GENERIC ENVIRONMENTAL IMPACT STATEMENT SAND DUNE MINING

Geological Survey Division
Lansing, Michigan

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FOREWORD

Executive Order 1974-4 requires each state agency to prepare an EIS on any proposed major action within their jurisdiction that may have significant impact on the environment or human life.

The issuance of sand mining permits is an administrative action which may result in general public concern or controversy. In accordance with Executive Order 1974-4 guidelines, this document has been prepared by the Geological Survey and Environmental Enforcement Divisions of the Department of Natural Resources which has administrative authority over sand mining permits under Act 222, P.A. 1976. Because several applications for permits are being reviewed and additional applications for permits may be filed in the future for designated dune areas, a generic review of dune sand utilization is deemed appropriate.

This document is intended to introduce anticipated impacts of sand dune mining. Discussions of future, site specific environmental impact statements will center on impacts as they differ from those discussed here.

I. INTRODUCTION

The sand dunes along Michigan's Great Lakes shore zone are among the youngest geomorphic features found within the State. Most are related to shoreline positions of higher glacial lakes during the last 13,000 years, although some are associated with the modern lakes. The largest dunes found today were formed approximately 3-4,000 years ago near the end of the Nipissing Lake Stage (in which the water level stood 25 feet higher than the present Lake Michigan), and they have undergone considerable change since then. Because of favorable conditions, they were best developed on the eastern and southern shores of Lake Michigan. The dunes are valued by many for their aesthetically pleasing backdrop to the lakeshore, for the ecological communities which they support and for the recreational potential they provide. In some cases, the dunes act as a buffer between shoreline and terrestrial communities and are unique in that the environmental conditions under which they formed no longer exist. Once destroyed, it is unlikely that they will ever regain their present significant size and extent. Few areas exist in the United States which are comparable to Michigan's dunes. The dune environment is not static, however, even without sand mining. All dune areas are subject to erosion and deposition of sand through the influence of wind, water, vegetative succession and man's intrusions.

Sand mining along Michigan's western shore dates back to the last century and for much of this time has been controversial. Following concerted efforts by numerous individuals, organizations and units of government to initiate wise management of the dune areas, the Sand Dune Protection and Management Act (Act No. 222, P.A. 1976) was passed. This act provides the Michigan Department of Natural Resources (DNR) with the authority to undertake specified steps to ensure the wise management and protection of Michigan's sand dunes within two miles of the ordinary high water mark along all its Great Lakes shorelines. (See Appendix A.)

II. JURISDICTION

A. ACT 222 STUDIES

The immediate goal associated with implementation of Act 222 is procedural review, then permit issuance of those applications found to comply with the management and protection goals of the act, and permit denial of those which do not. All sand mining companies currently engaged in mining of sand dune areas have applied for permit. Permit applications are accompanied by an EIS, Progressive Cell Unit Mining and Reclamation Plan and a 15-year mining plan. Those permits may be issued for up to three years with provision for review and possible change at the end of that period.

Long-term Department goals are to develop, through comprehensive studies and inventories, a broad environmentally sound management plan for sand dune areas. Many of these studies have been initiated and some are complete. Results of mandated studies are used extensively in this document. Act 222, Section 3 requires the following from the Department:

- An economic study of current and projected sand dune mining practices in the State, showing where sand is marketed, its uses and amount of reserves.

- A geologic study of sand areas within Michigan, other than Great Lakes sand dune areas having sufficient reserves and properties suitable for use as foundry core, molding sands, etc.

- Identification of sand dune areas that, for environmental or other reasons, should be protected through purchase or easements, and priority list of sand dune areas to be acquired by the Department.

- Identification of and designation of barrier dunes along the shoreline, showing their effect on aesthetic, environmental, economic, industrial and agricultural interests in Michigan.

- A study of methods for reusing sand for industrial and commercial purposes and alternatives to use of dune sand and its economic impact.

Section 6 requires that no more than three cells may be under permit at any one time. Existing cells may not exceed 30 acres and new or expanded cells may not exceed 10 acres. Section 11 mandates that the Department conduct surveillance, monitoring, administration and enforcement of sand dune mining areas. Studies which have been initiated are listed below:

An Economic Study of Coastal Sand Dune Mining in Michigan

Authorized under the Sand Dune Mining and Protection Act, this study was contracted to Ayres, Lewis, Norris and May, Inc. of Ann Arbor, Michigan, by the U.S. Army Corps of Engineers for the Geological Survey Division, Department of Natural Resources and was completed in September, 1978.

This report provides background information regarding the production and consumption of Michigan coastal dune sand. Current dune sand extraction operations, methods, costs, sales and land holdings are outlined. The sand consuming industries, their uses and sand specifications, as well as future demand are addressed. Recoverable reserves are expected to be depleted between the years 2000 and 2010 while demand continues to increase.

Geologic Study of Sand Deposits in the State of Michigan

This study was undertaken by the Institute of Mineral Research, Michigan Technological University, Houghton, Michigan. The purposes of the study are: (1) to identify non-coastal dune sand deposits in Michigan by location, geologic type, and to a lesser extent, quantity and quality; (2) to assess the suitability of selected individual deposits for each of the major industrial uses of sand; (3) to determine on a limited basis the amenability of selected sands to beneficiation to meet specifications for various industrial uses; and (4) to formulate recommendations for the continuation of the study by the Geological Survey Division of the Michigan Department of Natural Resources of those areas not covered by the project. This study will be completed in the Fall of 1979. Phase I of this study details the chemical and physical properties of sand required by the various user industries.

Dune Type Inventory and Barrier Dune Classification Study of the Lake Michigan Shore

This study, authorized under Act 222 and contracted by Geological Survey Division to the Remote Sensing Project at Michigan State University, was completed in September, 1978. The specific objectives of this study project were:

1. To develop a classification system by which the various coastal dune types of the state, especially those of Lake Michigan, can be defined on the basis of their morphology.

2. To inventory all dune types within designated high priority areas along the Lake Michigan shore.

3. To identify and designate "barrier dunes" within the seven designated high priority areas.

4. To inventory land cover/use within the designated high priority areas (in connection with another DNR-Remote Sensing Project).

The results of the study are a dune morphology classification for the shore zone of Lake Michigan and other Great Lakes. The scheme is based on dune form, relative relief, orientation and the relationship of the dune to the underlying formation. Dune assemblages were identified and mapped according to this classification in priority areas.

Identification of "barrier dunes" cannot be accommodated in the classification scheme because dune types vary along the shore, and therefore, so does the form of the barrier dune. Consequently, designation of the barrier dune assemblage is generally assigned to the dune assemblage with the highest relative relief within the priority areas; this assemblage is typically adjacent to the shoreline, or, if present, adjacent to the ephemeral low relief dunes near the upper beach zone.

This study has been coordinated with two other projects under contract to Michigan State University. The Remote Sensing Project is conducting research aimed at developing procedures to inventory and monitor sand dune mining activities. The cost of an airborne surveillance program is contrasted with the social cost of sand mining violations. Factors affecting the expected number of violations are discussed.

Aesthetic-Social-Impacts of Sand Mining on Barrier Dunes in Michigan

This study, authorized under the Act, was undertaken by the Department of Resource Development, Michigan State University under contract to Geological Survey Division, and was completed in September, 1978.

It represents a first step toward the identification and assessment of the environmental impact of land-based sand extraction. It also suggests a system of impact assessment specifically for sand mining on the beach dunes of Michigan.

An Economic and Environmental Assessment of Offshore Sand Mining

This study authorized by the Sand Dune Mining and Protection Act and provided for by the Coastal Zone Management Act of 1972 was conducted by the Coastal Zone Laboratory, University of Michigan, under contract to the Coastal Programs Unit, Land Resource Programs Division, Michigan DNR. Phase I of this study was completed in October, 1978.

The overall objectives of the Offshore Sand Resources Program (Phase I of the study) are to evaluate the extent, characteristics, economics and environmental setting of the offshore sand resources of the State of Michigan. Offshore sand resources are identified and economic feasibility of extraction and use is outlined. Preliminary determination of environmental impacts of offshore mining is made.

Ecological and Floristic Surveys of the Eastern Shore of Lake Michigan Sand Dunes, Phase I, proposal submitted, November 1978. Completion is expected in 1980.

This study, authorized by Act 222, is under contract to Cranbrook Institute of Science, Bloomfield Hills, Michigan, by Geological Survey Division, DNR.

An ecological and vegetational survey of specific dune types within the initial series of designated sand dunes bordering Lake Michigan's eastern shore is underway. The purpose of this work is to characterize plant habitat types and to correlate this information with the different types of dune morphology. The work by W. R. Buckler on "Dune Type Inventory and Barrier Dune Classification Study of the Lake Michigan Shore" (September, 1978) will serve as a guide for the dune-related phase of the project. Particular attention will be given to the search for unique habitat types for each of the nine dune forms proposed by Buckler.

Copies of completed studies are available through the Geological Survey Division, DNR.

Proposed Studies

Three studies required by Act 222 are not yet underway. However, preliminary staff determinations regarding methods, scope and timing have been made. These will be subject to fluctuations in availability of funds.

Section 3(e) of the statute requires that methods for recycling or reusing sand for industrial and commercial purposes along with alternatives to the use of dune sand and its economic impact be studied. One alternative, offshore mining, and its economic impact has been studied as referenced above.

The Department is presently negotiating with the Corps of Engineers to work out the funding and scope of such a project. It is expected that a contract may be finalized within the 1980 fiscal year.

