details like seed mixes, fertilizer rates, and mulches should be specified in the mining plan. A monitoring schedule to evaluate the success of revegetation efforts should also be discussed.

For long-term operations, it can be difficult to predict reclamation activities when the mining operation is expected to continue for several years. In these cases, the mining plan should include a discussion on the general concept for reclamation. Details can be provided near the actual time of reclamation through updates to the mining plan.

A discussion on reclamation activities that continue beyond active mining should be part of the mining plan. Post mining management will probably be necessary for some kinds of reclamation end uses.

Intermittently active pits represent a large number of pits in Minnesota. These are sites that become active for short periods of time to supply material for local road construction. For the most cost-effective reclamation, intermittently active pits should be mined according to a comprehensive mining plan in a series of stages that are reclaimed progressively.

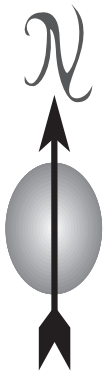
PROGRESSIVE RECLAMATION

The objective of progressive reclamation is to reclaim as soon as the gravel is removed and an area is permanently abandoned. Progressive reclamation occurs over the life of the mining operation as each stage is completed, rather than at the end of operations when the deposit has been depleted. It is a process that includes final site grading, reapplication of reserved topsoil, and the establishment of vegetative cover as each stage is concluded. Progressive reclamation takes advantage of on-site equipment and promotes cost-effective disposal of waste material. There may also be benefits to wildlife since many species need plant communities in varying stages of succession.

Progressive reclamation, however, is not always feasible nor is it recommended for all mining operations. It is an approach with particular application for larger sites in long-term operations. The concept of progressive reclamation should be an integral component of a mining plan whenever appropriate.

MAPS

Maps are an important and valuable means of displaying information. The setting of a proposed operation is often shown on topographic quadrangle maps. These maps, at a scale of 1 inch to 24,000 feet (1:24,000), can be used to display regional information relative to the proposed mining operation. An example of pertinent information that can be readily displayed is the watershed in which the project is located. The route of any water discharged from the site can also be traced on these maps.



Mining plans are often depicted on more detailed plan view maps. A scale of 1:200 is commonly used in the preparation of mining maps. Proposed features of the mining operation (stripping areas, cuts, excavations, processing facilities, roads, stockpiles, ditches, berms, water control structures) and reclamation features (screened areas, areas to be revegetated, final slopes and grades) can be depicted. Vertical details are shown with contour lines and cross-sections.

A series of sequential maps can illustrate how operations will proceed over time. A base map with overlays of clear mylar or acetate can be prepared to quickly and effectively show stages of the mining operation.

MINING PLAN EXAMPLES

Figure 2 is an example of a mining plan depicted on a series of four maps. These maps illustrate the components of a good mining plan. The first map shows premining conditions including existing vegetation, land uses, and water courses. The next map depicts the proposed staging of operations. The processing plant location is indicated as well as berms and vegetative plantings that will serve as screens. The next map shows anticipated pit contours and a cross-section. Finally, the last map describes final reclamation. Natural revegetation will be used in combination with plantings.

Figure 2a. Premining conditions.

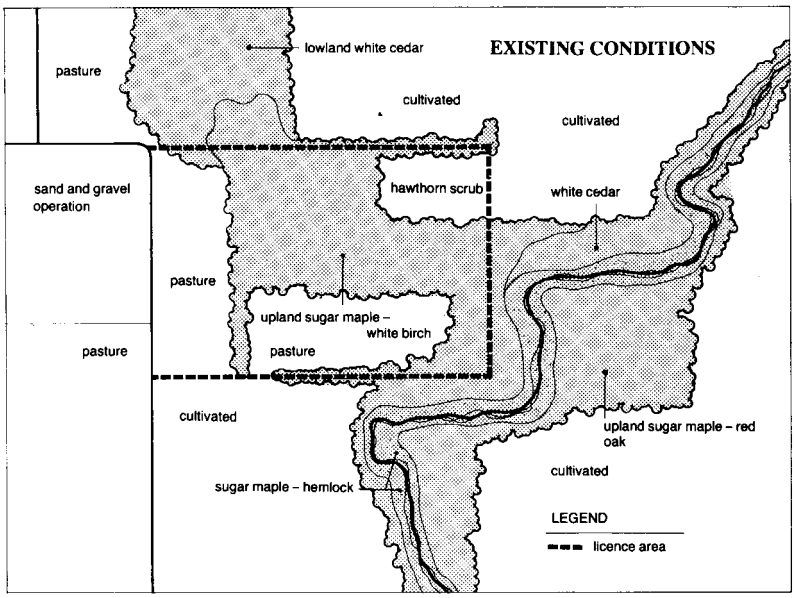
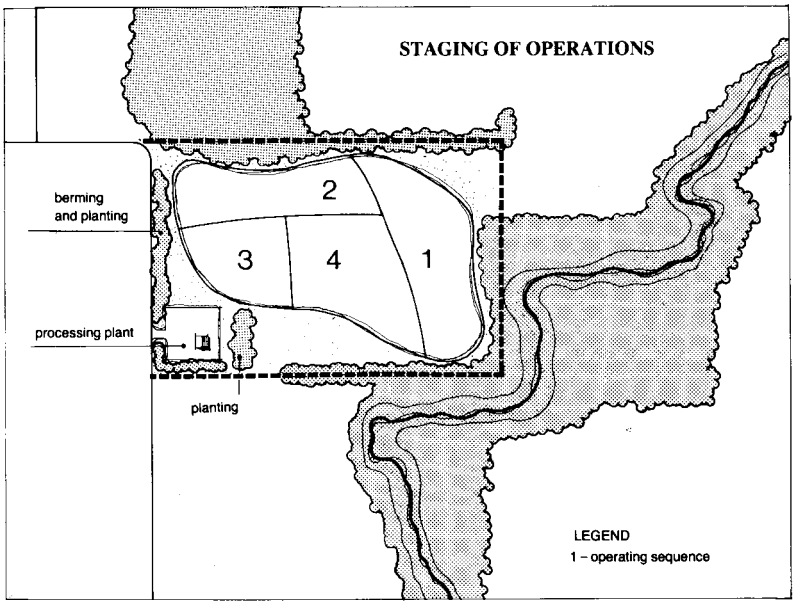


Figure 2b. Staging of operations.



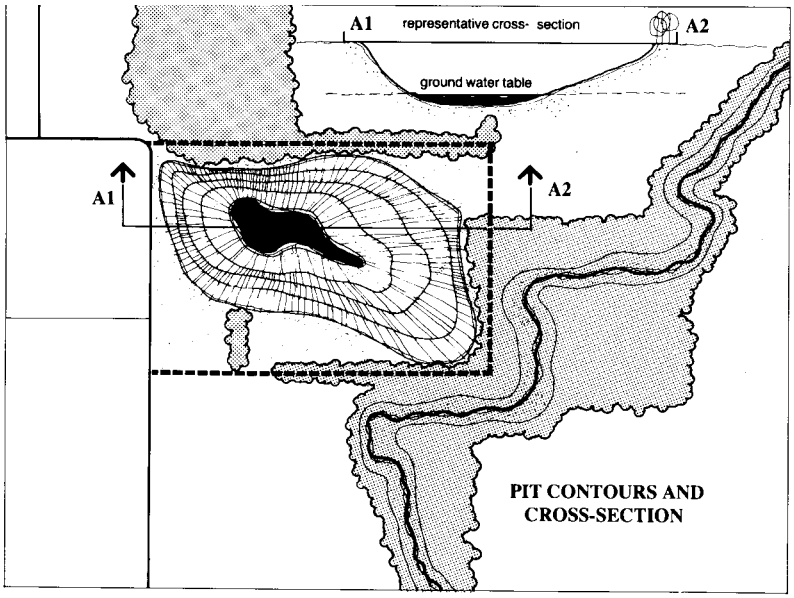


Figure 2c. Pit contours and cross section.

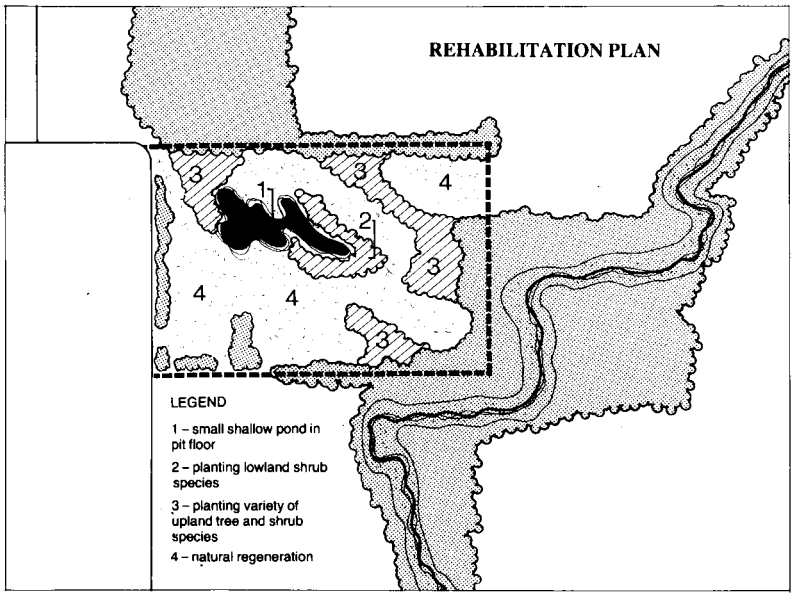


Figure 2d. Final reclamation.

(Figures 2a - 2d are from Michalski [1987], Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources.)

Figures 3 to 7 describe the proposed development and reclamation of an 80-acre sand and gravel operation. The map in Figure 3 depicts premining conditions of the site including roads, residences, previous excavations, proposed excavation areas, existing vegetation, and buildings. Contour intervals of five feet are drawn on the map to show changes in elevation. The edge of the excavation is illustrated by a dashed line. The x's denote the location of permanent boundary stakes.

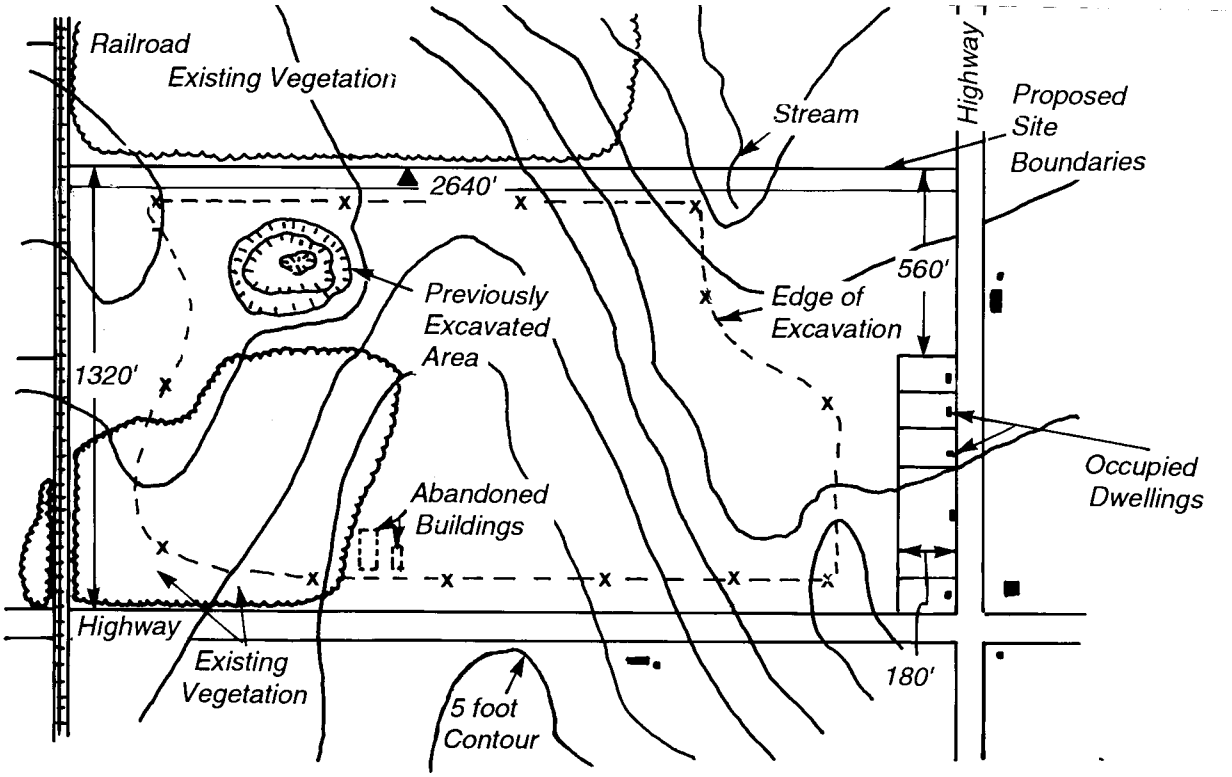


Figure 3. Premining assessment. (Figures 3 - 7 are modified from Bauer [1970], A Guide to Site Development and Rehabilitation of Pits and Quarries, Ontario Dept. of Mines and Pribanich and Rozewicz [1985], Sample mining plan, Marathon County Planning Office, Marathon County, Wisconsin.)

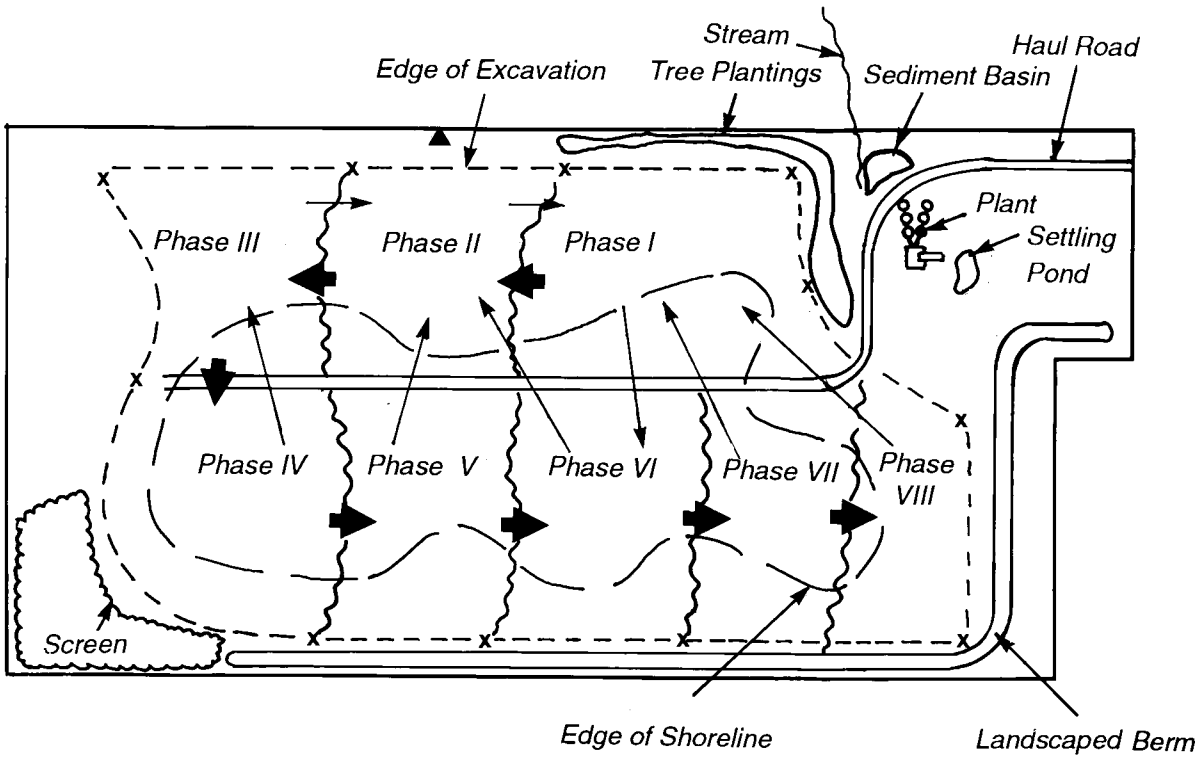


Figure 4. Dry mining phases.

Figure 4 illustrates the dry mining phases of the proposed operation. Mining will proceed in eight distinct stages or phases denoted by heavy arrows. Overburden materials will be stripped from one phase and stockpiled in another area as denoted with a small arrow. In this fashion, removal of topsoil and overburden become coordinated activities that reduce handling of the material. Overburden from initial stripping operations will be used to construct vegetated berms between the mining operation and private residences. Existing woody vegetation will be retained to serve as a buffer. Access points, haul roads, and processing facilities are sited to reduce dust, noise, and view. The plant will be relocated to the pit floor after phase 1 is completed to provide further screening. The north bank of the pit will be shaped with overburden and topsoil and then seeded as the operation advances.

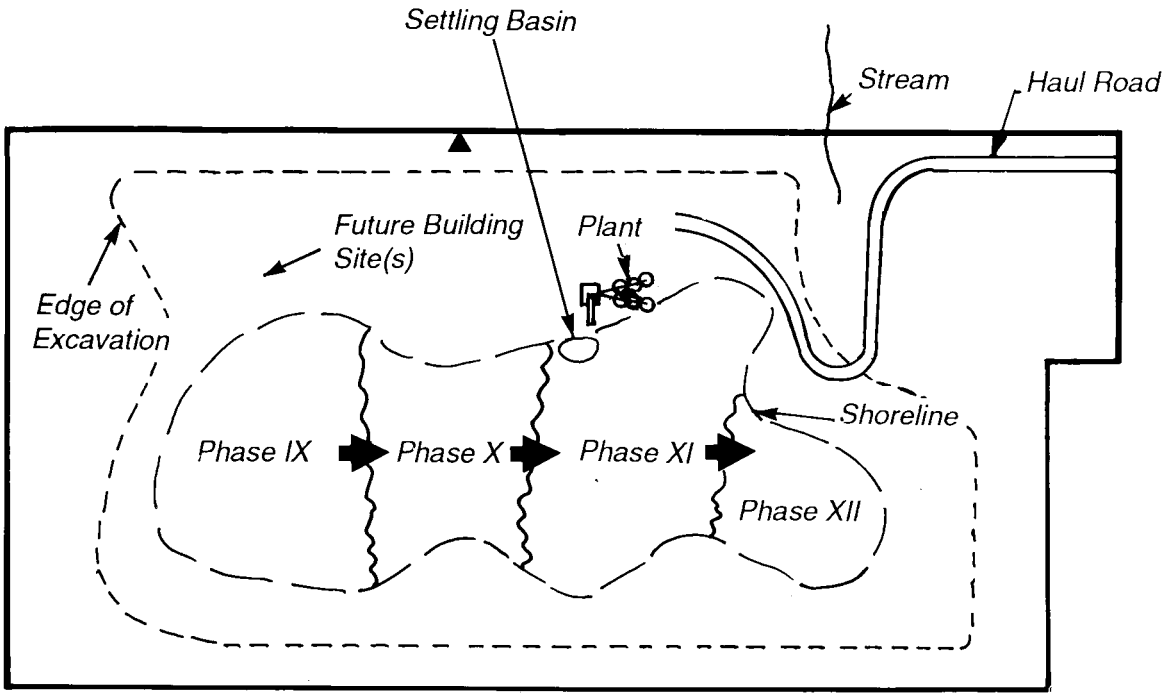


Figure 5. Mining phases below the water table.

Figure 5 depicts mining stages that are below the water table. The future shoreline will be shaped and landscaped concurrently with mining in the remaining four phases as displayed on the map. The plant site will eventually be removed. All remaining disturbed areas will be stabilized with vegetation. The haul road will be relocated and left intact to provide access to the water.

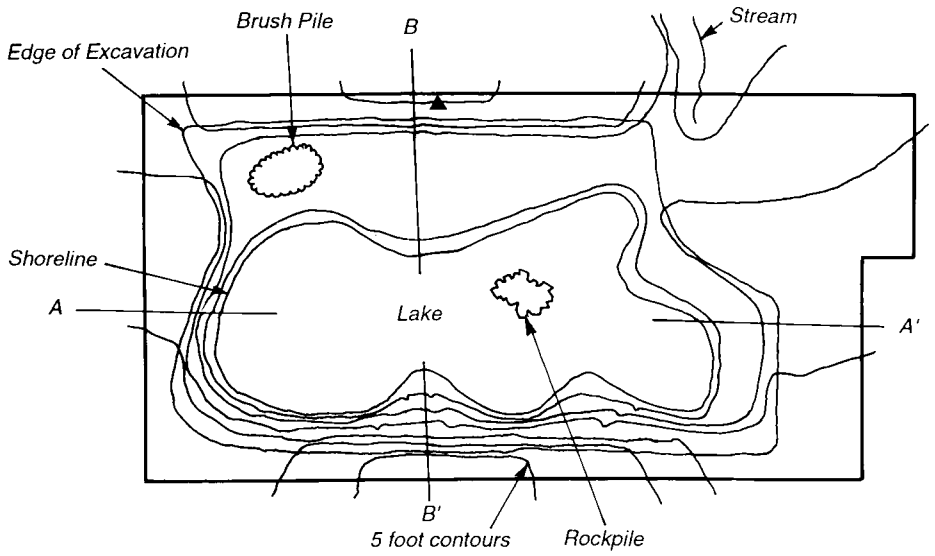


Figure 6. Final reclamation.

Figure 6 is the final reclamation map. The area will be reclaimed to allow construction of residential building sites along a lakeshore. Final contour elevations are shown. A rock pile has been created within the water body to provide diversity. The shoreline is irregular. A wood refuse pile has been left intentionally to enhance wildlife habitat. In the written portion of the plan, the type of vegetative plantings around the perimeter are described including seed mix, fertilizer rate, and mulch specifications.

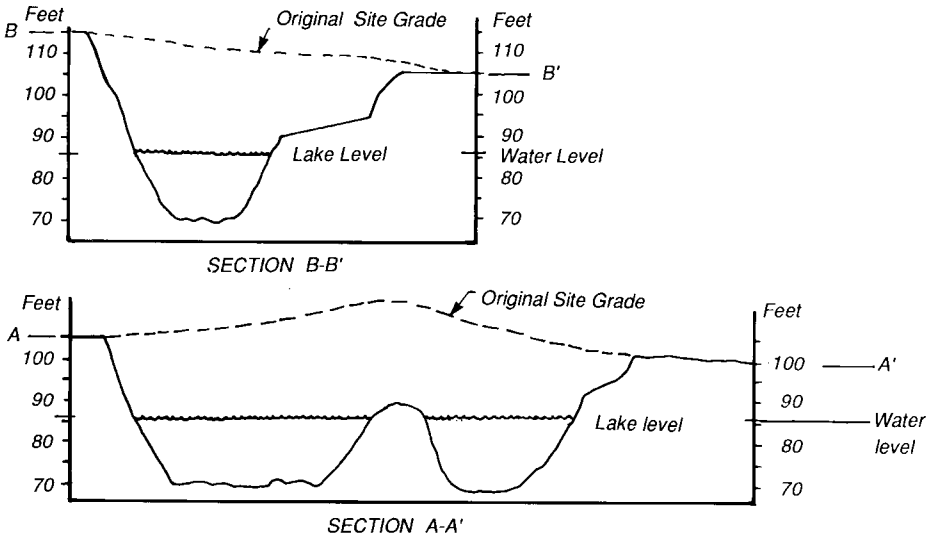


Figure 7. Cross-section through lake.

Figure 7 are cross-sections of the lake through imaginary east-west (A-A') and north-south (B-B') lines. The cross-sections provide a graphic picture of expected lake depth and topography. This lake with its relatively steep shoreline is not as beneficial to wildlife as lakes with more gentle slopes.

General Reclamation Guidelines

END USES

An "end use" is a term that describes the subsequent use of a site following mining. Some gravel pits are reclaimed to end uses that require post mining management such as wildlife habitat and forest plantings.

In these cases, the end use is usually known at the start of operations. The mining plan includes a description of post mining management necessary to support the end use and identifies the responsible party for conducting it. Later chapters of the handbook provide information on wildlife and forest planting end uses.

For most gravel pits, however, no managed end use is contemplated. The goal of reclamation for these pits is to leave the site in a safe, nonpolluting condition that has future land value. Final reclamation is directed at slope stabilization, revegetation, and cleanup. This chapter presents guidelines for activities such as clearing, stripping, grading, and establishing vegetation in pits where no managed end use is planned. A typical mining plan might include:

- Clearing and disposing of vegetation.
- Stripping and reserving topsoil.
- Construction of a berm from overburden material.
- Designating a working face in the pit and directing activity at that face until depletion.
- Final grading of the pit face and other slopes to 3:1.
- Reapplication of topsoil.
- Seeding with a nurse crop of oats to stabilize the surface from erosion.
- Allowing for natural revegetation in combination with tree plantings and seeding of native grasses.

CLEARING

Opening a new gravel mining site usually involves clearing or removal of existing vegetation. Trees, brush, and other vegetative debris from clearing activities should be temporarily stored in a location that will not interfere with future mining operations. The debris may be permanently disposed of by burning under the terms of a local burning permit. It may also be buried in the pit as backfill in a practice referred to as in-mine disposal.

Woody debris may be intentionally retained for future use as structure at the bottom of fish ponds or for the construction of brush piles to create diversity in upland habitat for wildlife. Brush piles can also be used for access control.

In the forested regions of the state, timber of commercial value may be growing over the gravel resource. If the trees are to be harvested from the site prior

to mining, logging should follow the best management practices for water quality outlined in the 1990 manual entitled "Water Quality in Forest Management". The manual is available from DNR forestry offices.

STRIPPING

Stripping of the material that overlies the gravel deposit often takes place immediately after the vegetation has been cleared. In some cases, the gravel deposit may be at the surface. Most often, though, there may be as many as three distinct layers that overlie the gravel deposit described as topsoil, subsoil, and overburden, respectively. The thicknesses and quality of these layers can vary dramatically between operations and even within a single site. These materials should be stored in separate piles in a location that will not interfere with future mining operations.

Topsoil is the dark soil layer immediately below the surface litter layer. The black color of the topsoil is from an accumulation of organic matter that is derived from the decomposition of plant remains. Organic matter is essential for plant establishment because it is a source of essential nutrients.

Reserving topsoil is of great importance to the eventual reclamation of the site. Whenever feasible, topsoil should be carefully stripped from the proposed mining area and stored. Vegetative debris and large rocks should not be mixed with the topsoil. If topsoil will be stored for a long period of time, the surface of the pile should be seeded with a cover crop to preserve nutrient value and control erosion. In situations where the supply of reserved topsoil is inadequate to cover the entire area disturbed by mining, reserves can be concentrated into "topsoil islands" and seeded to a different type of vegetation than the surrounding area.

Subsoil is a brownish layer under the topsoil containing less organic matter. In sandy soils, it may be difficult to distinguish between the topsoil and the subsoil. In practice, subsoil is often stored with either the topsoil or the overburden. For some agricultural end uses, it can be important to segregate the subsoil from the topsoil so that it may be reapplied in the reverse order removed.

Overburden is the remaining material, excluding topsoil and subsoil, that overlies the gravel deposit. It typically does not contain appreciable quantities of organic matter and should be stored separately from topsoil. Overburden can be used to construct final landforms within the mining area such as berms which, in turn, may be covered with topsoil and revegetated. Vegetated berms can restrict access to the mining property and may screen the mining operation from surrounding land uses to reduce noise level, dust, and view concerns.

Boulders and oversize material from clearing and stripping activities should be temporarily stored or permanently disposed of in a location that will not impede

mining or reclamation efforts. These materials can be used as reclamation progresses in the construction of final landforms or disposed of through in-mine disposal. Alternatively, rock piles can be strategically placed to provide wildlife habitat.

GRADING

Steep and uneven terrain in gravel pits can pose a safety concern, promote erosion, and inhibit plant establishment. In general, final slopes in gravel pits should be graded to a maximum steepness of 2.5:1. This figure is a ratio that describes a slope with a 2.5 feet horizontal distance for every one foot rise in elevation or vertical distance. The larger the ratio, the flatter the slope. Figure 8 illustrates slope relationships.

2:1 -the maximum slope considered for long-term stability of a pit site.

3:1 -generally considered to be the maximum gradient for safe side hill vehicle travel, for effective surface erosion control, and for safe pedestrian access up and down slope.

10:1-slopes in the range of 3:1 to 10:1 are generally satisfactory for forestry, recreation, and some agricultural uses.

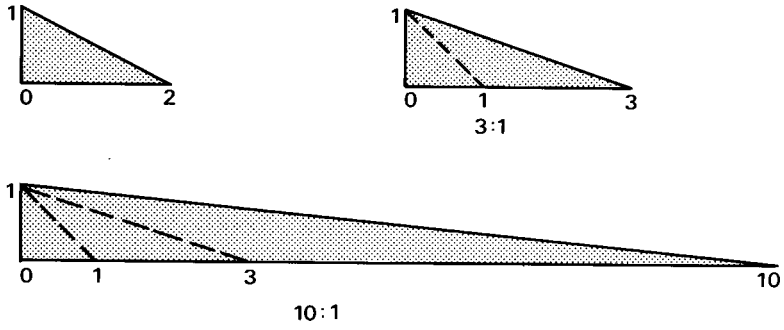


Figure 8. Slope gradients. (Taken from Miller and Mackintosh [1987], Sand and Gravel Pit Rehabilitation in Northern Ontario, Ontario Ministry of Natural Resources.)

A slope of 2.5:1 is the limit for the efficient operation of heavy equipment. Flatter slopes of 3:1 to 10:1 are recommended for forestry, recreation, and some types of agriculture. Vertical cutbanks may be retained in certain settings for use by bank dwelling birds like swallows.

INTERIM RECLAMATION

When mining activities are expected to cease for longer than six months, interim reclamation measures should be taken to reduce erosion potential and safety concerns. Interim reclamation measures might include grading steep slopes and vegetating areas that are especially prone to erosion. Use of signs, gated accesses, or fences to reduce unauthorized activities before active mining resumes could also be considered. Appropriate and reasonable interim reclamation measures should be evaluated on a site-specific basis.

ESTABLISHING VEGETATION

The key to reclamation is establishing vegetation. The objective is to produce a vegetative cover over the mined area that is self-sustaining and requires little maintenance.

Efforts to establish vegetation should begin by the first full growing season following closure of an area. Areas that will need to be revegetated include not only the pit but also stockpile areas, roads, equipment storage areas, office and plant facilities, and settling basins among others.