Two other studies required by Sec. 3(c) and Sec. 3(f) of the statute have not yet been formally initiated. Sec. 3(c) requires that a priority list be made of sand dune areas that, for environmental or other reasons, should be protected through purchase by the state or private interests. Sec. 3(f) requires development of recommendations for the protection and management of sand dune areas for uses other than sand mining. These two studies will likely be implemented together and are expected to be initiated by January 1980. A task force will be set up to develop criteria for designation of such areas as mentioned in the act and recommending areas for purchase.

The source of purchase dollars has not yet been identified. Possible sources are the private sector, Recreation Land Trust funds or other legislative action.

It has keen the Department's thinking that these studies should await the complete designation and mapping of sand dune areas. Series I & II have been mapped and Series III is due for completion by January 1980. (See Figure 1.)

*Figure 1 Designated Sand Dune Areas along Lake Michiga. See **Appendix B**.*

The sand mining companies shall provide with each application for a mining permit, an environmental impact statement to include assessment of:

1. Computability of mining operations with adjacent existing land uses or plans.

2. Impact on flora, fauna or wildlife habitat.

3. Economic impact of mining on surrounding area.

4. Effects on groundwater supply and flow.

5. Effects on adjacent surface resources.

6. Alternatives to proposed site and reasons for choice of site.

These EIS requirements are not identical to the requirements of Executive Order 1974-4 and do not automatically signify a major state action.

A progressive cell unit mining and reclamation plan is required which must include:

1. Method and direction of mining.

2. Surface overburden stripping plans.

3. Depth of grade level over entire site of proposed removal.

4. Provisions for grading, revegetation, stabilization to minimize shore and soil erosion, sedimentation and public safety problems.

5. Location of buildings, equipment, stockpiles, roads and/or other features necessary to mining.

6. Provisions for buffer areas, landscaping and screening.

7. Interim use of reclaimed cell units before cessation of entire mining operation.

8. Maps and other supporting documents required by Department.

A 15-year mining plan shall be filed to include:

1. Location and acreage of area and amount of sand presently being mined.

2. Location and acreage of area planned for mining.

3. Schedule of planned activity and termination dates.

4. Any additional information requested by the Director of the Department.

5. Bonding covering acreage of all active cells, to be released at time of satisfactory reclamation.

B. DESIGNATED DUNE AREAS

Seven Series I dune areas, totaling 104,000 acres, adjacent to the Lake Michigan shoreline, were designated by the State of Michigan, effective in August, 1978. Fourteen more sites totaling 160,000 acres have been mapped and will be proposed for designation in Series II some time in 1980. An additional designation of remaining dune areas is planned for 1980 or 81, under the final segment of the program, as Series III. All current mining occurs within Series I designated dunes.

A designated dune area is identified as a land mass which exhibits the physiographic features of a dune-type ecosystem. Dunes are not stable components of the environment. They are formed through the interaction of wind and water, and are subject to change dependent upon natural factors.

The statute provides the department with the authority to designate dune areas within 2 miles of the Great Lakes shoreline. Physiographic features, by there very character, meander from point-to-point. The designated areas, as proposed, have been identified and described in 40 acre increments which include, in some cases, a transition zone. For this reason, actual sand dune acreage may be less than the acreage described as Series I, II and III.

C. MINING PERMIT REVIEW PROCESS

Procedures for reviewing, granting and denying mining permits are as follows:

1. Procedures For Review

a. The applicant prepares preliminary application documents which include a statute required environmental impact statement, progressive cell-unit mining and reclamation plan, and a 15-year mining plan.

b. The Geological Survey Division receives 8 copies of the preliminary application documents and forwards 7 copies to Environmental Enforcement Division.

c. The Environmental Enforcement Division distributes the preliminary application documents to pertinent Department divisions for evaluation.

d. Individual divisions review the preliminary application documents and forward comments, criticisms, etc. to the Environmental Enforcement Division.

e. The Environmental Enforcement Division in order to provide a coordinated and single DNR position compiles various divisions' comments and returns the preliminary documents to Geological Survey Division.

f. Geological Survey Division and Environmental Enforcement Division review comments and return the preliminary application documents to applicant for revision identifying substantive and procedural deficiencies in the proposed plans.

g. The applicant sends revised documents to the Geological Survey Division.

h. The Geological Survey Division and/or the Environmental Enforcement Division contacts various Department divisions to determine if concerns or deficiencies previously expressed or identified are satisfactorily addressed in applicant's revised documents.

i. If the Department concerns on the proposal as to substantive and procedural matters are adequately met, the application is considered administratively complete and designated formally as Applicant's Draft Sand Dune Mining Proposal. Within 120 days, the application must be issued or denied.

j. The Geological Survey Division, after consultation with the Environmental Enforcement Division, submits initial recommendation to the Director to issue or deny a permit. The recommendation shall include a declaration of this project as a major significant or minor environmental action pursuant to Executive Order 1974-4. The recommendation shall also include justification for mining in a barrier dune formation when this activity is part of the mining proposal.

k. The Director may then authorize denial of a permit or notify the public and the Natural Resources Commission of the Department's intent to issue a permit. Simultaneously, in the case of intent to issue a permit, the Director shall determine whether the proposed activity is major, significant or controversial enough to warrant an Executive Order 1974-4 Environmental Impact Statement. Such a statement will be reviewed by Michigan Environmental Review Board if new intrusions into a barrier dune are anticipated or if sufficient public controversy warrants it.

l. Geological Survey Division, shall do one of the following:

(1) If Director authorizes permit denial, notify the applicant in writing of the reasons for denial and include an opportunity for hearing.

(2) If Director authorizes "Notification to the Public", then a public notice shall be issued. The public notice of intent to issue a permit shall include the name and address of each applicant, the description of the lands included in the project, notice to hold public hearing and solicit public comments. Simultaneously, draft application documents and proposed permit conditions are put on public display for 30 days at key public governmental agency offices and/or in key Department field offices. Requests for individual copies of "draft" application documents shall be honored, but at reproduction costs.

m. The Geological Survey Division compiles a summary of the public hearing record and solicited written comments as well as any recommendations of the Michigan Environmental Review Board. The Geological Survey Division and Environmental Enforcement Division review initial recommendation of intent to issue a permit in light of public comments and submit a final recommendation to Director.

n. The Director, after evaluating recommendations from Geological Survey Division, makes a decision to deny or issue permit. If, as required by Sec. 8(3), the permit allows for removal of all or a portion of the barrier dune, written reasons for such permit is issued to the Natural Resources Commission.

o. Geological Survey Division executes Director's decision. (See Figure 2.)

Figure 2 Permit Review Procedures *See **Appendix B**.*

2. Example Of Special Permit Conditions

a. The permittee shall install and maintain fencing around the perimeter of active cell units within 45 calendar days of the date of issuance of the permit and in a manner restricting pedestrian access onto disturbed slopes within an active cell unit. The fence shall be the chain link type, no less than four (4) feet in height and shall be securely attached to support posts spaced a distance of 15 feet or less apart.

b. When sand dune mining in the cell unit is completed, within 10 days of the completion of mining, the permittee shall implement the revegetation plan and shall prevent vehicular and pedestrian access on reclaimed slopes, that being the distance from the top of the slope to the outer limits of the reclaimed slope until vegetation has stabilized the slopes or for 2 years, whichever is first.

c. The permittee shall not allow public access into the permit area nor allow privately owned, off-road recreational vehicles of any type into the permit area for the duration of the permit.

d. The permittee shall confine all vehicles and equipment fundamental to the sand dune mining operation to the limits of the active cell units. Vegetation in the undisturbed portions of the permit area indicated as buffer shall not be removed, damaged or destroyed in any manner.

e. The permittee may remove vegetation from the permit area only prior to March 1 or after May 25, the period when birds and mammals are less likely to be nesting or bearing young. The Department shall inform the permittee of those time periods of critical concern if other than designated in the permit.

SAND DUNE MINING PERMIT APPLICATION REVIEW PROCEDURE Act NO. 222, P.A. 1976)

NOTICE SENT TO PERSONS WHO HAVE REQUESTED

Applicant is entitled to contest Departments decision in accordance with the provisions of the Administrative Procedures Act (Act No. 306. P.A. 1969. as amended).

f. If, after Department conference with History Division, the site appears likely to have archeological significance, a study will be initiated to determine the historic value of the site. In the event that any materials of possible archeological, historic or cultural values are unearthed during the course of the mining operation, the permittee shall immediately suspend the operation and inform the Department. Operations will not recommence until written approval is obtained from the Department.

g. Prior to the disturbance of land, the permittee shall file with the Department an approved surety bond as provided for in Section 12, Act No. 222, P.A. 1976.

h. At the time the permit is considered for renewal, it is possible that any, or all, of these special conditions be amended or deleted or new conditions added as determined by the Department.

i. The Department, upon written application from the permittee and public hearing, may modify or permit variance from the progressive cell unit mining and reclamation plan or special permit conditions if such modification or variance is not contrary to the public interest and in accordance with Act 306, P.A. 1969.

j. The permittee shall not discharge any wastewater or other polluting materials generated from any activity including but not limited to storage areas, process operations, waste treatment and disposal practices to the waters of the State unless he is in possession of a permit as required by P.L. 92-500 and Act 245, P.A. 1929.

k. The permittee shall store, handle transport and dispose of any solid waste generated from any activity including, but not limited to, storage areas, process operations, waste treatment and disposal practices in accordance with the provisions of Act 641, P.A. 1978 and rules.

l. All operations at the facility shall be consistent with the terms and conditions of the permit. Any changes in production capacity, process modifications or facility expansion which result in new or increased operations must be authorized by a new permit or by modifications of the permit.