Establishing a self-sustaining, low maintenance vegetative cover that is cost-effective can be a challenge. Because topsoil is often in short supply, reclamation is frequently a problem of revegetating subsoils, overburden material, or exposed gravel surfaces. Droughty conditions, high temperatures, erosion, lack of organic matter and other plant nutrients combined with wind blasting create a hostile environment for establishing vegetation. Ground compaction from heavy equipment, especially on the pit floor, can further inhibit plant growth.

Success in establishing vegetation depends on proper plant species selection, appropriate timing of plantings, adequate fertilization, and an ample supply of organic matter. A soil test is often necessary to provide information about fertility conditions at the site. Information gained from soil testing such as pH, organic matter content, soil texture, and levels of nitrogen, potassium and phosphorous is used to develop fertilizer and species recommendations.

Reapplication of reserved topsoil can be critical to the success of revegetation efforts. Topsoil should be spread at a depth of 6 - 12 inches. Any amount of topsoil, however, will be beneficial in plant establishment. Reapplication of topsoil becomes more crucial in coarse-textured, droughty soils.

After planting, the success of revegetation efforts should be monitored for several years to observe signs of erosion and other failures. Replanting should be conducted as needed, until the vegetation is established and self-sustaining.

Natural revegetation

Natural revegetation is a passive process where surrounding vegetation serves as a seed source for adjacent disturbed areas like gravel pits. Natural revegetation can be a slow process that results in a plant community with low species diversity.

In gravel pits, conditions are often drastically different and more hostile than those found in the surrounding area. Only those plants that tolerate harsh conditions survive. Weeds and other exotic species may invade aggressively and outcompete more desirable species. For natural revegetation to succeed, site conditions in the disturbed area must be conducive to the establishment of species found in the surrounding undisturbed area.

Natural revegetation is not appropriate in every setting. In areas of steep slopes prone to erosion, natural revegetation will probably occur too slowly to provide the necessary cover. Natural revegetation is enhanced when the site is graded and topsoil is reapplied, especially in dry sites. In general, natural revegetation is best used selectively and in combination with direct seeding.

Exotic species

Exotic species are plants and animals not originally native to Minnesota that were introduced intentionally or arrived by accident through trade, commerce, and transportation. Many introduced or exotic plant species are invasive, aggressive, and difficult to control compared to native species. They can displace native species in undisturbed habitats and take over disturbed areas like gravel pits. In Minnesota, 20% of all non-cultivated plants species are exotic.

In 1989, the Minnesota Legislature mandated the establishment of an inter-agency exotic species task force to examine the issues. The task force report, published in 1991 by the DNR, contains a list of exotic species already present in Minnesota that pose a moderate or severe future threat to the environment. Some exotics on the list include species commonly used for erosion control such as Kentucky bluegrass, white and yellow sweet clover, bird's foot trefoil, crown vetch, and smooth bromegrass. Others are more widely known as weeds and include Canada thistle, quackgrass, spotted knapweed, purple loosestrife, and leafy spurge. Managing exotic species can be an important aspect of gravel pit reclamation. Consult the exotic species final report for more information.

Mulch

Application of a mulch is often necessary after seeding operations. Mulching helps to prevent erosion and moisture loss. Hay, straw, or wood fiber mulch have all been used in revegetation efforts. Hay mulch has the advantage of providing another seed source, but the presence of weed seed can be a serious problem. Hay and straw mulches are normally applied with a conventional blower at a rate of 1-1/2 to 2 tons per acre. The mulch is then crimped in usually with a slotted disk.

On steep slopes, an asphalt tack or other tack can be used to anchor the mulch. Anchoring with a disk or a tack should be done perpendicular to the slope. Wood fiber mulch is applied in a slurry using a hydro-mulcher. Chemical mulches can also be used in certain unique settings.

Direct seeding with cool-season species

Direct seeding with cool-season species followed by mulching has been the conventional method for plant establishment in disturbed areas like gravel pits. Cool-season species are those that germinate early in the season and experience maximum growth in the spring and fall. Common cool-season grasses and legumes include fescue, redtop, crownvetch, and bird's foot trefoil. These species do well in a wide range of soil texture and fertility conditions. For best results, cool-season species generally require fertilizer applications.

A cool-season legume-based grass mixture will have the greatest chance of success when planted in the spring. For seeding in the summer or fall, a two-stage process is suggested. Seeding of oats or rye in the summer or fall will provide a quick cover crop to control erosion. The following spring, seeding of a grass-legume mixture can proceed, followed by tree and shrub planting as needed.

"Standard Specifications for Construction for 1988", a manual published every five years by MnDOT as an aid to contractors preparing bids for road jobs, contains recommendations for several cool-season seed mixes for use in vegetation establishment on road shoulders, in borrow pits, and in other areas disturbed by road construction. These mixes are designed to provide a fast-growing vegetative cover to stabilize a site from erosion.

Two of these mixtures, referred to as Numbers 700 and 800, are shown below. These mixtures are provided as examples of what may be appropriate for revegetating certain gravel pits. Note that seed mixture, seeding rate, and fertilizer recommendations depend on soil conditions and must be tailored to meet site conditions for best results.

Refer to the Minnesota Department of Transporation (MnDOT) website at www.dot.state.mn.us/environment for current seed mixture recommendations.

MIXTURE NUMBER 700

Plant Species	Rate (lb/acre)	Relative %
Switchgrass	4	11.4
Timothy	4	11.4
Smooth bromegrass	13	37.2
Creeping alfalfa	4	11.4
Perennial ryegrass	10	28.6
TOTALS	35	100.0

MIXTURE NUMBER 800

Plant Species	Rate (lb/acre)	Relative %
Creeping alfalfa	14	35.0
Switchgrass	3	7.5
Timothy	4	10.0
Redtop	3	7.5
Smooth bromegrass	8	20.0
Perennial ryegrass	8	20.0
TOTALS	40	100.0

Problems with Cool-season Species

Research suggests that cool-season grasses and legumes do not survive over the long-term when planted in extremely coarse-textured soils that are droughty with little or no organic matter such as those commonly found in gravel pits. Long-term survival under these conditions may depend on the continued application of fertilizer.

In New Hampshire, numerous gravel pits seeded in prior years to cool-season grass and legume mixtures were studied. Red fescue was the only surviving species on gravel where there was less than 15 percent fines. Percent fines is a measure of the amount of soil particles passing through a 200-mesh sieve. The lower the percent fines, the coarser the texture of the soil. For success in establishing cool-season grasses on extremely coarse-textured soils, reapplication of topsoil appears critical.

Research by Gaffney and Dickerson in 1987 on species selection for revegetating sand and gravel pits in the northeast U.S. concludes:

- Cool-season grasses planted alone are not effective long-term species when fines are below 20 percent. Application of topsoil appears necessary if cool-season grasses will be used.

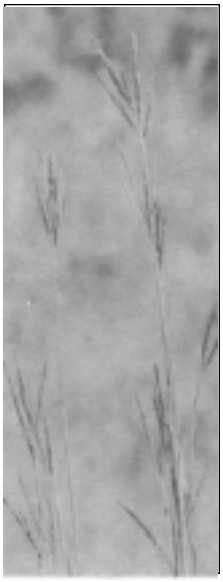
- Where percent fines are less than 15 percent, certain warm-season grasses (switchgrass, big bluestem, little bluestem) are the only effective herbaceous species for long-term, low maintenance cover identified to date.

- Long-term fertilizer needs are reduced with warm-season grasses and legumes.

Warm-season Native Grasses

Warm-season species are those that germinate under higher soil temperatures and experience maximum growth during the summer. Warm-season native grasses include big and little bluestem, switchgrasses, and grama grasses among others, all of which were typical of original native prairie landscapes in Minnesota.

Although little research has been conducted in this state, the use of native grasses in gravel pits looks promising. Native grasses are specially adapted to drought conditions and coarse-textured soils with low organic matter, conditions often encountered in gravel pits. The attributes of warm-season native grasses that make them attractive for use in gravel pit reclamation are:



- Deep and extensive root systems that develop rapidly after germination.
- Apparent low fertility requirements.
- Ability to thrive during hot summer months.

Warm-season grass seed germinates at a minimum soil temperature of approximately 60 degrees Fahrenheit. These temperatures are achieved earlier on sandy soils than on agricultural soils. For germination, seed must be moistened for a two-week period when soil temperatures have reached 60 degrees. In droughty gravel pits, the surface 2 to 3 inches of the seedbed is too dry most of the time to keep the seed moist long enough to germinate.

While most warm-season grass seed will remain viable in or on the soil for several years, it will not germinate until prolonged moisture is available at warm temperatures. As a result, it may be the spring after seeding before seedlings are observed. In fact, it is usually the second year when success becomes evident.

Warm-season grasses establish an extensive root system during the first year after germination. The top growth during this time amounts to a small narrow leaf which can be difficult to see. To the inexperienced, the seeding may appear as a failure the first year. Patience is needed when using native grasses for reclamation.

Once established, native grasses can provide a long-term vegetative cover that is self-sustaining and requires little maintenance in areas where cool-season grasses might ordinarily fail. Another advantage is that native grasses do not usually require fertilizer amendments for establishment. They also have a high value to wildlife.

The disadvantages in using native grasses are that seed is relatively expensive and that a specially adapted drill is sometimes needed for seeding large areas. Hand seeding followed by raking is a feasible method for small areas provided the seed has contact with the soil. With the popularity of native species growing, these disadvantages are quickly being overcome.

MnDOT Recommendations for Native Grasses

The Office of Materials and Research at MnDOT has recently developed guidelines for planting native grass and wildflower seed along Minnesota roadsides based on soil type, moisture, and presettlement vegetation patterns. Native grasses and wildflowers are recommended for use in the following areas:

- Low maintenance areas that are not going to be mowed, including almost all rural highways and some urban highways.
- Roadsides with sandy soils where regular turf grasses do not do well and weeds are a problem.
- Roadsides planted for wildlife.

Five native seed mixtures recommended in MnDOT's "Standard Specifications for Construction" have been designed for specific regions and site conditions in the state. These mixtures, described below, identify species and seeding rates that may be appropriate for use in some gravel pits. Seed mixture, seeding rate, and fertilizer recommendations depend on soil conditions and must be tailored to meet site conditions for best results. The DNR and the Soil Conservation Service can also provide recommendations on native grass seedings.

MIXTURE 100 FOR WESTERN MINNESOTA

Plant Species	Rate (PLS lbs/acre)	Relative %
Big bluestem	5.0	22
Green needle grass	1.0	4
Indian grass	4.0	17
Little bluestem	4.0	17
Sideoats grama	6.0	26
Slender wheat grass	0.5	2
Sand dropseed	0.5	2
Switch grass	1.0	4
Wildflowers	1.0	4
TOTALS	23.0	100.0

MIXTURE 150 FOR STATEWIDE USE

Plant Species	Rate (PLS lbs/acre)	Relative %
Big bluestem	5.0	15
Canada wild rye	2.0	9
Indian grass	4.0	10
Little bluestem	3.0	13
Sideoats grama	6.0	26
Slender wheat grass	0.5	2
Sand dropseed	0.5	2
Switch grass	1.0	4
Wildflowers	1.0	4
TOTALS	23.0	100.0

MIXTURE 200 FOR SANDY SITES

Plant Species	Rate (PLS lbs/acre)	Relative %
Big bluestem	6.0	26
Indian grass	2.0	9
Little bluestem	5.0	22
Prairie dropseed	1.0	4
Sand dropseed	0.5	2
Sideoats grama	5.0	22
Slender wheat grass	0.5	2
Switch grass	2.0	9
Wildflowers	1.0	4
TOTALS	23.0	100.0

MIXTURE 250 FOR WET SITES

Plant Species	Rate (PLS lbs/acre)	Relative %
Big bluestem	6.0	27
Canada wild rye	4.0	18
Indian grass	5.0	23
Prairie cord grass	2.0	9
Slender wheat grass	1.0	5
Switch grass	2.0	9
TOTALS	20.0	100.0

MIXTURE 300 FOR SHORT HEIGHT GRASSES

Plant Species	Rate (PLS lbs/acre)	Relative %
Blue grama	3.0	32
Little bluestem	6.0	27
Sand dropseed	0.5	2
Sideoats grama	8.0	36
Slender wheat grass	0.5	2
TOTALS	22.0	100.0

MnDOT's research on native grasses indicates that seed mixtures should be seeded with a seed drill which will accurately meter the types of seed to be planted and keep all seeds uniformly mixed during the drilling. The drill should be equipped with disk furrow openers and packer assembly to compact the soil directly over the drill row. The maximum row spacing should be 8 inches. Final planting depth should be 1/2 to 1 inch. All drill seeding should be done at a right angle to surface drainage.

An alternative method to seeding with a native grass seed drill is to till the site and broadcast the seed. Planting depth should be from 1/4 to 1/2 inch. The site should be dragged with a rake or harrow and packed following seeding. Hydroseeding is not an acceptable method of planting.

A cover crop should be seeded with all native seed mixtures. The type of cover crop depends on the season of planting. MnDOT recommends that oats at a rate of 20 lbs/acre be used for spring plantings, winter wheat at 20 lbs/acre for fall plantings, and annual rye grass at 10 lbs/acre for dormant seedings.

Wildflowers complement native grasses by adding color and diversity and are a component of a natural prairie community. They also extend their roots deeper in the soil and act to further stabilize native grass plantings. Wildflower seed can either be drilled with the grasses or broadcast prior to drilling.

The best time of year to plant native grasses from seed is May 1 to June 15. Dormant seeding (after October 15) is also a good time to seed, but the seeding rates should be increased slightly to account for seed mortality over the winter. Many species of wildflowers require a cold period to break dormancy and are best seeded after October 15. If seeded in the spring they may not be seen until the second year.

Seedling plants can be used to add extra diversity and color to plantings. Many desirable species are difficult to propagate from seed and are only available as seedlings. Seedlings are best planted in the fall, preferably during mid-September. They should be watered when planted.

During the first growing season, if the cover crop or annual weeds reach 18 inches or more in height, the site should be mowed to a height not less than 6 inches with a rotary mower. Prescribed burns can be implemented on a 3 - 5 year rotation starting the third or fourth year after planting. Fall haying is an alternative to burning for those sites where burning is not possible.

Native seed can be purchased from several sources throughout the state. MnDOT has developed specifications for native seed vendors that address purity, germination, and seed treatment. A current list of approved vendors is available from MnDOT. (See Appendix C.)

Native Prairie Preservation Efforts

In northwestern Minnesota, gravel resources are often found on the beach ridges of former Glacial Lake Agassiz in the area now known as the Red River Valley. The original vegetation in the Red River Valley was predominantly short- and long-grass prairie. During settlement times, beach ridges were not plowed because the soils were poor compared to rich soils found in the old lake bottom. Because of the gravelly soils on the beach ridges, remnants of the original native prairie were preserved.

The beach ridges, however, also hold readily available and local sources of gravel. Efforts are underway at the DNR to gain a better understanding of where the gravel resource lies and the extent of native prairie vegetation so that more informed land use decisions can be made. Although this issue is most apparent in the northwest, conflicts between gravel mining and prairie preservation efforts occur throughout the state.

For potential gravel mining sites where original native prairie still exists, a DNR prairie biologist can provide information on programs to identify and preserve the highest quality prairie sites. Such sites may be candidates for enrollment in the native prairie tax credit program.

In other circumstances, it may be possible to conduct native prairie plant salvage activities prior to mining. Harvesting of native prairie seed could also be conducted for subsequent replanting on the site. In these cases, reclaiming the site to native prairie grasses after mining would be a highly appropriate end use. As noted earlier, native species have advantages over conventional cool-season species for reclamation in some circumstances.