After notice and opportunity for a hearing, the permit may be modified, suspended or revoked in whole or in part, for cause including, but not limited to: a) violation of any terms or conditions of this permit, obtaining a permit by misrepresentation, or failure to disclose fully all relevant facts; or, b) a change in conditions or the existence of a condition which requires either a temporary or permanent change in process operations.

In accordance with Act 222, a permit shall be denied if it will cause irreparable, harmful effect on the environment. Because the same geological conditions which created the dunes do not exist today, we may reasonably consider removal of those dunes irreparable. It is at least irreparable in the sense that they would not be naturally reproduced within several human lifetimes unless drastic climatic changes were to occur.

The term “harmful” is a far less objective one. All harmful effects must be considered in terms of human health and well being. Health effects are reasonably assessable, at least over the short term. The objective then, is to define “harmful effect on the environment” in terms of human well-being. For a number of people, quality of life is affected by the presence of dunes along the western shore of Lake Michigan.

In consideration of permitting or denying mining of a site, the Department assesses the overall harmful effect the proposed action will have on the environment. An important factor in this consideration is how important the site is in Michigan and in the area. Does it have unusual topographic features or vegetative communities? Does it serve as a weather buffer for inland areas? The history of land use in the area is also important. Some areas have a history of local and state recognition which have emphasized uses other than mining. Local zoning often displays a community’s commitment to some areas for non industrial purposes.

These factors along with the applicant’s plans for mining as indicated in the EIS and cell unit plan ultimately determine whether mining will be permitted or denied. In some cases, an applicant will revise the application to exclude a mining practice or area initially considered for mining which is determined likely to produce harmful effects. If, after review, an application is deemed likely to produce irreparable, harmful effects, a permit will be denied.

D. SURVEILLANCE & ENFORCEMENT

The Sand Dune Protection and Management Act provides civil and criminal penalties for violation of the act, its rules or a permit issued under the act (Sec. 14).

The act also specifically mandates the Department to deny a permit if, based on review of an environmental impact statement, the Department determines that the sand mining operation will have an irreparable harmful effect on the environment (Sec. 9).

The act allows the Department to charge a fee of up to 1 cent per ton per year for sand mined to cover the actual costs of surveillance, monitoring, administration and enforcement (Sec. 11).

A license or permit applicant must also furnish a surety bond in favor of the state (~lO,O0O per cell unit or ~l,0OO per acre whichever is greater). Liability under the bond lasts until the mining site is reclaimed as set forth in a reclamation plan approved by the Department.

In summary, the act provides for bonding, licensing, environmental review, funding in the form of surveillance, fees for monitoring, and enforcement of criminal (~5,OO0) and civil sanctions against those persons violating the act.

1. Surveillance

Each site is aerial photographed twice a year in the spring and fall. The imagery (Scale 1:20,000+) is analyzed by the remote sensing lab at Michigan State University. Any changes in disturbance are recorded. Accurate analysis to about one acre is provided with this method. See "Proposed Monitoring Procedures for Sand Dune Mining Operations in Michigan", by Ger Schultink.

Each area under permit may be inspected on site as often as once every two weeks. If warranted, the entire site is inspected. A report of each inspection is kept on file in Geological Survey Division files with a copy sent to the operator.

2. Enforcement

If, on field inspection, it is determined that a violation has occurred, evidence is collected. The Geological Survey field inspector discusses the violation with the program administrator. After concurrence from the administrator, a decision may be made to refer the violation to the Environmental Enforcement Division for formal enforcement action. If the violation is of a nature that does not cause damage to the environment, the company will be given an opportunity to comply. Failure to comply will result in formal enforcement action. Environmental Enforcement Division confers with the program administrator to determine the extent of enforcement action necessary and type of relief required. With advice of the Attorney General, the Environmental Enforcement Division determines whether civil and/or criminal action is indicated. If criminal action is the only action, a formal complaint and request for assistance is forwarded to the District Law Supervisor from the Environmental Enforcement Division. The district law supervisor investigates and issues a summons. If civil action is involved, depending on the severity of the violation, mining may be halted through a restraining order.

E. OTHER STATUTES AND PROGRAM CONSISTENCY

The Michigan DNR, under authority of Act 17, P.A. 1921, is responsible for protecting and conserving the natural resources of the State: That responsibility includes not only those natural resources associated with state owned lands and waters, but those associated with private lands and waters as well. State and federal statutes mandate more specifically how public values and those resources are protected and conserved through both incentive and regulatory programs. In addition to the permit program administered under Act 222, P.A. 1978, sand mining activities (which must be separated from potential redevelopment activities) may involve the following programs and permits administered by divisions of the Department of Natural Resources.

I. If the mining operation involves the discharge of contaminated wastewater to the surface waters of the State, a National Pollution Discharge Elimination System (NPDES) permit is required. Although these permits are issued under the authority of the Federal Water Pollution Control Act (P.L. 92-500), the Michigan DNR has been delegated the authority to administer the permit program from the U.S. Environmental Protection Agency. In many operations where processing is done on site, a floculant or surfactant is used. If process waters containing this agent are discharged to surface waters, an NPDES permit is required.

2. If the mining operation involves the discharge of contaminated wastewater to the ground, a state groundwater discharge permit is required. These permits are issued under the authority of the Water Resources Commission Act (P.A. 245, 1929 as amended). In cases where a discharge may contaminate a water supply or surface waters, mitigation (such as a liner) may be required.

3. If the mining operation involves alteration or occupation of lands in a floodplain, streambed or channel of a stream, a permit is required in order to insure that structures are not placed in channels and floodways and that the capacity of the flooding is not unduly restricted. These permits are issued under the authority of the Flood Plain Control Act (P.A. 167, 1968).

4. If the mining operation involves construction, dredging, filling or alteration of flow in an inland lake or stream, a permit is required. Construction or enlargement of an artificial channel or pond which will be connected to an existing waterway or which is within 500 feet of the ordinary high water mark of an existing body of water is also subject to state regulation. Construction of minor drainage structures and waste collection and treatment facilities are not subject to permit. The inland lakes and streams permitting program is administered under the authority of the Inland Lakes and Streams Act (P.A. 346, 1972). This permit is reviewed and issued jointly with the U.S. Army Corps of Engineers.

5. If the mining operation involves dredging, filling, modification, enlargement or extension of Great Lakes waters, or operations below the ordinary high water of the Great Lakes, a permit is required. The program is administered on the State level under the authority of the Great Lakes Submerged Lands Act (P.A. 247, 1955 as amended).

6. Any operation involving an earth change of one acre or more requires State approval. This permit program is administered by local enforcing agencies under the authority of the Soil Erosion

and Sedimentation Control Act (P.A. 347, 1972 as amended). If it occurs in two or more counties the Department of Natural Resources Administers the Act. The act specifically exempts industries generally referred to as mining. However, the extraction of sand is not considered “mining” as defined in the Mining Reclamation Act (P.A. 92, 1970 as amended).

7. If the mining operation involves the installation or operation of an air contaminant source or the installation of air pollution control equipment, a permit is required. This permit program is administered under the authority of the Air Pollution Act (P.A. 348, 1965 as amended). Mining operations with processing plants on site normally require air quality permits.

8. Prior to the initiation of mining activities, the operator should insure that the activity will not adversely impact the habitat of threatened or endangered species. Although a survey is not required by the Endangered Species Act (P.A. 203, 1974), all activities within the State must be consistent with the mandates contained in the act.

9. If the mining operation is located in designated sensitive environments, certain use restrictions may apply. The Shorelands Protection and Management Act (P.A. 245, 1970) administered by Land Resource Programs Division, was enacted to regulate environmentally sensitive areas of the Great Lakes shoreline by implementing use restrictions to prevent further alteration of existing conditions to maintain fish and wildlife. The implementation of these use restrictions is through local zoning ordinances or by permit from Land Resource Programs if no zoning is adopted.

10. If the mining operation is located in a designated shoreland or natural river area, certain use restrictions may apply. The Natural Rivers Act (P.A. 231, 1970) was enacted to protect the natural quality of rivers of statewide significance and to regulate their use and development. The administration of Act 231 is through Land Resource Programs Division. The implementation of use restrictions is through local zoning ordinances, or through the Department of Natural Resources in the absence of local zoning.

11. In addition to these permits and approvals, all mining projects proposed in Michigan’s coastal area must be consistent with the State’s planning and protection objectives as developed by the Coastal Zone Management Program. This program was developed under the authority of the Federal Coastal Management Act (P.L. 92-583) and is administered in Michigan by the Coastal Zone Management Unit of the Land Resource Programs Division.

One of the mechanisms in the Coastal Management Act for identifying and addressing coastal areas which need management attention is through the use of the area of particular concern (APC) process. APC’s are those special lands and waters which experience problems or offer opportunities that merit special attention in the actions and concerns of citizens and local state and federal governments.

Areas of Particular Concern are identified either as (a) state legislated areas of particular concern or (b) nominated areas of particular concern. A guide to identifying APC’s is included in Appendix B.

(a) Legislative APC’s. Certain state statutes specifically mandate that coastal areas receive special management attention. The following areas mandated by state statute are recognized as legislative APC’s: designated Great Lakes high risk erosion areas, flood risk and environmental areas; public access and mooring facilities; historic districts; designated wilderness areas, wild areas and natural areas; natural rivers areas; and sand dune areas.

(b) Nominated APC’s. APC’s may be nominated by any individual, group or agency, and are grouped within five resource areas.