Wildlife Habitat

RECLAIMING GRAVEL PITS FOR WILDLIFE

Because mining is a temporary land use, land containing valuable deposits of sand and gravel may experience a series of land uses that are all different from each other. One possible use for gravel pits after mining is wildlife habitat.

While sand and gravel mining may disrupt wildlife habitats during active operations, reclamation offers the chance to create new and sometimes better habitats for some species. Operators have demonstrated that under proper management, mining concurrent with progressive reclamation can be successfully accomplished in sensitive areas while minimizing disturbance to wildlife. Some reclaimed gravel pits provide more productive areas for waterfowl than what the land sustained prior to mining.

The wildlife values of gravel pits were recognized in 1931 when a nationwide census of the rare Great Crested Grebe in Great Britain indicated that a substantial number were using gravel pits. Another species, the Little Ringed Plover, expanded its breeding range in Great Britain in the mid-1900s by using water-filled gravel pits as nesting sites. Bird surveys of all species at gravel pits in Great Britain suggested that these artificial wetlands increased the number of bird species observed throughout the year.

Meanwhile, across the U. S., the amount of land available for fish and wildlife habitat has been steadily shrinking as a result of increasing urban, industrial and agricultural development. At the same time, the number of gravel pits has increased dramatically since the 1960s. Reclaiming gravel pits for wildlife is one way to gain additional and desperately-needed habitat.

This chapter provides information on methods to reclaim gravel pits for wildlife by integrating their needs into final reclamation. General habitat requirements for wildlife are considered with emphasis on species diversity. Also discussed are methods to enhance the wildlife potential of both wet and dry gravel mining areas.

MANAGING WILDLIFE HABITAT

Traditionally, wildlife management has involved the manipulation or shaping of landscapes and vegetation to meet the habitat requirements for a wildlife species or group of species. The key to establishment of quality wildlife habitat is diversity of plant cover. Barren ground will not attract or support an abundance of wildlife. Questions to consider when developing a reclamation plan for wildlife habitat are:

- How can the mining area best be reclaimed to provide diverse and productive habitats?

- What plants can survive on the land to be reclaimed?
- What species of wildlife use these plants for food and cover?
- What planting design would provide habitat for wildlife?
- What are the wildlife preferences of the landowners and the community?

Wildlife species indigenous to surrounding lands will use gravel mining areas to a certain extent even without reclamation. As natural revegetation progresses, a constantly changing variety of wildlife will inhabit the area. Wildlife habitat is frequently viewed as the least costly reclamation to accomplish. In practice it has often meant little actual effort but rather a reliance on natural revegetation or "Mother Nature" for reclamation success. Although this approach is appropriate in some cases, planning for the creation of habitat can benefit wildlife species to a much greater degree.

Reclamation of gravel pits for wildlife should emphasize the development and maintenance of habitats. Ideally, reclamation should favor a diversity of species rather than concentrate on a single species. However, designing the reclamation plan for a few key species, rather than for all species present, simplifies the task of integrating wildlife uses with other land uses. The resulting habitats for key species will also be attractive to other wildlife. When basic habitats for key species have been established, habitat components can be added that will benefit other species.

Knowledge of wildlife species living in the surrounding area and the needs of those species is necessary to develop a reclamation plan before mining begins. With information about existing and potential site features (landforms, water bodies, vegetation types, wildlife populations and distributions), the reclamation plan can be designed to combine surrounding land uses with a post-mining landscape. Such integration will maximize benefits to wildlife and help reduce reclamation costs. The need for long-term management of wildlife habitat after mining ceases should also be addressed in the reclamation plan. Wildlife recommendations on a site-specific basis can be obtained from the local DNR area wildlife manager (see Appendix A).

BASIC NEEDS OF WILDLIFE

Wildlife consists of game and nongame species including birds, mammals, reptiles, amphibians, fish, and insects not generally regarded as pests. All wildlife has four basic needs — food, water, shelter, and space. A reclamation plan should consider these needs to maximize the benefits to wildlife.

A recent publication of the DNR's Nongame Program entitled "Landscaping for Wildlife" outlines principles for enhancing wildlife habitat on residential or agricultural property. These techniques apply to sand and gravel pit reclamation as well. Following are selected excerpts from the text beginning with a discussion on the basic needs of wildlife.

Food

Every species has its own unique food requirements. Food requirements change as an animal grows older and from one season to another. Food includes obvious nutritional parts of an animal's diet as well as supplements like salt. Several types of foods can be provided in a reclamation plan by planting the appropriate species. Examples of wildlife foods are fruits and berries, grain and seeds, nectar sources, nuts and acorn, browse plants (twigs and buds), forage plants (grasses and legumes), and aquatic plants.

Water

The importance of water for wildlife cannot be overstated. Any permanent or intermittent water or wetland created by mining will be a major attractant for wildlife, especially if shallow.

Shelter

Shelter, or cover, is necessary for protection from adverse weather and for hiding from predators or other disturbances. Shelter is particularly critical while animals are nesting and raising their young. It is also necessary for animals to sleep or rest. Wildlife seek shelter in trees, shrubs, grasses, flowers, or in structures like rock piles, brush piles, cutbanks, hollow trees, bird houses, and burrows.

Space

Every wildlife species has unique needs for space or territory. By understanding the territory defended by a pair of house wrens or bluebirds, for example, an estimate on how much wildlife may reasonably be expected to use the mining area can be obtained.

Other considerations

A range of plant species with different heights (ground cover, shrubs, trees) will attract a greater diversity of wildlife to the mining area. Use of plant species that are native to the area will likely have a higher value for indigenous wildlife.

Also consider the winter needs of wildlife. The relative arrangement of food, water, and cover is important to maximize the value to wildlife. A food plot with no nearby winter cover serves little purpose. The direction of prevailing winds and snow drifting characteristics should be taken into account when planning the location of winter food sources and cover.

HABITAT COMPONENTS

"Landscaping for Wildlife" lists 16 plant and structural components necessary to fulfill habitat requirements for wildlife. When developing a reclamation plan for wildlife habitat, integrate as many of these plant components as practical into the plan for maximum benefit to wildlife throughout the year. Plant components include:

- Conifers that provide protective winter shelter, summer nesting cover, and some food.
- Grasses and legumes that provide nesting cover, winter cover, and food.
- Flowering plants that provide nectar for bees, moths, and butterflies, and food for caterpillars.
- Flowering plants that provide nectar for hummingbirds and orioles.
- Plants that provide summer wildlife foods and some shelter value.
- Plants that provide fall foods and some shelter.
- Plants that provide winter wildlife foods and some shelter.
- Hardwood trees and shrubs that provide nuts and acorns.

Structural components are nonliving habitat features that fulfill wildlife needs. Integrating structural components into a reclamation plan designed for wildlife will provide maximum opportunities for a variety of species. Structural components include:

- Nest boxes and nest platforms.
- Retention of selected dead trees, fallen trees, and perches.
- Brush piles and rock piles.
- Retention of selected cutbanks (if safe to do so).
- Salt source.
- Sites for dusting beds and grit.
- Water source.
- Feeders.

An extensive list of species for each plant component is found in an appendix to "Landscaping for Wildlife" in addition to detailed information on design and construction of structural components.

Wetland habitat mitigation banking program

Wetlands are among the most productive environments on earth. Beside providing valuable habitat for fish and wildlife, wetlands also play an important role in maintaining environmental quality through removal of excess nutrients, sediments, and pollutants. Historically, the draining and filling of wetlands for agriculture, urban development, and highway construction have been responsible for the loss of many wetlands in Minnesota.

To ensure that wetland impacts from highway construction were assessed and mitigated, MnDOT in cooperation with other state and federal agencies developed the Wetland Habitat Mitigation Banking program (WHMB). Under WHMB, the unavoidable loss of wetland habitat during highway construction is offset by wetland enhancement, restoration, and creation. Procedures were agreed to by the DNR, U.S. Fish and Wildlife Service, Federal Highway Administration, and MnDOT through a Technical Memorandum in June, 1987. Revisions to the WHMB program are currently being contemplated in light of recent wetlands legislation.

Off-site mitigation under WHMB has included the creation of wetlands in gravel pits. One example is the Lake George Borrow Pit in Hubbard County that was created when borrow material was excavated below the ground water table. The 40-acre borrow pit, adjacent to the highway for which the borrow was needed, now contains eight small wetland basins of various sizes and depths. When the site has completely revegetated, it will support a 12-acre wetland complex. Because the borrow material was needed for highway improvements, the project was done at little extra cost.

Constructed ponds and wetlands

Many ponds and wetlands resulting from sand and gravel mining have rectangular shorelines, steeply sloped sides, and uniform depths. Wetlands with these characteristics have limited value for fish and wildlife. Following are guidelines for the construction of ponds and wetlands that could be incorporated into mining plans and implemented during active mining. Many of these guidelines were developed for use in the WHMB program.

- Shorelines should be irregular with as many bays, inlets, peninsulas, and sand bars as practical. Figure 9 shows two ponds of similar area with different shoreline configurations. The pond illustrated on the left provides greater potential for wildlife due to increased shoreline development.

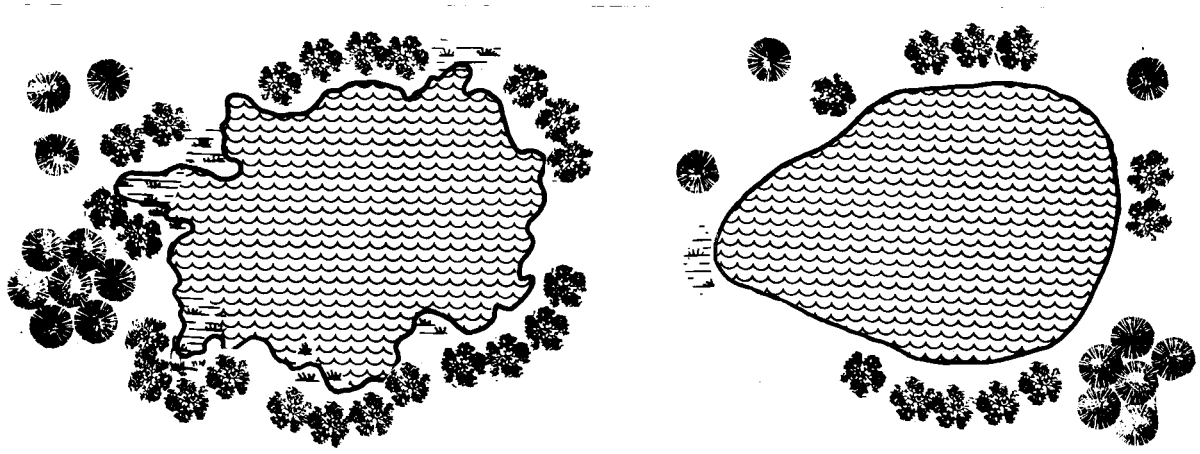


Figure 9 . The pond illustrated on the left provides greater potential for wildlife due to increased shoreline development. (After Szafoni, 1982).

- The bottom of the ponds should be undulating to provide a variety of water depths. Ponds greater than 3 acres in size should be constructed with a pattern of undulations.

- In general, water depth of 1/2 - 3 feet will result in shallow water areas that will promote the growth of emergent vegetation. Depths ranging from 3 - 5 feet will result in open water.

- Whenever possible, 6 - 8 inches of topsoil should be replaced on shorelines, wetland bottoms, and on islands to promote the growth of vegetation and aquatic invertebrates.

- Placement of vegetative debris (from clearing activities) in the wetland may provide habitat for waterfowl and promote habitat for invertebrates.

- In order to supply adequate food, cover and space for wildlife, wetlands should be a minimum of 1/2 acre in size.

- A buffer strip of undisturbed vegetation along shorelines is important for wildlife as well as for reducing erosion. The wider the buffer, the more productive for wildlife especially for nesting waterfowl. It is not necessary for the buffer to go completely around the wetland, but the longer the buffer, the greater the benefit. Use of buffer strips is encouraged in other parts of the mining operation as well.

- To maximize the value of a gravel pit wetland to upland nesting waterfowl, large areas of dense upland cover should be established. Blocks of upland cover are more secure from mammalian predation than cover in strips. Cover blocks should be close to but not necessarily adjacent to the wetland.

- Nest boxes may be placed on trees or posts near the wetland for use by wood ducks.

- Gradual slopes of 10:1 to 20:1 on approximately half of the wetland shoreline are recommended to provide mudflats, emergent vegetation, feeding and hiding cover for wildlife, and to minimize soil erosion and slope slumping. Ponds and wetlands are more productive for wildlife if constructed with flat slopes since wildlife primarily use shallow water.

- Use of water level control structures may be needed to maintain acceptable water levels.

- Where practical, tall tree species on south and west sides of wetlands should be avoided to allow for more solar exposure in the wetland.

Island construction

- Islands provide nesting and loafing sites for wildlife and add value to a wetland.

- Islands, when constructed during active mining operations, begin as peninsulas (see Figure 10) which are graded to provide the appropriate shapes and slopes. Channels are then dredged to separate them from the mainland when final water levels are known. Material from channel excavation can also be used to construct islands.

- To provide both loafing and nesting habitats and to minimize shore erosion from wave action, islands should be 1/2 - 3 acres in size and have rock riprap on those shorelines facing large expanses of water.

- Nesting islands can be any size and shape, however, they should be constructed in deeper water to provide protection from predators.

- Irregularly shaped islands are more advantageous for wildlife than round islands.

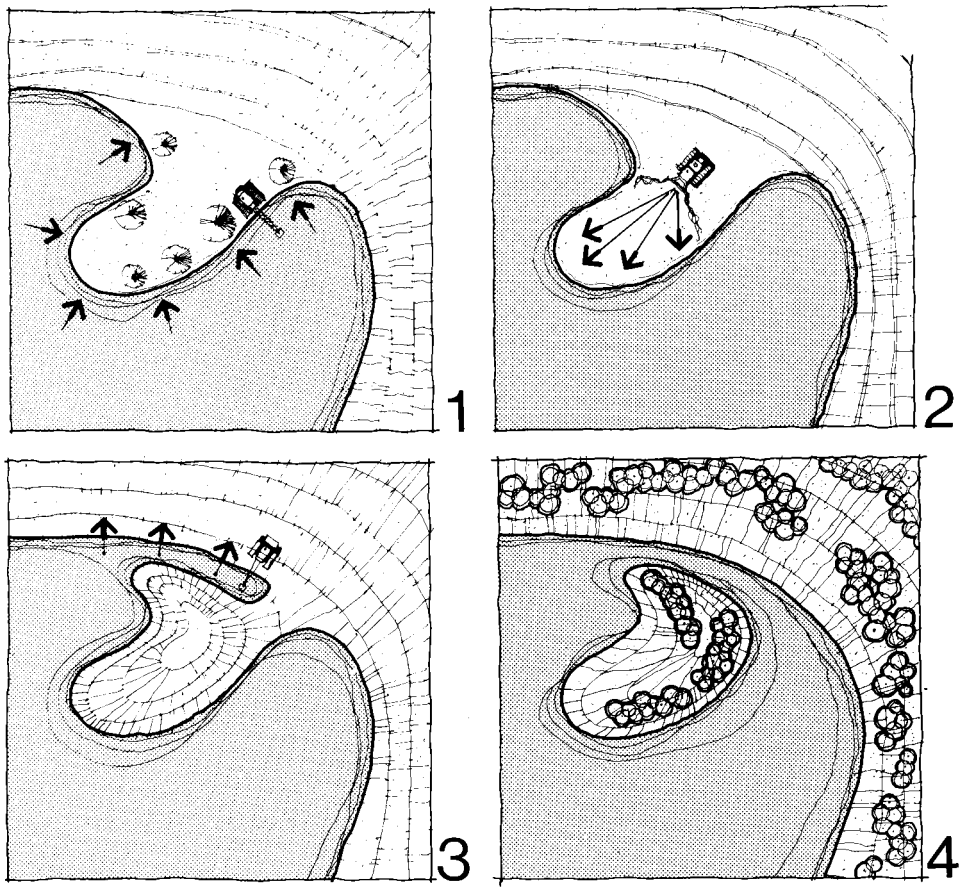


Figure 10. Island construction during active mining. (From Michalski [1987], Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources.)

- Whenever possible, islands should be covered with topsoil to promote growth of vegetation.
- Floating, anchored rafts can provide waterfowl nesting sites in deeper water.
- Rock piles can be used as loafing islands and can serve as riprap for islands in large wetlands subject to erosive wave action.
- Horseshoe-shaped islands are ideal for waterfowl. The mouth of the horseshoe should be in the lee of the prevailing wind to provide shelter for waterfowl broods. The inner banks should be more gently sloped than the outer banks to increase the sheltering effect (see Figure 11).

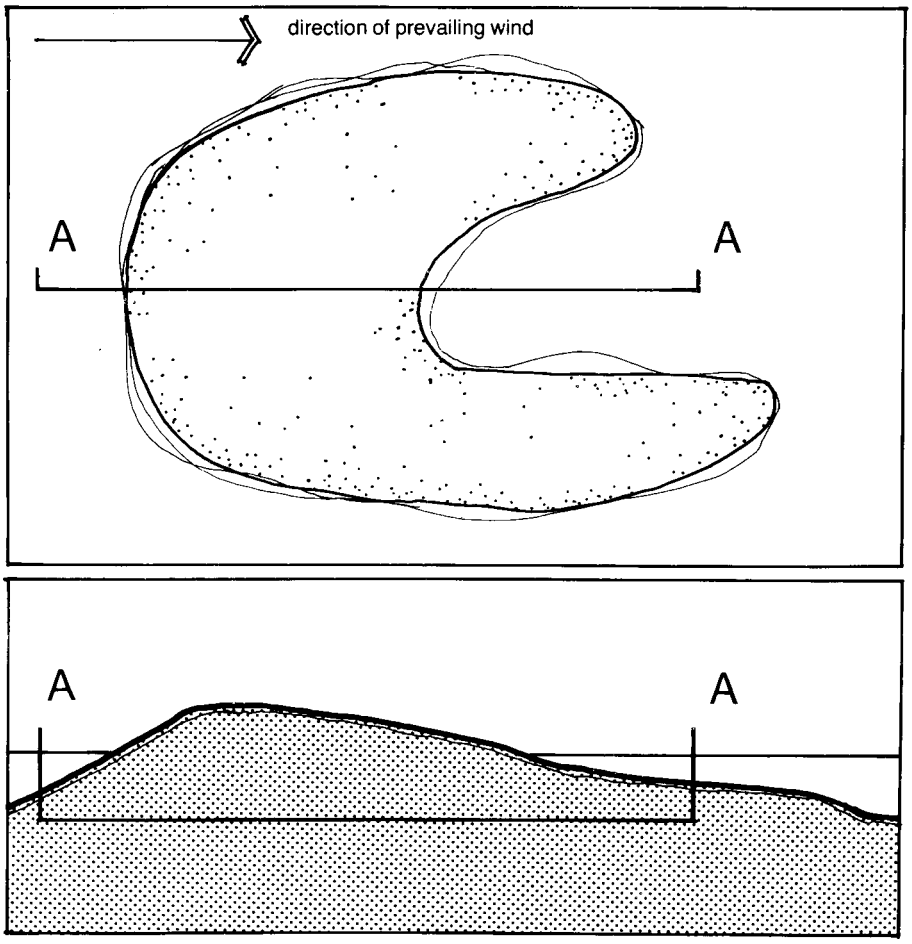


Figure 11. Horseshoe island construction. (From Michalski [1987], Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources.)

Fisheries

Most ponds created by gravel mining will be too shallow to support a viable fish population. If plans are to produce a deep body of water with substantial area, contact the local DNR area fisheries manager for advice on species and habitat improvements. Stocking of fish requires a permit from the DNR. Following are suggestions for improving fish habitat.

- Fish habitat can be quickly improved after mining is completed by adding structures which duplicate the habitat requirements of the desired species. Brush piles and submerged tree crowns provide excellent cover (see Figure 12).

- Materials such as boulders can be disposed of in ponds to provide cover for fish and a substrate for invertebrates.

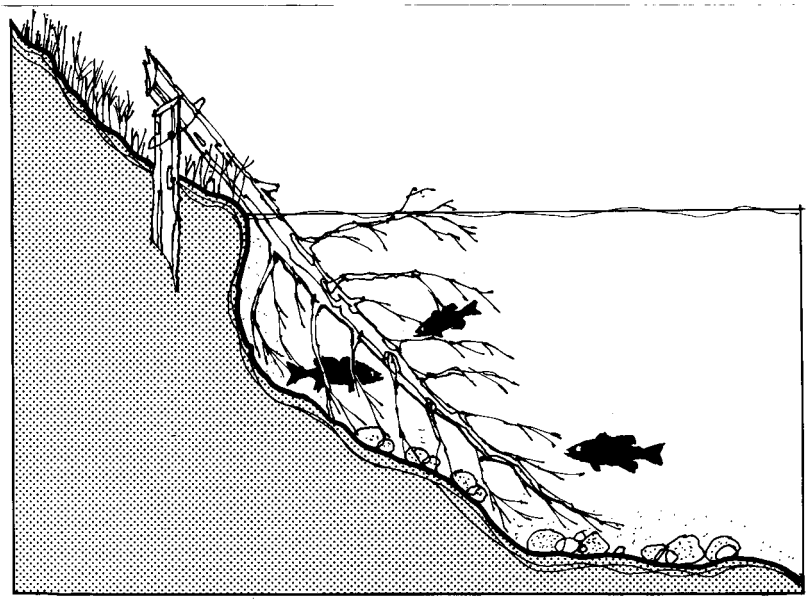


Figure 12. Submerged tree crowns provide cover where banks drop off steeply. (From Michalski [1987], Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources.)

- Panfish generally have the least stringent requirements for spawning. Protected spawning and nursery habitat can be provided by laying tiles, culverts, crib structures, and rock piles on the pit floor (see Figure 13).

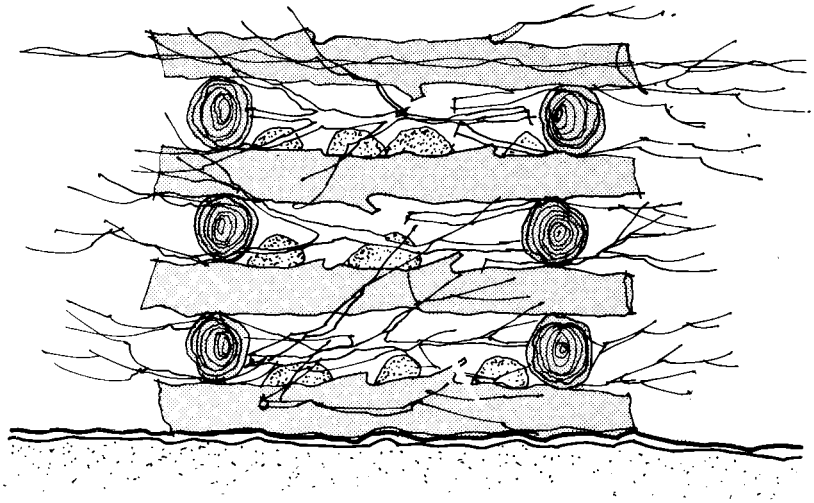


Figure 13. Crib structures can provide feeding and cover for fish. (From Michalski [1987], Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources.)

- Stream spawners usually only reproduce successfully in ponds that have gravel bottoms and inflowing springfed streams or upwellings. Sites without these characteristics are unlikely to support natural reproduction and will require restocking.

- Shade is important for some species. Pools near shore of 5 feet in depth provide protection when overhung by vegetation. Too many deciduous trees planted near shorelines of small ponds that have neither an inlet or outlet can lead to an abundance of decaying leaves. The leaves have a high oxygen demand which can reduce the dissolved oxygen levels in the pond and negatively impact fish populations.

Examples

Below are three shoreline plans designed to enhance wildlife habitat. Figure 14 is a shoreline plan that features a shallow bench with islands that provide food, cover, and nesting areas. The bench area is most easily created through shallow mining along the edge of the gravel pit. Emergent vegetation will grow in the shallow water areas both along the bank and around the islands on the bench.

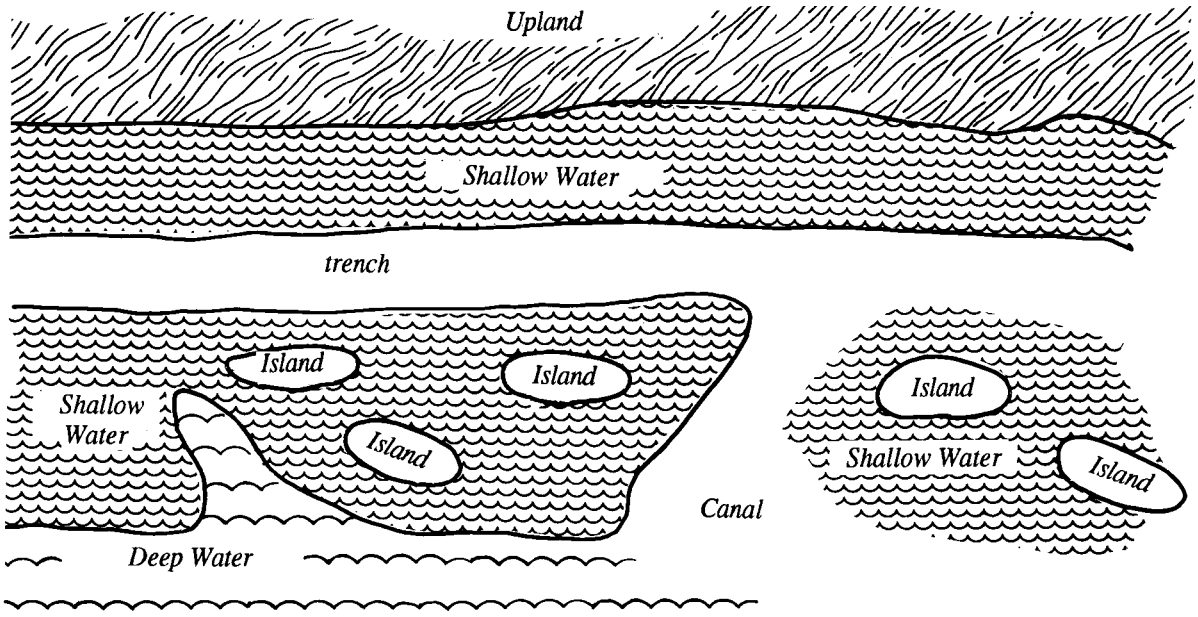


Figure 14. Shallow bench with islands. (After Washington DNR [1989], Gravel mine reclamation guidelines.)

Figure 15 is a shoreline plan that produces habitat for fish and waterfowl. The highly irregular shoreline is easily adapted to irregularly shaped gravel deposits. Such a shoreline can also be created through backfilling with noncommercial material or unwanted fill. For existing pits with regular shorelines, features like bays, shallow areas, and peninsulas can be created by bulldozing portions of the bank into the pit.

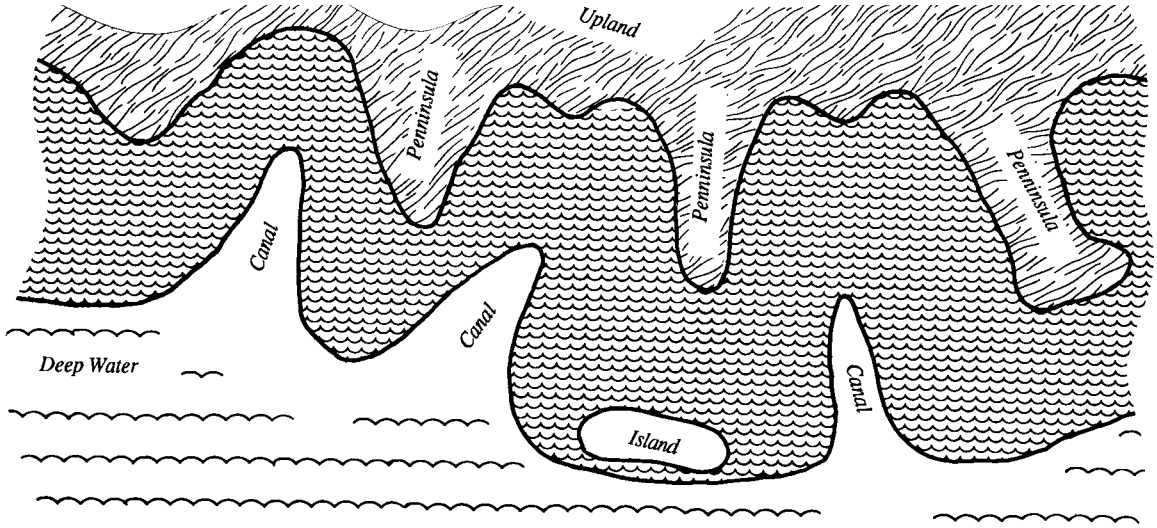


Figure 15. Bays and peninsulas. (After Washington DNR [1989], Gravel mine reclamation guidelines.)

Figure 16 shows a steep shoreline that will minimize the growth of emergent vegetation which may be desired in areas planned for residential development. This shoreline plan is easily adapted to discontinuous gravel deposits. Disposal of unwanted fill material is used to create the islands.

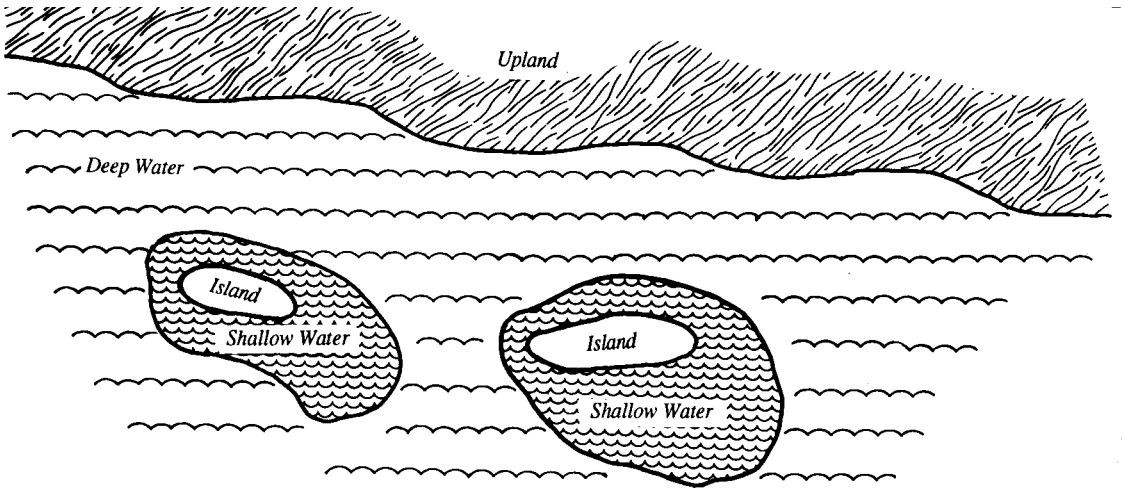


Figure 16. Scattered islands. (After Washington DNR [1989], Gravel mine reclamation guidelines.)