All applications for federal permits, federal grant or loan activities, and direct federal action in the coastal zone must be consistent with the management objectives of the approved Coastal Management Program. Other activities that have no federal involvement, but require a state permit are also reviewed by the Coastal Management Unit. If there are any inconsistencies found, recommendations are made to the agency for which the permit has been applied. Sand mining permit applications are one of the activities that usually does not involve a federal permit, but is reviewed by the Coastal Management Unit.

New development in an APC is not necessarily prohibited, but the new development should be consistent with the planning and management objectives for the area. Some sand dune mining area have been identified as APC’s and these mining activities have been incorporated into the long term planning objectives.

12. The Michigan Environmental Protection Act (P.A. 127, 1970)

In those instances where existing administrative or regulatory procedures do not provide adequate mechanisms for the protection of the State’s natural resources, any individual or legal entity may seek temporary or permanent judicial relief in order to protect those resources from pollution, impairment or destruction. The individual seeking the relief must prove that the action of concern has, or is likely to pollute, impair or destroy the natural resources. It then becomes the defendant’s responsibility to show that no feasible, prudent alternative exists to accomplish the action.

III. MINING INDUSTRY

A. LOCATION

There are six areas where industrial sand is mined in the State of Michigan. The most important are: (1) inland dunes, (2) coastal dunes, and, (3) coastal sand strips. Some sand mining also occurs in (4) outwash plains, (5) Great Lake bottomlands and, (6) sandstone deposits.

Inland dunes are sometimes located up to 30 miles or more from the existing Great Lakes shoreline. These are older sand dunes that were formed by wind action during higher lake stages. Inland dunes usually exist in the form of ridges, small hills, and knolls found on ancestral lake beds and outwash plains. Inland dune sand usually has a slightly higher silt and clay content, smaller, more angular grains, and a slightly differing chemical composition than coastal dune sand. In addition, being much older and not subject to as much wind and wave action as the coastal variety, these sand features are usually well stabilized with protective vegetation.

Coastal dunes are found predominantly along the Eastern shoreline of Lake Michigan from the Indiana border to the Straits of Mackinac. Additional dune formations are found along the Great Lakes shoreline in eastern St. Clair, Alger, Luce and Houghton counties. Coastal dune sand is generally free of silt and clay, has a common range of grain sizes, and is generally more rounded than other types of sand deposits. Coastal dunes frequently reach a height of over 100 feet above the surrounding terrain and form prominent knolls, peaks, mounds, and ridges. When not stabilized by vegetation, they are extremely unstable and migrate in the direction of the prevailing winds.

Coastal sand strips can be found along all of Michigan's Great Lakes shoreline. They frequently occur with very low, wind formed ridges near existing shorelines. In some places, however, this shore type may extend inland and is the most recently formed type of dune formation. Coastal sand strips are generally free of clay and silt and physically resemble sands found in dune type formations. However, the sand usually has a significantly higher proportion of carbonates.

B. INDUSTRY

The Bureau of Mines reports that Michigan is the leading producer of industrial sand, followed by Illinois, New Jersey, and California. Reasons for Michigan's high production output of industrial sand are: 1) the availability of abundant sand reserves of very high quality; 2) accessibility to transportation networks; and 3) the ability to maintain a fair market price.

The value per ton of sand mined in Michigan has increased continually over the past 20 years, from $l.3O in 1958 to about $7.00 per ton in 1979. The quantity of all sand mined in Michigan increased nearly five-fold, from about 1.8 million tons in 1958 to nearly 5.4 million tons in 1976, with an estimated total value of about $20 million. The U.S. total production for 1976 was approximately 30 million tons valued at $169 million.

The total acreage of sand dune areas (Series I, II and III) within two miles of Lake Michigan in Michigan is 269,760 acres. Of these, less than 2% are owned by mining companies, over 30% is in public ownership and the remainder in other private ownership. The. sand mining industry has filed 15 applications for current and proposed mining totaling approximately 2000 acres or 2% of the Series I dune areas. (See Table I and Figure 3.) An extensive amount of mining has occupied in the past on small parcels of land, but most are now inactive. Applications for permits to mine are anticipated for some of these, but not for those which have previously been mined out.

Table 1. Mining Operations under Jurisdiction of Act 222. See Appendix A.

C. SAND TYPES AND USES

Dune sand is utilized for a variety of commercial purposes. The major consumer of this resource is the foundry or metal casting industry for cores and molds. Other uses include glass, fiberglass, and metallurgical industry, traction and blasting sand, and filter sand. Although consumption by the glass industry is not as great as use by the foundry industry, strict specifications demanding a high-silica, low-impurity sand make dune sand ideally suited for the industry. The foundry industry has been heavily dependent upon the availability of dune sand to serve its purposes either in fabricating molds or cores. Approximately 90% of the casting of automobile engine blocks utilize dune sand. See Figure 4. Other uses include the manufacture of the major components of water and sewer systems which include bathtubs, sinks, and plumbing fittings. Also included is agricultural machinery and construction machinery. Locomotives and railroad cars also are fabricated through the use of dune sand.

*Figure 3. Location, Operators' Names and Number of Sites of Sand Dune Mining in Michigan. See **Appendix B.***

One of the prime indicators of superior sand quality is fineness of grain size. Grain fineness is a measure of the amount of sand passing through screens with specified mesh openings. Inland dune sands are generally finer than coastal dune sands. Grain size and shape effect both the escape of hot gases from the molten metal when poured into the mold and the surface texture of the casting. The finer the sand used, the smoother the finish. Generally speaking, the finer grained sands are used on smaller size castings. Extraneous materials, such as clay or broken grains, will plug the pore spaces of the mold causing blistering, pock marks, and possible weakening of the casting. The sand grains themselves must be durable if the sand is to be reclaimed and recycled. Sand may be recycled up to 25 times, depending upon the type of casting and techniques employed. Because the major use of dune sand is for foundry use, specifications for that industry are identified below.

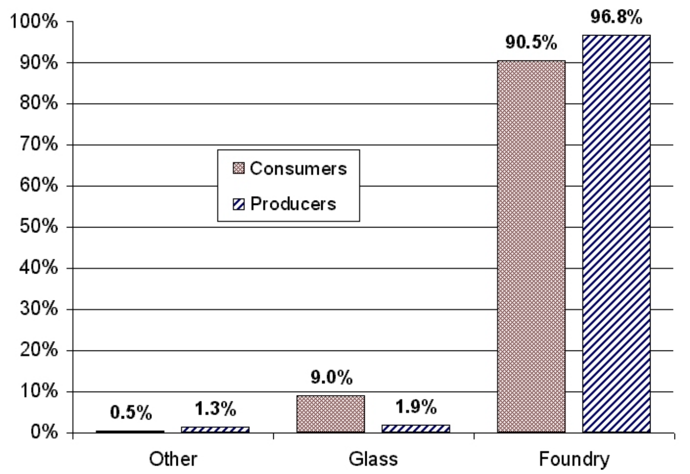


Figure 4 Dune Sand Utilization in Michigan.

Sand and clay in various forms are the most common raw materials used in the foundry industry. In fact, the use of sand molds of one type or another accounts for at least 96 percent of all castings made. Michigan supplies about 90 percent of the foundry sand used in the automotive industry and 40 percent of all the foundry sand used for all purposes in the United States.

In the United States the foundry industry utilizes two general types of sands, classified as: 1) lake and bank sands and 2) silica sands. The lake and bank sands contain 92 to 94 percent 5i02 whereas silica sand has in excess of 98.5 percent 5i02, usually washed to upgrade it to 99.5 percent or more 5i02. Included in the lake and bank sands are some river sands that are used chiefly for construction purposes.

Three general categories of silica sand molds are in use:

1. Naturally bonded sand. This is a silica sand containing sufficient clay, as mined, to be formed satisfactorily into molds after milling and tempering with water. The clay content ranges from 10 to 15 percent in finer grained sands to 20 to 25 percent in coarser grained ones. Generally these naturally bonded sands are relatively low in silica, containing relatively high amounts of Fe_2O_3, $A1_20_3$, CaO and alkalies, in the form of feldspar and other accessory species. Such sands have fusion points as low as 2400^0F. This characteristic renders them unusable in the casting of steel, which is cast at up to 3027^0 F. However, they are suitable for most types of iron and non-ferrous applications. The use of naturally bonded sand has been decreasing.

2. “Synthetic green sand”. This is a high-silica sand to which a clay such as bentonite is mixed.

3. Chemically bonded sand. These are sands that are bonded in several ways: a) by sodium silicate hardened by passing CO2 gas through the mold; b) by sodium silicate with organic esters used as a hardening agent; and c) by several different types of resin binders and their catalyst systems.

Naturally bonded sand is usually recycled. Chemically bonded sands formerly were used only once; but today much of the resin-bonded sand is reclaimed. Reclamation of sodium-silicate sands is more expensive. In general the use of both “synthetic green sand” and chemically bonded sands in place of naturally clay-bonded sands leads to a very large increase in the quantities of high-silica sand used by the foundry industry. In turn, increasing costs of transporting waste, difficulties in finding suitable waste-dumping sites, increasing cost of high-silica sand and environmental control regulations governing the discard of phenol-impregnated sands all have led to an increase in sand reclamation and recycling.

The foundry industry produces three types of castings:

I. Gray iron foundries. The gray iron castings’ largest market is the automotive industry in Ohio, Northern Kentucky, Indiana, Illinois and Michigan. These castings are poured at temperatures ranging from 24000 to 27000F. Silica sands or lake and bank sands will satisfy the requirements for gray iron castings. From 2.5 to 3 million tons per year of sand are shipped from Michigan for gray iron castings by the lake and bank sand producers.