DRY MINING SITES

In forested regions, gravel pits provide permanent openings in the forest. A large number of forest wildlife species make extensive use of these openings. In agricultural areas, gravel pits (both wet and dry) offer unique habitat for wildlife not found elsewhere in the area. Following are general guidelines for enhancing the wildlife potential of dry gravel pits.

- Progressive reclamation should be practiced whenever possible. It provides vegetation in stages of ecological succession which will support a wider range of wildlife.

- Revegetate as soon as possible. A combination of natural revegetation and deliberate planting is the most effective means to establish vegetation for wildlife.

- Initial planting efforts should concentrate on providing control cover in critical areas. In dry sites, a grass/legume mixture is recommended that contains both annual and perennial species (provided there is an adequate amount of topsoil and the soil texture is not too coarse).

- Use of warm-season native grass species is encouraged in dry sites with coarse soils. Certain native grasses are especially adapted to these conditions and have benefits to wildlife.

- Secondary planting efforts should include woody plant species that will create vertical and horizontal diversity.

- Trees are an important component of wildlife habitat, particularly those that produce nuts, acorns, or berries. Coniferous plantings function primarily as windbreaks and should be restricted to small patches.

- To encourage prairie species, tree plantings should be minimized.

- Woody vegetation can be planted in two types of spatial plantings. Strip planting is the development of long, narrow rows of vegetation consisting of a single species. Field borders or windbreaks are examples. Block planting is the establishment of vegetation in patches which create more interior habitat for wildlife. The two types of planting schemes can be used effectively in combination. They are shown in Figure 17.

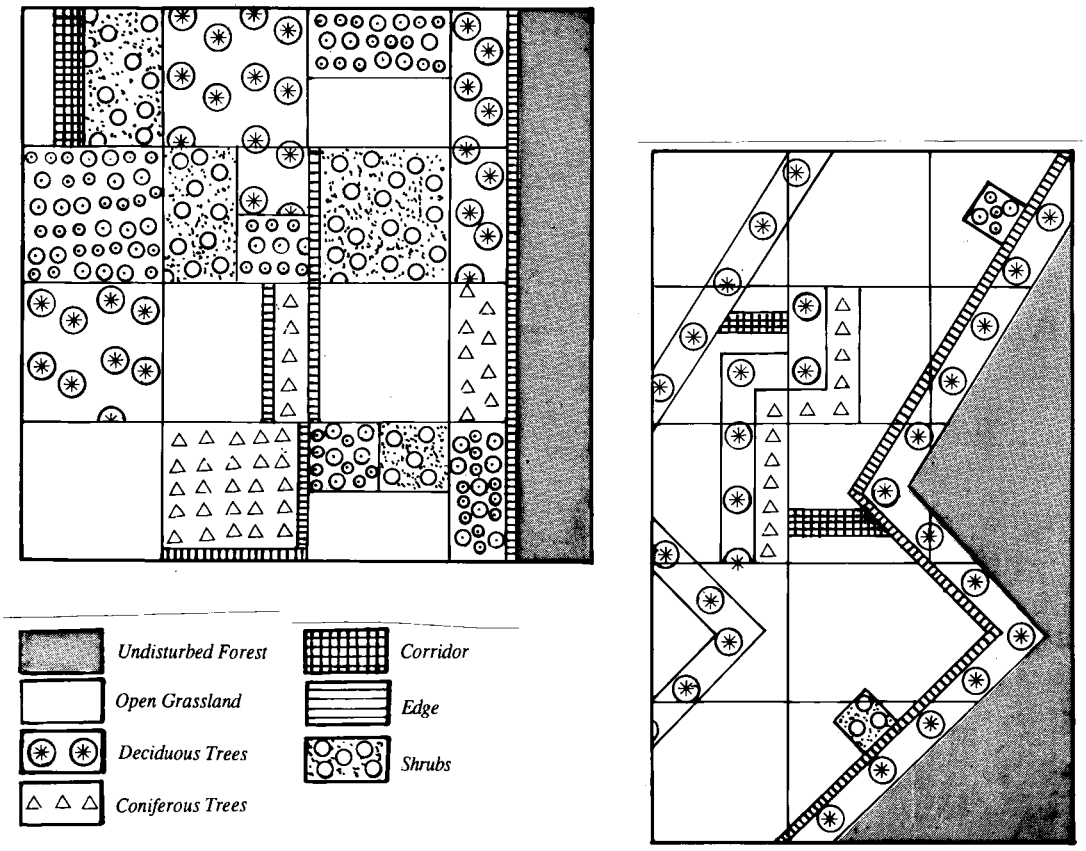


Figure 17. Block and strip plantings. (After Szafoni, [1982])

- Retention of small barren areas scattered throughout the mine site provides habitat diversity. These barren areas should never be large enough to discourage the presence of wildlife.

- Any ponded areas on the pit floor should be retained wherever possible. An irregular topography on the pit floor with some mounds and small depressions increases habitat diversity.

- Cutbanks may be retained where feasible and safe to provide nesting sites for swallows and cliff dwelling birds.

- Randomly distributed logs and stumps provide cover and sunning spots for reptiles and amphibians, denning and nesting sites for furbearers and small mammals.

- Small rock and boulder piles provide food, cover, and hibernacula for reptiles, amphibians, and mammals.

- Brush piles can be constructed in many sizes and shapes depending on the species of interest. Figure 18 shows the construction of a typical brush pile.

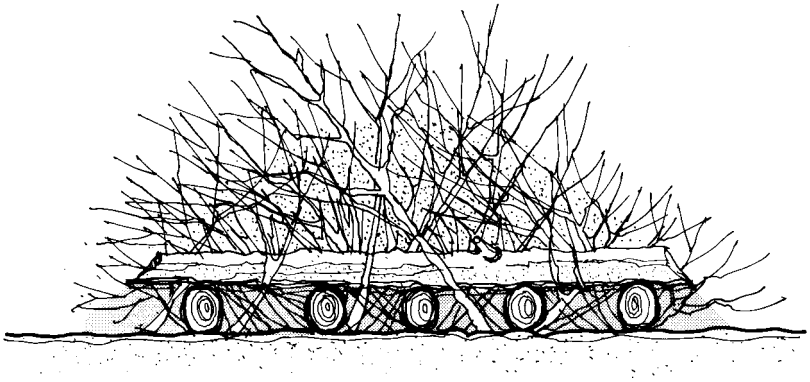


Figure 18. Brush pile construction. (From Michalski [1987], Rehabilitation of Pits and Quarries for Fish and Wildlife, Ontario Ministry of Natural Resources.)

Forest Plantings

Benefits

The dry infertile conditions found in many gravel pits may be more suitable for certain commercial tree species than for agricultural crops. Tree plantations are less costly to establish and maintain than agricultural crops and will provide a landowner with economic benefits including revenue from periodic cuttings and final harvest.

Other benefits from forest cover include protection against soil erosion. Forest cover has long been recognized for its value in watershed protection. Trees have been used successfully to screen mining areas from public view. Forest plantings can usually be designed to provide quality wildlife habitat.

Postmining landscapes, however, may not be suitable for commercial forest production. For instance, slopes may be too steep for standard forestry equipment. Irregular topography or an excess of rocks on the surface may limit access for heavy equipment or inhibit seedling establishment. With appropriate site conditions and under proper management, commercial wood products can be harvested, from former gravel mining areas.

Reforestation of gravel pits

Natural forestation

Any barren land, such as might be found in a gravel pit, constantly receives seed from adjacent vegetation. This begins the process of natural revegetation. New plants appearing on barren land include only those species whose nutrient and moisture requirements are met by the site. Seeds of native and commercial forest tree species typically invade and develop according to a predictable pattern. In the early stages, grasses, legumes, and occasional tree seedlings can be observed. Gradually, scattered woody plants develop and eventually dominate the area. Later, the site grows into an immature forest. After many decades, the resulting forest may be similar to surrounding undisturbed forest land. Successful use of natural forestation for gravel pit reclamation is limited to appropriate sites and best used in combination with artificial forestation efforts.

Direct seeding

Artificial forestation includes the direct seeding of tree seed. This method has been used with modest success in mineland reclamation applications. Research shows that Jack pine and black spruce can be regenerated through direct seeding. For best results, seeds should be treated with bird and rodent repellents and sown during the spring at a rate of two to four ounces per acre. Success depends on favorable site and weather conditions during seed germination and establishment. This method should be limited to those areas with moist soils and frequent rain during the spring and early summer.

Tree seedlings

Planting tree seedlings is the most common method of establishing forest cover. Successful planting programs involve selection of suitable planting sites, tree species, and plant materials combined with adequate site preparation.

Many gravel mining areas contain sites that have potential for growing trees and shrubs. In general, planting of tree seedlings should be avoided on sites with the following characteristics:

- Slopes steeper than 3:1.
- Soil depths less than 18 inches to bedrock or a permanent water table.
- Sites subject to inundation, severe erosion, severe drought, late frosts, and frost heaving.

Sites with these characteristics should be identified and their boundaries mapped. As an alternative to tree planting, these areas could be revegetated and retained as small openings in the forested landscape to enhance wildlife habitat.

For the purposes of commercial forest production, additional economic considerations may apply. The following conditions may limit the feasibility of commercial forest production:

- Areas less than 10 acres in size.
- Large gravel pits that require substantial amounts of fill to meet slope and soil depth conditions.
- Lands identified for future industrial, commercial, or residential uses. (Generally, the closer to an urban area, the more unlikely commercial forest production will be because of land use pressure.)

Suitable tree species

Trees and shrubs have specific requirements in terms of soil, moisture, and sun. Proper selection of forest tree species requires analysis of the environmental factors found in the gravel pit. For site-specific species recommendations, consult the local DNR area forestry manager, the Soil Conservation Service, or the local Soil and Water Conservation District. Later in this chapter, information is presented on common trees and shrubs found in Minnesota together with a description of their characteristics and planting requirements.

Selection of plant materials

Tree and shrub seedlings can be purchased in three forms:1) bare-root stock, 2) containerized seedlings, and 3) cuttings. Bare-root stock is the form most commonly used in reclamation under suitable weather and site conditions. One notable problem can be the difficulty of digging a planting hole in rocky soils.

Containerized seedlings, although more expensive initially than bare-root stock, offer several advantages including shorter cultivation time, extended planting season and easier planting on rocky sites.

Many tree species can be cultivated from cuttings. Cuttings can produce rapidly growing ground cover. Both rooted and unrooted cuttings are available. This technique has not been widely used in the upper Midwest.

Bare-root stock and containerized seedlings can be obtained from DNR tree nurseries, Soil and Water Conservation Districts, and from private growers. See Appendix C for local sources of plant materials.

Site preparation

Gravel mining areas will generally require physical or chemical modification prior to planting to ensure tree survival and growth. Site preparation is the process where unwanted vegetation is removed from an area that is being readied for planting. Specific treatments vary with site conditions and the size of the area. Site preparation can be done mechanically, by burning, or with herbicides. Eliminating competing weeds and brush and opening sites to the sun will help increase tree survival.

Severely compacted sites that threaten plant survival can be treated by ripping, disking, chisel plowing, or harrowing. Planting of mechanically-treated sites may need to be delayed until the soil settles. This will eliminate dry air pockets in the rooting zone. Air pockets can also be partially eliminated with a second light disking or harrowing. Sites with serious erosion potential should first be stabilized with ground cover before planting tree seedlings.

Planting

Plant seedlings in the spring for best results. Planting can begin as soon as the ground is free of frost and can continue as long as the seedlings to be planted have not started new growth.

The time period between taking seedlings from their nursery "beds" and planting them at their permanent site is critical. Anything to shorten this time period will increase the survival of the seedlings. Keep packaged seedlings out of direct sunlight and plant them immediately after they are removed from their packaging. Protect seedlings at the planting site. Exposing roots to hot sunlight and drying winds for three to five minutes can cause seedling mortality.

Plant seedlings within 24 hours of receipt using a method that avoids air pockets around or below the roots. If planting within 24 hours is not possible, place packaged seedlings under refrigeration at a temperature of 40 to 50 degrees Fahrenheit. If planting must be delayed for a week or more, heel in the seedlings by spreading the roots out in a trench so that soil is in contact with all roots. Keep well watered.

Tree spacing

Spacing of trees and shrubs depends on the species and the landowner's objective. Following are recommendations on tree spacing for forest products, Christmas tree production, shelterbelts, and wildlife plantings.

- Forest Products: For conifers, plant 600 to 800 trees per acre spaced 7 - 8 feet apart with rows 9 - 10 feet apart. For hardwoods, plant 400 trees per acre spaced 10 feet apart, between trees and between rows.

- Christmas Tree Production: For pine, plant 1,200 trees per acre spaced 6 feet apart, between trees and between rows. For balsam fir and spruce, plant 1,700 trees per acre spaced 5 feet apart, between trees and between rows.

- Shelterbelts and Wildlife Plantings: For small shrubs, plant 6 feet apart with rows spaced 15 feet apart. For tall shrubs and medium-height trees, plant 8 feet apart with rows 15 - 20 feet apart. For tall deciduous trees, the spacing should be 20 feet between trees and between rows. For tall conifer trees, spacing between trees should also be 20 feet, between trees and between rows.

Cultural treatments

The survival and productivity of forest plantings can often be enhanced through various types of cultural treatments such as application of surface mulches. Mulches conserve soil moisture, lower surface temperatures, and control wind and water erosion. Use of nurse crops may also be helpful. Nurse crops can provide rapid, temporary stabilization against erosion and add organic matter to the soil.

COMMON TREES

Described below are common trees found in Minnesota and used in forest plantings. Included is a brief description of their characteristics and respective planting requirements. The descriptions are excerpts from a 1991 DNR publication entitled "Tree Planting Notebook".

Norway (red) pine

Excellent timber, windbreak, and Christmas tree. Long-lived, it can attain a height of 60 to 80 feet. Although found on a wide variety of sites, the Norway pine grows best in areas exposed to full sunlight and having moist, well-drained soil. It grows rapidly, has few important pests, and is Minnesota's state tree.

White pine

Excellent timber and Christmas tree. Long-lived, it can attain a height of 60 to 80 feet. Although adaptable to most sites, the white pine grows best in areas

exposed to full sunlight and having medium to heavy, moist, well-drained soil. It grows rapidly but is susceptible to white pine blister rust, white pine weevil, and air pollutants.

Jack pine

Good timber tree. Short-lived, it can attain a height of 35 to 80 feet. Jack pine requires full sunlight and does best in dry, sandy soil. It grows rapidly but is not recommended for field windbreaks or planting in southern Minnesota.

Scots (or Scotch) pine

Used primarily for Christmas trees and windbreaks. Moderately long-lived, it can attain a height of 30 to 60 feet. A hardy, adaptable tree, the Scots pine likes full sunlight and dry, well-drained soil. It has a medium growth rate but is not recommended for planting for timber because of poor form at maturity. The Scots pine is not native to North America so some varieties have problems adapting to Minnesota's winter climate.

White spruce

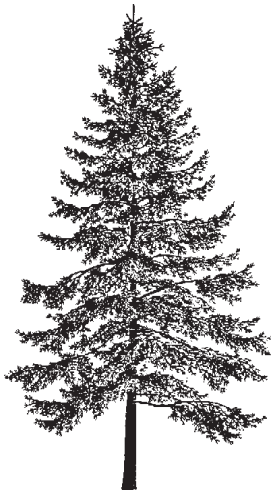
Excellent timber, windbreak, and Christmas tree. Long-lived, it can attain a height of 60 to 80 feet. It grows best on medium to heavy soils and although quite tolerant of partial shade, likes full sunlight. White spruce grows rapidly, especially after the first three to five years.

Black spruce

Used primarily for pulpwood. Moderately long-lived, it can attain a height of 30 to 50 feet. It is found growing naturally in organic soil but also does well on fertile, upland soil. Black spruce can blow over in high winds because it has a shallow root system. It is not recommended for planting in areas south of the Twin Cities.

Colorado spruce

Used primarily in shelterbelts and windbreaks. A large tree, it can attain a height of 80 to 100 feet. It is slow growing, can tolerate shady and alkaline soils, and is able to withstand drought and extremes of temperature. It often loses its lower branches to Cytospora canker.



Norway spruce

Planted widely in windbreaks and shelterbelts and used for pulpwood and sawlogs. A rapidly growing tree, it can attain a height of 60 to 70 feet. Although not native to North America, the Norway spruce has proven itself to be quite adaptable since it grows well on a wide variety of soils and under various climatic conditions. Large trees of this species adorn may old farmsteads.

Balsam fir

Popular Christmas tree and used for pulpwood and sawlogs. Short-lived and medium-sized, it can attain a height of 40 to 60 feet. Although shade tolerant, the balsam fir requires abundant moisture for best development. It is susceptible to spruce budworm and can blow over in high winds because of its shallow root system.

White cedar

Used for timber and wildlife habitat. A long-lived tree, it can attain a height of 40 to 50 feet. Its growth is slow even under favorable conditions and although it is found on a variety of soils, reaches its best development on sites where organic soil is prevalent. White cedar provides cover and forage for wildlife. Heavy deer browsing can be a problem.

Red cedar

Provides cover and food for wildlife. Native to southern Minnesota, it is moderately fast growing and can attain a height of 40 to 50 feet. Red cedar tolerates poor, gravelly sites and is usually found growing in the open. It is very drought resistant.

Green ash

Planted widely in shelterbelts and used for timber and firewood. This long-lived, fast growing Minnesota native is a small to medium-sized tree that can attain a height of 50 feet. Green ash prefers sites having full sunlight and soil that is moist and well-drained.

White ash

Used for timber and firewood. It can attain a height of 50 to 80 feet and grows best on sites that are well-drained and exposed to full sunlight. It is not tolerant of extremes in moisture.

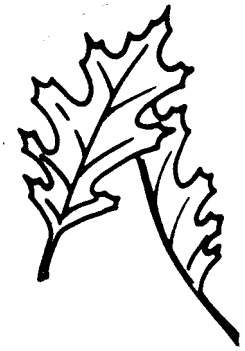
Silver maple

Used in shelterbelts and for timber and firewood. A medium-sized tree, it can attain a height of 60 to 80 feet. Silver maple prefers bottomland sites but will grow almost anywhere where moisture is good. It will tolerate partial shade and temporarily-saturated soils. It is a fast growing tree that soon reaches maturity. The branches are brittle, breaking during high winds or when loaded with snow or ice. This tree is often referred to as one of the “soft” maples.

Black walnut

Used for timber, including veneer, and the fruit (nuts) it bears. One of the most highly valued of North American hardwoods, it is a long-lived tree that can attain a height of 50 to 70 feet. It is fast growing on sites exposed to full sunlight and having little or no competing vegetation and soils that are deep, rich, and moist.

It is very sensitive to soil conditions and grows much more slowly on poorer sites. It does well planted on north and east slopes.



Red oak

Used for timber, firewood, and to create wildlife habitat. It grows relatively fast except on dry soils and can attain a height of 60 to 80 feet. It is quite tolerant and can be found in field windbreaks and in plantations, alone or mixed with other tree species. Red oak can be planted under an existing tree overstory, provided some sunlight reaches the forest floor.

White oak

Used for timber and firewood. Considered one of the most valuable forest trees because of the fine wood it produces, the white oak is long-lived and can attain a height of 60 to 80 feet. It grows slowly, is found in bottomlands and on dry ridges, and is tolerant of most soils except those that are very wet. Its acorns are quite sweet and provide food for many kinds of wildlife.

Hybrid poplar

Used for windbreaks, shelterbelts, and to create wildlife habitat. A short-lived tree propagated from mixed hybrids of poplar and cottonwood, it can attain a height of 40 to 60 feet, it is fast growing and frost hardy.

Siouxland poplar

Used for windbreaks, shelterbelts, and to create wildlife habitat. Fast growing, it can attain a height of 40 to 60 feet. It is a seedless (cottonless) cottonwood and is suitable for planting throughout Minnesota. This poplar likes deep, well-drained soils.

Ginnala (Amur) maple

Used for windbreaks. Often considered a hardy shrub, this small tree is a member of the maple family and left unattended, can attain a height of 20 feet. It grows on a wide variety of soils but does best on those sites exposed to full sunlight. Leaves turn crimson in the fall.

Wild plum

Used for food and cover for wildlife. Considered a fast growing shrub or small tree, it can attain a height of 12 to 20 feet. It is quite hardy, does well in full or partial sunlight, and will tolerate both dry and wet soils. If densely planted, it will form a thicket that is good for wildlife habitat. Its fruit also provides food for wildlife.

TREES AND SHRUBS FOR WILDLIFE

The following shrubs and small trees make up the four-season wildlife food packet available from DNR tree nurseries. These species can survive on a wide variety of soils and will provide summer foods for wildlife and in some cases, fruits will persist into fall and winter. All provide wildlife cover used for nesting, escape from predators, or resting sites.

Caragana

Used for windbreaks, erosion control, and food and cover for wildlife. A hardy shrub, it can reach a height of 15 to 20 feet. It is very adaptable but grows best on open, sunny sites that have well-drained, sandy soils. It will tolerate partial shade.

Crabapple

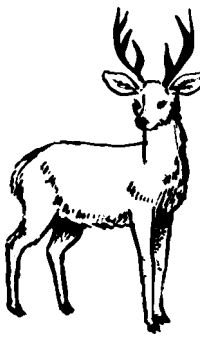
Trees have white to deep pink flowers. Fruit ranges in size and color from small yellow to medium-sized red crabapples. Many species of birds and animals are attracted to crabapples including the cedar waxwing, purple finch, robin, red fox, and cottontail rabbit. Crabapples do best in full sun or partial shade and on well-drained soils.

Wild plum

This small and sometimes shrubby tree frequently suckers, thereby producing thickets that offer good protective cover for wildlife. It has fragrant white blooms and fruit that varies in quality from tree to tree. Many species of birds and animals are attracted to the wild plum including the red and gray fox. Plum trees grow best on well-drained, loamy soils with full or partial sunlight.

Ginnala (Amur) maple

Prefers a slightly acid, sandy loam soil. Maple seeds, as well as buds and flowers, provide food for many kinds of birds and animals. Squirrels and chipmunks eat the seeds, frequently storing them in caches after removing the hull and wing. The brilliant fall color of ginnala maple add to its aesthetic value.



Nanking cherry

A very hardy, medium to large shrub that produces showy white flowers. On occasion, severe cold can damage flower buds above the snow line causing the plants to only flower and fruit close to the ground. The attractive fruit is small, bright red, and tart. Several species of birds and animals are attracted to the Nanking cherry including cedar waxwings, squirrels, and chipmunks. This plant will grow in sandy soil but does best in clay soil with full sun.

Red-osier dogwood

Native to Minnesota, this shrub has been widely planted for its brightly colored red winter stems. Dogwoods prefer fertile moist soil and full or partial sunlight. The fruits are white and ripen in late summer but can persist into the early winter months. Evening grosbeaks, chipmunks, and white-tailed deer are just a few of the birds and animals attracted to dogwood. This shrub will spread through suckering.

Cotoneaster

Attractive to catbirds, mockingbirds, and purple finches. Pink flowers bloom in early spring and black fruit ripen in late summer, early fall. It is susceptible to oystershell scale and fireblight.

Juneberry

Also known as a serviceberry or shadeberry. Juneberries have white flowers and blue-black fruit that matures in July. Songbirds, ruffed grouse, mourning doves, skunks, fox, bear, squirrels, and chipmunks eat the fruit. Cottontail rabbits, beaver, white-tailed deer, and moose browse on the twigs. Juneberries like well-drained soil and full sun.

Chokecherry

Native to Minnesota, this hardy shrub can attain the height of a small tree. It produces white flowers and tart, purplish fruit. Songbirds, ruffed and sharptail grouse, pheasant, raccoon, black bear, red fox, white-tailed deer, cottontail rabbit, and gray squirrel feed on its fruit and twigs. It prefers rich, moist soils and grows in full sun or shade.

Hawthorn

A dense shrub or small tree, the hawthorn has sharp thorns on its stem and branches. It produces showy white to pink flowers and fruit that is small, yellow to red, and apple-like. The fruit often remains on the plant all winter, providing food for pheasant, ruffed and sharptail grouse, gray fox, cottontail rabbit, and white-tailed deer. The hawthorn's dense crown offers excellent nesting sites for many kinds of songbirds. It is not particular as to soil but likes sunny sites.

Appendices

A. Environmental Permits

B. Model Permit Application

C. Sources of Maps, Photos, Soils Information, Native Seed, and Planting Stock

D. Selected References

Appendix A

ENVIRONMENTAL PERMITS FOR SAND AND GRAVEL MINING

Directory of Governmental Agencies.

Listed below are governmental agencies that may have regulatory authority for certain aspects of sand and gravel mining activities. A brief discussion of each governmental agency including addresses, telephone numbers, and websites are provided.

- Minnesota Environmental Quality Board
- Minnesota Department of Natural Resources
- Minnesota Pollution Control Agency
- Board of Water and Soil Resources
- U. S. Army Corps of Engineers
- Minnesota Department of Transportation
- Minnesota Historical Society
- Local government

Environmental Quality Board (EQB)

Environmental review in the form of an EAW (mandatory for operations greater than 40 acres) or an EIS (mandatory for operations greater than 160 acres) may be required for new gravel pits or for expansions of existing pits. For more information, contact:

Environmental Quality Board
3rd floor, Centennial Office Bldg.
658 Cedar Street
St. Paul, MN 55155
(651) 296-9027
website: www.mnplan.state.mn.us/eqb/review.html

Minnesota Department of Natural Resources (DNR)

The DNR-Waters Division has regulatory authority for gravel mining activities that involve pit dewatering or gravel washing. Currently, a water appropriation permit is needed if appropriations will exceed 10,000 gallons/day or 1,000,000 gallons/year. If the mining activity will impact a protected waters, a work in the beds of protected waters permit may be needed from the Waters Division. A burning permit from the Division of Forestry may also be necessary to burn brush from clearing and stripping operations.

The DNR also is responsible for three other programs established by law which might affect certain sand and gravel operations. These laws, the Shoreland Management Act, the Floodplain Management Act, and the Minnesota Wild and Scenic Rivers Act, are “land use” or “zoning” laws. They require the DNR to prepare minimum statewide development standards for shoreland, flood plains, and wild and scenic rivers. These standards must then be adopted by local units of government (city, townships, and county) which will enforce and regulate the standards through local zoning or land use ordinances. Because the law allows local units of government to be more restrictive that the minimum standards established by the DNR, appropriate local units of government must be contacted to determine how regulations might affect a particular sand and gravel operation.

Directory

The shoreland regulations, for example, require that sand and gravel mining must be a permissible land use in a given lake or river shoreland zoning use district. A "Development and Restoration Plan" must be prepared that addresses dust, noise, possible pollutant discharges, and hours of operation. The plan must also identify actions to be taken to mitigate adverse environmental impacts, particularly erosion, and must clearly explain how the site will be reclaimed after mining ends.

In addition to regulatory questions, technical assistance on the following subjects can be obtained by contacting the appropriate DNR division:

- Division of Fisheries: fisheries habitat.

  Division of Wildlife: wildlife habitat, nongame species.

- Division of Forestry: tree plantings.

- Division of Ecological Services: endangered and threatened species, exotic species, prairie restoration.

- Division of Lands and Minerals: mining and reclamation planning.

- Division of Waters: protected waters, wetlands, shorelands.

For more information, contact the DNR central office in St. Paul or regional offices located outstate.

Minnesota Department of Natural Resources
500 Lafayette Road
St. Paul, MN 55155-4001
(651) 296-6157 (Metro Area)
Toll-free (1-888) MINN-DNR (1-888-646-6367) (elsewhere)
Website: www.dnr.state.mn.us

DNR Regional Offices

Region 1
2115 Birchmont Beach Rd. NE
Bemidji, MN 56601
(218) 308-2700

Region 2
1201 E. Highway 2
Grand Rapids, MN 55744
(218) 327-4455

Region 3
1200 Warner Road
St. Paul, MN 55106
(651) 259-5800

Region 4
261 Highway 15 S.
New Ulm, MN 56073-8915
(507) 359-6000

Minnesota Pollution Control Agency (PCA)

Permits that may be required by PCA for sand and gravel mining typically relate to air and water quality. The air quality permits address smokestack discharges from processing plants and fugitive dust from operation areas. Applicable water quality permits might include a State Disposal System (SDS) Permit or a National Pollutant Discharge Elimination System (NPDES) Permit.

Other PCA permits may be required as follows: 1) permit regulating noise; 2) permit for storage and disposal of hazardous materials and wastes such as fuels, oils, lubricants, and certain electrical equipment; 3) solid waste disposal permits; 4) permit for open burning of brush from clearing or stripping operations; and 5) a permit for storage of liquids in above ground tanks.

For more information on these permits, contact the appropriate division at the central PCA office in St. Paul or one of the regional offices.

Minnesota Pollution Control Agency

520 Lafayette Road
St. Paul MN 55155-4194
(651) 296-6300 or 1-800- 657-3864
website: www.pca.state.mn.us

Majors and Remediation Division
-air emissions, water discharge, and hazardous waste

Regional Environmental Managemet Division
-focus on water and solid waste

PCA Regional Offices

Northeast Region
525 Lake Avenue South
Suite 400
Duluth, MN 55802
(218) 723-4660

North Central Region
1800 College Road South
Baxter, MN 56425
(218) 828-2492

Northwest Region
714 Lake Ave., Suite 220
Detroit Lakes, MN 56501
(218) 847-1519

Southwest Region (2 offices)
1420 E. College Drive
Suite 900
Marshall, MN 56258
(507) 537-7146

201-28th Avenue SW
Willmar, MN 56201
(320) 214-3786

Southeast Region (2 offices)
18 Wood Lake Drive SE
Rochester, MN 55904
(507) 285-7343

1230 S. Victory Drive
Mankato, MN 56001
(507) 389-5977

Directory

Minnesota Board of Water & Soil Resources (BWSR)

Sand and gravel mining sometimes impacts wetlands. The Wetlands Conservation Act, enacted in 1991, calls for an interim program which prescribes a moratorium on draining, burning, or filling wetlands as defined and delineated by the "Federal Manual for Identifying and Delineating Jurisdictional Wetlands". Numerous exemptions limit the scope of the moratorium and individuals can drain, burn, or fill a wetland if a local governmental unit certified that the wetland areas will be replaced. Administration of the interim program is directed by BWSR. A permanent program of wetland regulation began in 1993. For more information, contact the BWSR central office in St. Paul or one of the regional or field offices.