2. Steel castings. Steel castings are used in the heavy construction industry, railroad equipment, power equipment, mining equipment and other equipment requiring high-strength castings. These industries are located in the East, Midwest, and on the West Coast. Steel castings are poured at 27500 to over 30000F. Silica sands are used for steel castings because of their chemical purity, which enables them to better withstand the high thermal shock. Silica sands also are desirable because of the higher reclamation factor.

3. Non-ferrous castings. Non-ferrous castings are bronze and aluminum castings, poured at 1200^0 to 2000^0F. This industry can use either silica sands or lake and bank sands or combinations of the two.

The physical characteristics of sands are important to foundrymen because the shape of the sand grain relates to its surface area. Sands are divided into the following four general shapes: 1) angular, 2) subangular, 3) rounded, 4) compounded.

Subangular and rounded sands are generally preferred by foundries. The amount of surface area for any particular mesh size is increased progressively when comparing rounded, subangular, and angular sands. Thus, rounded grain sands require the least amount of binder. However, angular sands have a certain unique characteristic and that is, they appear to have the best thermal shock resistance due to their packing characteristics and their interlocking strength.

The surface area figures of sands from various states are as follows (Table 2). These figures are based on the theory that 1.0 equals a perfect sphere.

State Coefficient of Angularity

Michigan	1.11	Texas	1.31
Arkansas	1.14	West Virginia	1.36
Wisconsin	1.21	New Jersey	1.47
Nevada	1.21	Tennessee	1.49
Illinois	1.22	South Carolina	1.59
Oklahoma	1.27		

Table 2. Surface Area of Sand Grains

Packing characteristics of sands are as follows: 1) rounded grain: highest density packing characteristics; 2) subangular: moderate density packing characteristics; 3) angular: least density packing characteristics, but maximum interlocking. The so-called compounded sand grain is the least desirable sand grain because during the mixing process when the binder is being applied to the sand grains, the compound grains will separate from each other and make the bonding characteristics more difficult. Also at high temperatures these same grains will fracture or separate themselves thus creating fines within the foundry sand system, which is undesirable.

Major impurities of dunes include: soil zones, marl and peat lenses, zones of ‘buried vegetation, thin shale plates (“fly sand”), carbonate root pipes and fulgurites. Where younger dunes migrate onto older ones, a fossil soil layer containing organic debris and residual limonite-hematite concentrations separates the two.

All the accessory species except calcite undergo less thermal expansion than does quartz, and feldspars and the other accessories increase the dimensional stability of the sand at temperatures at which the molds are filled by molten metal.

Chemical analyses for the significant compounds resulted in the following representative ranges, expressed in percentages:

Compound	Percent	Compound	Percent
SiO_2	87 to 94	NaO_2	0.30 to 0.61
Al_2O_3	2.6 to 6.2	KO_2	0.90 to 1.8
Fe_2O_3	0.34 to 1.40	ZrO_2	0.003 to 0.009
TiO_2	0.06 to 0.28	Cr_2O_3	0.004 to 0.07
MgO	0.20 to 0.80	SO_3	0.01 to 0.06
CaO	0.5 to 3.0	Org. mat.	0.06 to 0.70

Table 3. Major Dune Sand Constituents

Without flotation beneficiation however, dune sands, (even after magnetic treatment) generally still contain too much Fe203 to be used as a glass sand. Schemes for mixing processed dune sand with equal amounts of crushed Sylvania Sandstone for amber glass sand have been suggested. Although lake dune sands may be beneficiated to glass-sand grade chemically and their grain-size distributions also suitable for glass sand, it is unlikely that they will ever be used on a large scale for glassmaking raw material. This is largely because of the preeminent position they occupy in the foundry sand industry.

A survey by the National Industrial Sand Association indicated that the companies have an estimated 20 to 30 years’ production at the present rate of mining on current reserves. Because of the intense competition for lake shore acreage for purposes other than mining, acquisition of additional reserves is difficult and expensive. Ultimately these problems will lead to increased reclamation of used foundry sand and the substitution of sand from non-dune deposits, which will require more complex and expensive preparation.

Physical and chemical specifications sought by other industries utilizing sand are of a quality similar to dune sand. For abrasive uses, sand should be free of adhering clay or coating of iron oxide and have a silica content ranging from 80 to 99 percent. Purity specifications vary with the type of abrasive action required. Angular sand grains are used when a fast cutting action is desired, while round grains are used to produce a smooth finish.

For locomotive traction sand, specifications call for a clean, hard sand of uniform grain size and an absence of clay and moisture. These qualities insure a rapid and steady flow through a pipe directed at the rails in front of the locomotive wheels. Subangular or angular grains are preferred because round grains do not remain on the track.

In metallurgical processing, silica sand is used as a flux in smelting ores of base metals. A flux is material which facilitates fusion at lower temperatures than normal. The silica content of sand used as a flux should be high, but iron, aluminum and basic oxide impurities are not objectionable.

Sand used as a filtering medium must consist of uniform grain size, be of high chemical purity and be free of clay and organic matter. It should not contain either iron or manganese, for these would react with chemicals used in the water treatment process. Sand with good permeability is preferred.

Sand used by the chemical industry in the manufacture of a number of products must be as pure as that used for glassmaking, or at least 99.0 percent silica. Permissible trace impurities vary according to use.

D. METHODS OF MINING AND PROCESSING

The open pit method of mining involves a variety of techniques. The most common and economic means of removing sand is by the use of a front-end loader. In some instances, the front-end loader is replaced by a crane and clamshell. Both types of operation remove sand from the base of a sand dune and unload it into a nearby hopper. The sand drops through a rough screen where debris and foreign elements are trapped, allowing the sand to be funneled onto a conveyor belt. The conveyor transports the sand to the plant site where it is stockpiled for processing at a later time. When the plant site is a considerable distance away from the mining site, the sand can be hauled by truck and stockpiled.

Other methods of mining sand include dredging and hydraulic mining. Often more expensive operations, these methods offer unique advantages. With hydraulic mining, water is jetted under high pressure against a dune bank, washing the sand into a small holding pond. The slurry (sand and water) is then sucked up and transported through a pipeline, to be stockpiled and dried. The water is drained

off and pumped back to the unit for re-use. An advantage of hydraulic mining is lower noise levels than open pit or dredge mining. When a dredge is used, the method of operation is somewhat different. Dredging removes sand below the water table, creating a sizable water feature. The advantage of dredging is the capability to remove sand up to fifty feet in depth. The sand is transported in a slurry through a pipeline and stockpiled. Excess water is drained off and channeled back to the water source. Hydraulics (jetting the water against a sand bank) may be combined with the dredge in removing the sand.

The stockpiled sand, whether delivered by conveyor, truck or pipeline will require some means of processing. At a minimum, washing and drying the sand is necessary. If the sand is to be transported by Great Lakes vessel, the washing and drying process is usually done at the destination terminal. For sands that are unusually high in iron or carbonates, further treatment is necessary. This process utilizes magnetic and float separation to remove impurities. After the sand has been washed and dried and contaminants have been removed. The sand is separated according to grain size by screening techniques and stockpiled for future blending (Figure 5).

IV. EXISTING ENVIRONMENT

Sand dunes cover more than 12 percent of Michigan's coastal area. A combination of natural factors and phenomena make these dunes a nationally recognized resource, from the perspective of recreational and aesthetic values as well as from the perspective of commercial and industrial applications. Use and removal of sand dunes may interfere with many natural systems inter-linked with dune structure and/or function. A general understanding of the dynamic natural environment associated with Michigan's sand dunes will provide a basis for understanding of the potential impacts which may result from sand dune uses and removal.

A. PHYSICAL

1. Geology

On the geological time scale the Great Lakes are very young, their origins dating from about 20,000 years ago. Their present form is the culmination of a complicated series of events including several glacial advances and retreats, and the subsequent tectonic uplift of the northern part of the basin. Lake drainage patterns have changed during different lake stages.

The surface deposits and landscape of Michigan were largely formed during and shortly after the retreat of the last major Pleistocene glacial advance. As the last glacier retreated, the moraines and outwash features which we see today were formed by deposition of materials. As the front of the ice sheet retreated northward, the ancestral Great Lakes formed and at various stages, stood at considerably higher, as well as lower, levels than the present Great Lakes. At higher water levels, large portions of Michigan were under water resulting in the deposition of lake sediments, beach deposits and near shore wind blown deposits throughout these areas. In places, these deposits were formed many miles inland from the present coastline (See figure

6). The higher lake levels were fairly transitory, whereas the present level of the Great Lakes has remained relatively constant for a long time.

During the period that the last Pleistocene ice sheet retreated northward across Michigan, extensive plains of gravel and sandy material were deposited by many streams which issued from the melting ice front. Sediment, varying from coarse sand to fine clay, was carried by the streams running into the Great Lakes and spread over the lake bottom. The coarser material was deposited near the shore where wave action worked it into sandy beaches. The finer material was carried further out into deeper more quiet water. Many such deposits are located along the eastern shoreline of Lake Michigan.

Glacial sand deposition was due largely to the melting of ice and the release of rock material. For a time, the melting ice front progressed at the same rate as the forward movement of the ice causing much of the material to be deposited in a relatively narrow belt along the ice front.

The major sand transport mechanisms in effect today are wind, wave action and currents. The flow of sand amounts to over 100,000 cubic yards of sand per year in some areas, and changes in the energy of these mechanisms can cause changes in the rate in which sand is moved. This in turn can produce changes in the volume of sand that comprises the beach. If the energy level is increased, as had clearly been the case with high lake levels of the past decade, then sand may be carried from a beach faster than it is carried to it and the sand supply of the beach may dwindle.

The primary atmospheric condition affecting both the deposition of sand and the subsequent build up of the dune is the wind. A prerequisite for dune formation is the occurrence of large sand deposits at a sufficient level for the surface area to dry out between high tides and wave action. Transportation by the wind is now taking place in Michigan in much of the same manner as it occurred immediately after the glacial period. The shifting sand dunes of Lake Michigan are a clear example of this wind activity. Sediment along the beaches is picked up by the wind. Its place of deposition will depend on the size of the sediment and upon its weight. The coarser sands which move more slowly are concentrated into dunes, the finer material being winnowed up and carried away. Sand dunes, therefore, occur very close to the source of the sand or sediment picked up by the wind. Because of the effectiveness of the wind in separating sediment according to sizes the sand contained in a dune is well sorted and generally of a uniform fineness. The size, shape and composition of sand grains are of much importance. Heavier or larger grains are less easily lifted and they progress by shorter jumps, while the finest products of abrasion can be picked up by more gentle breezes and may settle outside the dune area. On surfaces which have been compacted, as by rain or snow, the individual grains tend to interlock and the wind does not easily move them.

When a wave breaks, the up-rushing water on the beach carries sand and gravel with it. When the water loses its momentum, it reaches the limit of advance and there is a momentary halt. Then the backwash occurs, and the water flows down the beach and back into the lake. Because of winds and currents, most waves strike the shore obliquely. When such waves break, the up-rush is at an obtuse angle to the shore. Under the action of these waves sand and beach detritus are moved up and along the beach by the up-rush and then directly down the beach by the backwash. This to-and-fro shifting accounts for sand and other material traveling along the beach, a process known as long-shore or littoral drift. In addition to this transport of material on or near the beach, much sand is also shifted below the water by the drag of outbound wave action.

As the sediment is worked over by the waves and transported along shore, distinct changes take place in it. The beach sand and gravel at the foot of the bluffs are fairly free from clay, as clay is carried in suspension Out into the lake. Large stones are rather rare but there is commonly a considerable proportion of coarse gravel known as beach shingle and composed of crystalline and sedimentary rocks. These gravel pebbles are usually subangular and even the finer particles, such as sand are sharply-cornered. With wear from waves, the fragments of all sizes tend to become rounded. When exposed to the work of the waves pebbles and sand grains of less resistant minerals are rapidly abraded or decomposed. The net result of the transportation process on both the eastern and western shore of Lake Michigan is that the final product which reaches the dune is mostly fine quartz sand.

Buckler (1978) suggests classifying dune types along the shore of Lake Michigan based on dune form, relative relief, orientation, arrangement and the relationship of the dune assemblage to the underlying formation. Eight different dune forms are recognized in this classification and each assemblage of these types may be expressed as having high, moderate, or low relative relief. Parallel, perpendicular, arcuate or irregularly oriented dune forms are possible. Within each area a single or multiple number of individual dune forms of the same type may be designated. Dune assemblages may be non-elevated or may be perched on top of, or override a steep slope of a non-dune formation.

The eight classifications include parabolic dune, dune platform, domal dune, complex dune field, linear dune ridge, dune terrace, dune flat, and marginal sand apron. These dune types are discussed at some length in the Buckler study. Perhaps the most visible of these are parabolic dunes and linear dune ridges.

Individual parabolic dunes have ground plans which are bow, U, or hairpin-shaped. They generally have sharply defined limbs that increase in height inland, and an orientation perpendicular to the shoreline. The concave, or open side, of the dune form faces the shore and exhibits a relatively gentle slope, steepening somewhat near the crest and apex. Widths typical of individual dunes are up to one-quarter of a mile, with lengths in some cases greater than one-half mile; heights may be more than 150 feet. Generally, the highest relief on these dunes is at their apex. Parabolic dunes are typically grouped into an assemblage which trends parallel to the shore. Because of shoreline erosion, it is not unusual to encounter numerous examples where only remnants of parabolic dunes remain. Blowouts are frequently found between the limbs and on the open concave slope.

Blowouts may be initiated by man’s activities or by naturally occurring events. They begin at the shoreline and move inland with winds and unstable sand. As the wind deposits unanchored sand in previously stabilized areas, vegetation may die, contributing to the instability of that area. As the landward edge of the blowout is assaulted by winds, roots may be uncovered and plants die, moving the blowout landward.

Linear dune ridges are elongated sand ridges whose overall trend is parallel, arcuate, or, in rare cases, normal (perpendicular) to the present shoreline; some, especially those associated with older, higher, glacial lakes, have an irregular trend with respect to the present shore. The parallel and arcuate varieties frequently display a gentler slope lakeward and a steeper slope on the inland side. In places they may be breached, often due to natural blowouts or artificial leveling.

Boundary locations of the designated dune assemblages are not always precise lines, but may be transition zones. By its very nature, each dune has a form which is going through an evolutionary process. Therefore, a designated dune assemblage may contain dunes which do not exactly fit the ideal form; nevertheless, the interpreted form fits one class better than any other in the classification scheme.

The Sand Dune Protection and Management Act defines a barrier dune as “the first landward sand dune formation along the shoreline of a Great Lake or a sand dune formation designated by the department” (See Appendix A.) In terms of the dune morphology classification system, a barrier dune may encompass several different types of dunes. The inland boundary of the barrier dune is that landward boundary line at the base of the first dune assemblage which displays the greatest relative relief within two miles of the shoreline (the limit covered under the Act). This dune assemblage will generally be the first inland from the shoreline or adjacent to the more or less ephemeral low-relief dune assemblage which itself is adjacent to the upper beach zone.

The generally recognized function of the barrier dune is protection of landward areas from the lake effects. Another very real function may be as an aesthetically appealing visual barrier between the water and beach area and the landward environment.

2. Hydrology

In general, the shallow groundwaters in the coastal sand dune areas flow towards Lake Michigan. Locally however, streams, lakes, wells, or other discharge points may ‘control the flow direction.

The groundwater table in the area is usually a subdued reflection of the land topography and is recharged by precipitation. The groundwater levels in the coastal sand dune mining area may fluctuate during the year as a result of recharge received and groundwater usage in the area.

County	Rate In GPM		Bedrock	Water Quality
	10	10 - 100		
Berrien	X		Shale	OK
Van Buren	X		Shale	Ok to highly mineralized
Allegan	X		Shale	highly mineralized
Ottawa	X		Shale	highly mineralized
Muskegon		X	Sandstone	highly mineralized
Oceana	X		Shale(?)	OK
Mason	X		Shale(?)	OK

Table 4. Bedrock Aquifers (Coastal Only).

Much of the coastal area of the southwestern counties of Michigan lack groundwater of adequate yields for anything other than domestic uses. In these counties, groundwater pumpage from both bedrock aquifers and unconsolidated sediments is often less than 10 gallons per minute. Ample pumpage for municipal supplies, however, do exist in certain areas of the coast in the vicinity of St. Joseph, Benton Harbor, Saugatuck and Montague. (See Tables 4 and 5.)

3. Climate

The west coast of Michigan has a climate modified by the large volume of water in Lake Michigan. The Lake cools much more slowly in winter and warms more slowly in summer than does land. The prevailing westerly winds are therefore somewhat warmed in the fall and winter (until freeze up) by traveling across the warmer body of water. They are also cooled in the spring and summer by traveling across cooler water. The result is a much smaller degree of fluctuation in temperatures immediately inland from the Lake. The air off the Lake also carries considerable humidity to the shoreline areas.

County	Availability In GPM				Sediment Type
	10	10 - 100	100 - 500	500 +	
Berrien	X		X*	X*	till plain (till & bedrock)
Van Buren	X				lake deposits
Allegan		X			lake deposits
Ottawa	X				lake deposits
Muskegon	X	X**			lake deposits
Oceana			X		moraines, lake deposits
Mason			X		moraines, lake deposits

* St. Joe, Benton Harbor area.
** Whitehall area.

Table 5. Groundwater from Unconsolidated Sediments (Coastal Only)

The high humidity and relatively stable temperatures are important in the development of some coastal areas for agriculture.

The Michigan Weather Service reports the following data (Table 6) for three weather stations which reflect coastal area climate.

Weather Station	Monthly Avg. Temp (^{0}F)		Avg. Annual Precipitation
	Jan	July	(inches)
Grand Rapids	23.2	71.5	32.39
Muskegon	24.0	70.0	31.53
Salute Ste. Marie	14.2	63.8	31. 7

Table 6. Climate for Lake Michigan Coastal Areas (Avg. 1941-1970).

B. TERRESTRIAL

1. Biotic Communities

The soil of the dunes is chiefly quartz sand which has marked peculiarities that strongly effect vegetation. As a rule, sandy soils are poor in plant nutrients and do not quickly develop a rich humus soil because of the rapid oxidation of organic matter. Topography accounts for many differences in the rates of deposition or erosion, and hence in the distribution of plant and animal species.

Plant life in the form of single plants, groups of plants and sparse to dense vegetation of herbs, shrubs and trees aids in the topographic formation of the coast and some backshores. Vegetation greatly influences dune microclimate. Where vegetation exists, overall temperatures are more moderate and fluctuate less drastically than areas devoid of vegetation. Moisture is held in all plant parts rather than immediately either evaporating or percolating to the groundwater. Evapotranspiration of moisture gathered from surface and subsurface sources along with shade from foliage serve to cool temperatures during the day, thus creating a somewhat less hostile environment for other flora and fauna. Plants have the ability to grow in three directions: horizontally, upward, and downward. In this manner they keep pace with deposition of sands and continue to alter the erosion cycle. The ability of dune plants to survive and reproduce themselves under severe conditions make them important agents for stabilization.