Minnesota Board of Water & Soil Resources

One West Water Street, Suite 200
St. Paul, MN 55107
(651) 296-3767
website: www.bwsr.state.mn.us

Field Offices

3217 Bemidji Ave. North
Bemidji, MN 56601
(218) 755-4235

394 South Lake Avenue
Room 403
Duluth, MN 55802
(218) 723-4752

40-16th St SE
Suite A
Rochester, MN 55904
(507) 285-7458

413 West Stanton Ave.
Fergus Falls, MN 56537
(218) 736-5445

1400 E. Lyon Street
Marshall, MN 56258
(507) 537-6060

Regional Offices (2)
217 South 7th St.
Suite 202
Brainerd, MN 56401
(218) 828-2383

261 Highway 15 South
New Ulm, MN 56073
(507) 359-6074

U. S. Army Corps of Engineers

The U. S. Army Corps of Engineers has authority for section 404 permits when fill is to be placed in a wetland. For more information, contact the central office in St. Paul or the appropriate field office.

U. S. Army Corps of Engineers
190 Fifth Street E.
St. Paul, MN 55101
(612) 290-5200

U. S. Army Corps of Engineers
8896 East Gull Lake Drive
Brainerd, MN 56401
(218) 829-2711

U. S. Army Corps of Engineers
Box 120 State Road

U. S. Army Corps of Engineers
Box 120 State Road
Two Harbors, MN 55616
(218) 834-6630

Directory

Minnesota Department of Transportation (MnDOT)

MnDOT has no regulatory authority for sand and gravel operations. However, a majority of sand and gravel pits developed in Minnesota are to supply material for highway construction. In order to keep construction and maintenance costs low, MnDOT has purchased or leased numerous aggregate sources throughout the state. While MnDOT has no specific standard established for how reclamation is to be accomplished for these sites, general guidelines are contained in section 1602 of MnDOT's "Standard Specifications for Construction." On private land, for example, every effort is made to accommodate the desires of the landowner as to pit reclamation after aggregate has been excavated for highway construction.

As noted earlier, MnDOT in cooperation with other state and federal agencies administers the Wetland Habitat Mitigation Banking Program (WHMB). For more information, contact the central office in St. Paul or one of the district outstate offices.

Minnesota Department of Transportation

Transportation Bldg
395 John Ireland Boulevard
St. Paul, MN 55155
(651) 296-3000
website: www.dot.state.mn.us

MnDOT District Offices

District 1
1123 Mesaba Ave.
Duluth, MN 55811
(218) 723-4870

District 2
3920 Highway 2 West
Bemidji, MN 56601
(218) 755-3800

District 3
1991 Industrial Park Road
Baxter, MN 56425
(218) 828-2460

District 4
1000 Highway 10 West
Detroit Lakes, MN 56501
(218) 847-1500

Metro District 5
Waters Edge Bldg.
1500 W. Co. Rd. B-2
Roseville, MN 55113-3174
(651) 582-1000

District 6 (2 offices)
2900-48th St. N.W.
Rochester, MN 55901-5848
(507) 285-7350

1010-21st Ave. N.W.
Owatonna, MN 55060-1005
(507) 455-5800

District 7
501 South Victory Drive
Mankato, MN 56002
(507) 389-6351

District 8
2505 Transportation Rd.
Willmar, MN 56201
(320) 231-5195

Directory

Minnesota Historical Society (MHS)

Sand and gravel mining may impact cultural resources. MHS and the State Archaeologist's Office (SAO) have responsibility for enforcing statutes which require agencies controlling state or state subdivision lands (county, township, municipal) to submit for review by SAO and MHS development plans affecting those lands when archaeological sites are known or suspected to be present. A review of any development project affecting unplatted cemeteries on public or private lands is also required. For more information, contact:

Minnesota Historical Society
345 W. Kellogg Blvd.
St. Paul, MN 55102-1906
(651) 296-6126
website: www.mnhs.org

Local Government

Local units of government (counties, townships, municipalities) have authority for regulating sand and gravel mining through zoning and land use ordinances. Contact the local county zoning office for information on permits that may apply to sand and gravel mining.

Appendix B

MODEL PERMIT APPLICATION

The following model permit application is intended to provide technical direction to counties in their role as the primary regulatory authority for sand and gravel mining. The application is comprehensive and seeks information on all aspects of mining including processing and reclamation. Not all parts of the application will apply to a given proposal. The application can be used in conjunction with existing county ordinances and should be modified to best serve local interests. Use of the permit application in part or in whole by county government is strictly voluntary. Additional questions to be considered by local regulatory authorities are below.

1. Trigger for permit: The regulatory authority should determine what triggers the need for a sand and gravel mining permit. In some counties, all gravel mining operations are required to obtain a permit regardless of size. In other counties, the need for a permit is triggered by a size or production figure threshold. Permit triggers are most appropriately determined by the local regulatory authority.

2. Term of permit: The regulatory authority should determine the term of the permit (one year, multiple years, or life of operation). If the permit will not be renewed annually, additional reporting requirements may be necessary in the permit.

3. Financial assurance: Many counties in Minnesota currently have the authority to require financial assurance for sand and gravel mining. Because of the diversity of operations in the state, the local regulatory authority should evaluate the need for financial assurance and an appropriate amount on a case-by-case basis.

Mining Permit Application

Part One: General Information

1. Name of Applicant _____
   Street Address _____
   City, State, Zip Code _____
   Phone No. _____

2. Name of Landowner _____
   Street Address _____
   City, State, Zip Code _____
   Phone No. _____

3. Describe relationship between applicant and landowner.

4. Attach a copy of the leasing agreement, if applicable.

5. Provide the legal description of the mining site including section, township, and range.

6. Specify total area (in acres) to be affected by this project. Include areas for future expansion, stockpiling, processing, haul roads, settling basins, buildings and parking facilities.

7. Draw a general location map below including roads and other pertinent landmarks.

8. Is environmental review required for this project?
   ☐ yes, attach copy of EAW or EIS ☐ no

9. List other permits necessary for this project, indicate status and provide a copy.

Permit	Status

Part Two: Premining Conditions

10. Describe current land uses within and adjacent to the project area.

11. Is proposed project area within 1,000 feet of a shoreline of a lake or within 300 feet from either bank of a watercourse or the landward extent of a floodplain designated by local ordinance?
   ☐ yes, refer to shoreland regulations ☐ no

12. Indicate the observed or estimated (circle one) groundwater elevation in the project area and reference depth to a permanent bench mark. _____feet

13. Provide a map of premining conditions as they currently exist in the project area at a scale of not less than one (1) inch equals two (200) feet that includes the following:

   a) Shape and extent of the gravel deposit.

   b) Location of boundary stakes delineating the project area referenced to a bench mark.

   c) Ownership within and adjacent to the project area.

   d) Location of all structures within and adjacent to the project area and the purpose for which each structure is used, including buildings, pipelines, cables, railroads, and powerlines.

   e) Contours within the project area at intervals no larger than five (5) feet.

   f) Existing vegetation within and adjacent to the project area.

   g) The location of all streams, lakes, and wetlands located within or adjacent to the project area.

h) Location of previous excavations in the project area.

i) Location of wells in the vicinity of the project area that could be impacted as a result of dewatering.

j) Location of known or inferred cultural resources within the project area.

k) Location of known or inferred threatened or endangered species within and adjacent to the project.

Part Three: Mitigating Impacts

14. List resources that may be impacted by this project, identify impacts, and describe measures that will be taken to mitigate those impacts.

15. Describe measures that will be taken to screen the operation from view of surrounding land uses or an explanation of why such measures are not needed.

16. Describe erosion control practices that will be used during mining. If no measures will be used, explain why none are needed.

Part Four: Description of Mining Activities

Proposed Mining Methods

17. Describe the sand and gravel products that will be mined from the project area.

18. Describe how the sand and gravel will be mined and what equipment will be used.

19. Describe how the material will be transported from the site, the proposed route of transport, and the ultimate destination.

20. Describe the methods that will be used to dispose of brush and other vegetative debris.

21. Describe the methods that will be used to retain topsoil.

22. Estimate the volume of material in cubic yards to be mined in the period covered by this permit.
_____ cubic yards

23. List the months, days, and hours in which mining activities are expected to occur.

    Months:_____

    Days:_____

    Hours:_____

24. Describe the methods used to control dust on haul roads.

25. Identify the number of employees expected to work at the site and the facilities that will be provided.

26. Describe dewatering activities and estimate volumes of water to be discharged from the site.

27. Provide mining plan maps at a scale of no less than one (1) inch equals two hundred (200) feet that include:

    a) Sequential phases of mining (plan view) with haul roads, storage areas, and processing areas identified.

    b) Cross-sectional drawings of any water impoundments, high wall reduction, benching or terracing, and erosion control practices.

Proposed Processing Methods

28. Describe the processing methods that will be used at the site.

29. List the proposed hours of operation for the processing faci

    Months:_____

    Days:_____

    Hours:_____

30. Describe the volume of water needed for gravel washing activities and the source of the water.

31. Describe how chemical substances will be stored on the site.

Mining Permit Application

Part Five: Staging of Operations

32. Describe the projected life of the operation including beginning and ending of operations and any phases or stages.

33. Describe progressive reclamation activities that will occur over the life of the operation.

34. Indicate which stages of the operation will be mined by the applicant and which stages will be mined by subsequent operators.

35. Describe the methods that will be used at the cessation of seasonal operations to stabilize slopes from erosion.

36. Describe the interim reclamation methods that will be used if the site will become inactive at the close of current operations for an unspecified period of time.

Part Six: Proposed Reclamation

37. Describe proposed reclamation including final slopes, high wall reduction, benching, terracing, and other structural slope stabilization measures.

38. Describe anticipated topography, water impoundments, artificial lakes, and future land use of the site.

39. Describe plans for the disposition of surface structures, roads, and related facilities after completion of mining.

40. Describe the methods proposed for the disposal or reclamation of oversize and undersize materials.

40. Describe or attach a copy of a seeding plan that includes methods of seed bed preparation, seed mixtures, seeding rates, mulching, and other techniques needed to accomplish site stabilization.

41. Describe long-term maintenance needed to support reclamation.

42. Provide an estimate of the reclamation cost of each phase of the project or the entire site if phasing is not planned.

To the best of my knowledge, I certify that the information provided on this application and accompanying documents is true and accurate.

Applicant's Signature _____ Date _____

Landowner's Signature _____ Date _____

Appendix C

SOURCES OF MAPS, PHOTOS, SOILS INFORMATION, NATIVE SEED, AND PLANTING STOCK

County Highway Maps

County highway maps show all roads, national and state parks, national and state forests, wildlife management areas and refuges. These maps are 18 by 28 inches with a scale of 1' = 2 miles. Sources:

County Highway Departments

MnDOT
Room B-110, Transportation Building
395 John Ireland Blvd.
St. Paul, MN 55155
(651) 296-2216

USGS Topographical Maps

These maps are available for the entire state. Most of the state is covered by the more detailed 7.5 minute maps, the rest by 15-minute maps. Sources:

Local map dealers

Minnesota Geological Survey
2642 University Avenue
St. Paul, MN 55114-1057
(612) 627-4782

USGS Information Services
Box 25286
Denver, CO 80225
(303) 202-4700
1-888-ASK-USGS

Aerial Photographs

Aerial photos may be useful in preparing a mining plan. These are available for much of the state, with several different scales available. The county name and township, range, and section numbers must be known to place a telephone order. In the agricultural regions of the state, aerial photos are often available from the county ASCS office. Other sources:

U.S. Department of Agriculture
Aerial Photo Field Office
2222 West 2300 S.
Salt Lake City, UT 84119-2020
(801) 975-3503

U.S. Geological Survey
EROS Data Center
Sioux Falls, SD 57198
1-800-252-4547
(605) 594-6151

Aerial Photographs Online
Department of Natural Resources
Forestry Division

website: www.ra.dnr.state.mn.us/airphotos/index.html

Sources

Soils and Geologic Data

Soil surveys are available for many Minnesota counties. Soil survey information is available from the local Soil Conservation Service office or the local Soil and Water Conservation District office. The Minnesota Geological Survey has available a variety of geologic maps and publications that may be of assistance in the preparation of a mining plan.

Soil Testing Laboratories in Minnesota

Information obtained from routine soil testing can be valuable in reclamation. Before submitting samples to laboratories, customers should request information on current testing fees, sample information forms, and instructions on collection and delivery of samples. Inclusion on the list below does not constitute endorsement by the state.

Minnesota Valley Testing Laboratories
326 Center Street
New Ulm, MN 56073
1-800-782-3557

Soil Testing Laboratory
University of Minnesota
Room135 Crops Research Bldg.
1902 Dudley Ave.
St. Paul, MN 55108
(651) 625-3101

Stork Twin City Testing Corporation
662 Cromwell Ave.
St. Paul, MN 55114
(651) 645-3601

Sources

MnDOT Approved Vendors for Native Seed

The Environmental Services Section of MnDOT prepares annually a list of approved native seed vendors. The use of approved vendors by MnDOT was instituted to provide a measure of quality control for native seed used in the establishment of native grasses and wildflowers along roadsides. As noted in an earlier chapter, native grasses appear to have unique application in gravel pit environments. Native seed may be available from sources other than the MnDOT approved vendors. MnDOT approved vendors for 2002 are shown on the MnDOT website: www.dot.state.mn.us/tecsup/tmemo/active/fm02/13env02.pdf

DNR Tree Nurseries

Tree seedlings of many species can be purchased for use in reclamation from one of two state tree nurseries.

Baudora DNR Tree Nursery
Route 2, Box 210
Akeley, MN 56433
(218) 652-2385

General Andrews DNR Tree Nursery
Box 9
Willow River, MN 55795
(218) 372-3182

website: www.dnr.state.mn.us/forestry/nurseries/ordering.html

Minnesota Department of Agriculture

A list of certified nursery growers in Minnesota is available from the Department of Agriculture. Planting stock for use in reclamation projects can be purchased from certified growers. For more information, contact:

Minnesota Department of Agriculture
90 West Plato Blvd.
St. Paul, MN 55107
(651) 297-2200
website: www.mda.state.mn.us/lis

Soil and Water Conservation Districts (SWCD)

SWCDs can provide technical information on tree planting, soils, and erosion control practices. Contact the local SWCD for more information.

website: www.maswcd.org

Appendix D

SELECTED REFERENCES

The references listed below are housed in the DNR-Lands and Minerals Division office at the following address. Also on file is a complete set of Minnesota county ordinances addressing extractive uses.

Department of Natural Resources
Lands and Minerals Division
1525 3rd Ave. E.
Hibbing, MN 55746
(218) 262-6767

The references are organized around the following topics:

- Site Design, Land Use Planning, and Reclamation
- Erosion Control and Water Quality
- Environmental Regulations
- Revegetation
- Wildlife Habitat
- Forestry
- Agriculture
- Other Reading

website: www.state.mn.us/lands_minerals/index.html

Site Design, Land Use Planning, and Reclamation

Alberta Environment. 1991. A users' guide to pit and quarry reclamation in Alberta. RRTAC Report 91-3.

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