The pioneer dune forming plants influence the movement of wind-borne sand and generally cause more deposition in an area than would normally occur if they were not present. The vigorous growth of the top part of dunes is often characteristic of the interference of these pioneer, dune forming plants with wind borne sand. Even when dead, the exposed upper parts of the plant may continue to act as sand traps.

The mechanical effects of underground parts of plants are complex. The fibrous root systems and adventitious roots from the joints or nodes along the stem act as very efficient sand binders. The rhizomes or root-stalks below the surface and the stolons or runners at or near the surface serve in the same capacity.

The roots selectively absorb some of the minerals present, altering the chemical characteristics of the dune. Dead plant material becomes humus, creating a shallow top soil in stabilized areas.

a. Beach and Shore

Living communities begin at the waters edge where simple forms of algae grow. As the high water line is passed, rooted plants appear. The first assemblage includes the sea rocket, bugseed and seaside spurge. Slightly further inland communities include beach wormwood, Marram grass, sand reed, little bluestem grass, Canada wild rye, beach pea, dune goldenrod, sand cress, hairy puccoon and bastard toadflax. These plants occur not only on the upper beach but on the foredune and other places of open, non-forested sand throughout the dunes.

Typical trees and shrubs occurring on the foredune and also in other dune areas are the dune willow, blue leaved willow, sand cherry, round leaved dogwood, wafer ash, and cottonwood. Other typical plants of the open sandy beach are bittersweet, poison ivy, starry false solomon's seal, red osier dogwood, gray dogwood and common juniper.

Common birds of the beach include gulls, terns, and sandpipers. Often observed near shore are herons, common grackles, and swallows.

An interesting bird of this habitat is the Prairie Warbler; a bird with the hulk of its breeding range further south. It hides its nests in shrubs of the non-forested sandy areas, especially along the fore dune.

Box turtles and the American toad are often found in the open sand areas - the toads along the beach, and the turtles up in the dunes.

Typical invertebrates indigenous to the dunes are the sand spider, burrowing spider, white tiger beetle, maritime grasshopper, long horned grasshopper and digger wasp. In the fall some insects migrate along the shore. Occasionally, large numbers of monarch butterflies can be observed.

An important component of the beach and shore biota is the endangered and threatened species, which are listed in Appendix C.

b. Wooded Dune

Ferns and flowering forbs inhabit the wooded portions of the dunes. Species include the marginal woodfern, christmas fern, grape fern, wild sarsaparilla, white baneberry, columbine, big-leaf aster, Canada mayflower, prince's pine, trailing arbutus and groundpine.

Trees characteristic of the wooded dunes include red and black oak, sassafras, hemlock, beech, sugar maple, mulberry, pawpaw, hackberry, black gum, white pine and jack pine.

Some of the characteristic breeding birds of this habitat are: yellow-billed cuckoo, black-billed cuckoo, great horned owl, screech owl, whippoor-will, hairy woodpecker, downy woodpecker, red-bellied woodpecker, yellow-shafted flicker, great crested flycatcher, eastern wood pewee, blue jay, blackcapped chickadee, white-breasted nuthatch, tufted titmouse, brown thrasher, red-eyed vireo, scarlet tanager and black throated green warbler.

Mammals of this habitat include whitetail deer, raccoon, fox, skunk, opossum, weasel, fox squirrel, red squirrel, southern flying squirrel, white-footed mouse, meadow jumping mouse and shrew.

The most conspicuous reptiles and amphibians in the wooded dunes are box turtles; and in the spring Blanding's turtles and painted turtles lay eggs in the dunes. American and Fowler's toads occur in the wooded dunes along with garter snakes, black rat snakes, and eastern hognosed snakes.

A few of the typical invertebrates are digger wasps, ant lions, flatbugs, grasshoppers, wireworms, snails, deerflies and mosquitoes. Endangered and threatened species of wooded dunes are included in Appendix C.

2. Community Succession

Plant succession is a continuous, dynamic reaction to all the environmental realities in a given locality. Primary dune succession begins with hardy, specially adapted, pioneer species invading a harsh environment characterized by extremely high daytime surface temperatures and by strong winds. These conditions increase transpiration and evaporation.

The initial plants on a fresh dune may include marram grass, sand reed, little bluestem and other grasses and herbs like beach pea and lesser solomon's seal. Common shrubs and trees on young dunes are sand cherry, false heather, juniper and cottonwood. Most early successional dune plants have adventitious roots which allow them to survive through the changes in the elevation of sand around their stems and roots. If sand builds up around the stem, new root fibers develop in the newly sub-surface area of stem. If sand is blown away exposing horizontal root parts, new root parts develop at the new, sub-surface level.

Succession occurs primarily because the establishment of new species in a community modifies the existing environment. In this way the species most suited to a given habitat are less able to compete effectively after a period of time in which they have altered that habitat.

Replacement of the pioneer community by forest is dependent on soil moisture, nutrient availability and organic matter. Typically, a mixed mesic forests of jack pine, white birch is established. This is an intermediate stage between early successional stages and late stages. Along the southeastern shore of Lake Michigan the moister climate resulted in the development of a mesic forests of sugar maple, beech and basswood on the older stabilized dunes, particularly on the lee slopes and in pockets.

Southern xeric (black oak) forest has developed on many stabilized Lake Michigan dunes and is a late community on the older ones. Blueberry and huckleberry often inhabit the black oak forest as the soils become more acid. Where steep slopes and damp depressions are present, basswood may be present, followed successionally by beech-maple forests.

Plant succession in dune assemblages proceeds very slowly over great periods of time. Thus, significant long-term changes in species composition, diversity, and carrying capacity are likely to occur when the process of plant succession is modified.

Each change in plant assemblage brings changes in animal species. Those animals which are highly competitive in early successional habitats will be replaced by animals better adapted to later successional habitats.

3. Unusual Aspects of Dune Communities

The geological formation, soils and climate combine to produce a unique resource in the forested coastal dunes of Western Michigan.

Soil development in dune areas is very slow due to the relative inability of the sand to hold nutrients. Slow soil development has resulted in a relatively thin layer of humus on which the vegetation is built. The soil at the beach tends to be highly alkaline and grades to very acidic soils in the forest dunes. The high relative humidity combines with lake modified temperatures to produce great diversity and complexity in soils that otherwise would not be particularly productive. Such .intithetiical features are also apparent in other ways. Species which have different temperature, moisture and pH requirements exist in combinations not usually found together.

Many of the plants and animals which occur in these areas are at the northern or southern extremes of their ranges. An area may combine elements of the more southern mesophytic forest with elements more characteristic of northern great lakes hardwoods.

An unusually large number of hybrids are found only in dunes. Locally abundant pockets of rare, threatened and endangered species occur in dunes, and many are found nowhere else. Particularly high canopies with many large individual trees are common in dune areas but unusual in similar serial stages throughout Michigan.

Probably because of access problems involved in hauling materials in the sand over steep hills and valleys, much of the dune areas were not logged to the extent that most of Michigan was. The slow successional rate over a two to four thousand year period has, for the most part, reached mid successional stages. A potential remains for further successional development.

Important avian flyways follow the coastline. The dunes are used extensively by both resident and migrating birds. All Michigan threatened and endangered birds except the prairie chicken have been reported along the coast. Of those, all but the barn owl are recorded annually. The barn owl is occasionally seen.

No single characteristic, but a combination of many physical and biotic factors make dunes an unusual and revered resource.

C. AQUATIC

1. Water Quality

a. Groundwater

Localized contamination of some isolated aquifers in sand dune areas, especially in the St. Joseph, Benton Harbor, Saugatuck and Montague areas restricts the use of some groundwater for municipal and domestic water supplies. The most common pollution problem is the seepage of wastes into shallow, unconfined aquifers. Septic tanks, tile fields, old brine well disposals, 1landf ills, spillage and leakage all add waste contaminants to sand and gravel aquifers. In addition, highly saline waters are present in at least part of all bedrock aquifers. Some of the salinity may have migrated into near-surface aquifers as a result of improper oil, gas and mineral well drilling and improper capping prior to 1930.

Water from domestic and municipal wells in the area meet all primary drinking water standards. The water is generally hard to very hard and often has an excessively high iron content.

The southern portion of Lake Michigan generally possesses medium to good water quality. Certain near-shore areas of the southern Michigan shore line have a higher trophic state (higher nutrient levels and productivity) than open waters. These areas of higher productivity can be attributed to the warmer waters of the littoral zone, prevailing westerly winds, lake currents and nutrient loading at river mouths. However, industrial discharge control and implementation of secondary treatment at waste water treatment plants upstream have somewhat relieved this situation in recent years.

All of the major rivers discharging to this section of the Lake Michigan coast possess medium to good water quality except the Kalamazoo River. Water Quality at the discharge point of the Kalamazoo River is considered poor as indicated by unsafe levels of certain toxic substances in fish from the river.

Contamination of the lake in the past with toxic substances has led to the issuance of health advisories for certain fish caught in Lake Michigan. Because of high levels of PCB (Polychlorinated biphenyls) it is recommended that no one consume any fish caught at the mouth of the Kalamazoo River. In addition, individuals are advised to restrict their intake of the following fish caught in Lake Michigan: Steelhead (due to high levels of POB), lake trout (due to high levels of PCB and DDT) and salmon (due to the high levels of PCB and Mercury).

For additional information on the water quality of Lake Michigan, the reader is referred to the "Environmental Status of the Lake Michigan Region."

2. Biotic Communities

All mining sites under regulation by Act 222 are within 2 miles of Lake Michigan. A fish species list for Lake Michigan is included in Appendix C.

Certain mining areas include or are close to rivers, and drains.

Those systems may include many of the biota associated with Lake Michigan.

The Fisheries Division of the Michigan Department of Natural Resources classifies Michigan streams and rivers as first or second quality cold water or warm water. This classification system is used to determine the stream's potential for present or future fisheries management. In general, the cold water classification indicates a potential for trout management, whereas the warm water classification indicates a potential for fish management other than trout.

Classification of those water sources included in sand mining counties are shown in Figure 7.

Generally, streams capable of supporting cold water or warm water fisheries have certain indicator species and conditions associated with them. Cold water fish streams will have summer temperatures between the high 50's and low 70's Fahrenheit and dissolved oxygen levels of not less than 6 mg/liter. Warm water streams supporting good fish populations will have summer temperatures between the high 60's and low 80's Fahrenheit, with concentrations of oxygen at 5 mg/liter or more.

Top quality cold water streams will usually include invertebrates such as black flies, stone flies, mayflies, caddisflies, damselflies and crayfish. Brook trout, salmonids, burbot, dace and sculpins are indicator fish. This is a relatively fragile ecosystem with fairly balanced numbers of each species present.

A second quality cold water stream will have higher temperatures (brown trout can survive in water at 750 F) and higher nutrient loads than top quality streams. Mayflies, caddisflies, aquatic earthworms, midges, leaches and crayfish are present; but organisms in each group which require colder water will be absent. Brown trout, northern pike, dace, mud minnows, creek chubs and suckers are indicator fish.

Top quality warm water streams will include northern pike, bass, walleye, darters, panfish, suckers and a large variety of invertebrates. Second quality warm water streams will have many of the same fish as top quality streams, with carp and gar also present. Carp and suckers will probably be dominant species in numbers and weight in second quality warm water streams.

In general, increased temperature, nutrient loadings and decreased oxygen concentrations indicate increased enrichment, insect biomass and a less balanced community. All freshwater fish are intolerant of acid, saline conditions.

Stream vegetation ranges from attached algae to rooted submergent and emergent vegetation. Algae in flowing streams are principally attached to the stream bottom or to submerged rocks, logs or other structures in the stream. Algae also occur as thin fibers on mud and silt and are found on rooted aquatic vegetation as well.

Algae are primarily microscopic but several genera do occur as very visible parts of the aquatic ecosystem (*Cladophora*, *Oedogonuim* and *Ulothrix*).

Diatoms can also form visible colonies on rocks, logs, etc., Algae are controlled in their growth by light, temperature, current, substratum and nutrient availability. In cold, well shaded, fast flowing streams, algae will be reduced in numbers of species and density. Principally attached algae such as *Cladophora*, *Ulothrix* and diatoms, are found in these types of waters. In slower, warmer and well lighted streams profuse growths of algae can be found.

Submergent and emergent higher plants include the Charales (*Chara* and *Nitella*) which are algae, the mosses and liverworts (Bryophyta) and the flowering plants which are most visible to the casual observer. These larger aquatic plants can be classified or segregated by three main types - attached to the surface of the substratum, rooted in the stream bottom and free floating.

Principally, the mosses and liverworts are attached to the substratum (*Musci* and *Hepaticae*).

Rooted aquatic vegetation makes up the bulk of the easily visible and identifiable stream vegetation. Rooted plants that do exist in streams do so because they have been able to adapt portions of their structure to an environment scoured by current. Most have greatly reduced or missing leaves, relatively large root systems and tough, flexible stems.

Rooted vegetation in the cold, fast flowing streams (not including the shoreline or wetland areas adjacent to and often inundated by the stream) is limited to a few genera (*Vallisneria*, *Sagittaria*, *Sparganium*) and can be characterized by their streamlined shapes and tough stems. *Potarnogeton* sp are found in streams but will be greatly reduced in size (leaves and or calm water) Water lilies (*Nuphar*) can also be found in relatively fast water but will be smaller in size and occur in less dense growths than the same species in calmer water.

Floating plants in running water consist principally of the duckweed family *Lemna* minor, *Spirodela*, *Wolffia* and *Wolfiella* and form only a minor part of the aquatic community in running water.

Aquatic plant communities in the stream itself are limited then to a relatively few hardy, specialized species that include mosses, attached algae and rooted and attached submergent and emergent vegetation. Free floating algae and higher aquatic plants make up a small part of the plant community in flowing streams.

Aquatic vegetation in streams is important in that the algae forms the base of the aquatic food chain; higher plants are very important to wildlife as food; provide shelter for aquatic invertebrates that are important fish food; help stabilize the stream bottom; and help produce oxygen and utilize carbon dioxide.

Aquatic plants are also important indicators of enriched, degraded or polluted ecosystems. Typically polluted environments will have large masses of aquatic vegetation present represented by few species. Algae are represented by profuse growths of *Cladophora glomerata* for example, to the extent that is appears no other form of plant can be present. In slower streams, dense mats of *Potamogeton crispus* will cover the stream bottom from bank to bank, indicating highly enriched conditions.

The area under consideration includes those nine counties where active or potentially active sand dune mining sites exist. Only Manistee has no current mining sites or any designated sand dune areas. It has been included because it has a site which has recently become inactive. All of these are included in the Series I designation except Manistee (See figure 1.) The counties are: Allegan, Berrien, Mackinac, Manistee, Mason, Muskegon, Oceana, Ottawa, and Van Buren.

1. Demographics

The nine county population in 1977 was roughly 700,000, nearly 8% of Michigan's population. Close to 25Z of this population lives in Berrien County and approximately 20% lives in Muskegon County. Between the 10 year period from 1960 to 1970, this nine county area experienced a population increase of 11%.

	1960	1970	1977	1977(1)	1970(2)
Allegan	57,729	66,575	73,800	89.3	22.6
Berrien	149,865	163,875	169,200	291.7	46.4
Mackinac	10,853	9,660	10,800	10.6	29.9
Manistee	19,042	20,094	21,800	39.4	38.4
Mason	21,929	22,612	25,200	51.4	39.9
Muskegon	149,943	157,426	158,100	315.6	69.1
Oceana	16, 547	17,984	21,000	39.2	0.0
Ottawa	98,719	128,181	146,100	259.5	48.3
Van Buren	48,395	56,173	61,800	102.5	21.6

(1) Density (people/square mile)

(2) Percent population in urban areas

Table 7. Populations of Counties within the Nine County Area.

Three cities along the coast of Lake Michigan have populations of greater than 20,000. They include Holland, Muskegon and the metropolitan region of Benton Harbor. Population characteristics for the nine individual counties follow in Tables 7 - 9.

Although Berrien County has the greatest population, Muskegon County is the most densely populated and has the highest percentage of urban dwellers. (See Table 7.)

Mackinac County, with the lowest overall population, has the highest percentage of elderly, at nearly 18%. (See Table 8.) Ottawa County, with 37% has the highest population of children under 18.

Berrien and Muskegon counties have the highest minority populations (Table 9.). These figures do not include, however, minority migrant farm laborers who work and live in these counties only during the growing or harvesting season, nor does it include seasonal tourist residents.

Table 8. Age and Sex of Residents within the Nine County Area 1975 data. See Appendix A

Table 9. Race/Sex Distribution within the Nine County Area. See Appendix A.

2. Land Use Patterns

Mackinac is the largest county, comprised of 1,014 square miles. Mason County is the smallest, at 490 square miles in size (Table 10.) Over 50% of Mackinac County is owned by the DNR and the US Forest Service (Table 11.) Berrien County has the least amount of DNR or Forest Service Land.

	Land area (sq. Miles)	Number of incorporated cities & villages
Allegan	826	9
Berrien	580	17
Mackinac	1,014	2
Manistee	553	6
Mason	490	5
Muskegon	501	10
Oceana	536	7
Ottawa	563	7
Van Buren	603	11

Table 10. Land Area, Cities and Villages Within the Nine County Area.

1978. One of the smallest parks, Holland State Park with 145 acres, had the most visitors in 1978, nearly 1.7 million. The park with the second highest number of visitors was Warren Dunes, in Berrien County. This county also has the greatest number of mining operations (Table I).

Private land use in the sand dune protection area is predominantly agricultural, with both large and residential farms. The area maintains a rural setting, but with an increasing growth of suburban residences in the more populated counties, including Muskegon and Berrien counties.

	In Acres DNR Owned	% Gross Area	U.S.F.S.	% Gross Area
Allegan	44,624.36	8.42	0	0
Berrien	873. 72	.24	-	-
Mackinac	203, 660. 92	31.3	147, 556.0	22.6
Manistee	24,009.8	69	63, 945.0	18.26
Mason	5,615.68	1. 78	57, 548	18.23
Muskegon	9, 266. 93	2.87	12,415	3.85
Oceana	4,764.17	1.38	47, 788	13.83
Ottawa	1,261.49	.35	-	-
Van Buren	1,197.37	31	-	-

Table 11. Acres of Land (by County) Owned by D.N.R. and U.S. F.S. 1973.

Table 12 State Park Use. See appendix A

The number of State and National historic sites which were within 2 miles of the lakeshore in 1975 are listed in Table 13. Figure 8 shows the location of these historic sites in all counties except Mackinac.

According to the Michigan History Division of the State Department, the number of known State historic sites has increased about 25% in the past four years, and will continue to grow as new State historic sites are designated.

	National Historic Sites	State Historic* Sites
Allegan	1	5
Berrien	3	6
Mackinac	12	20
Manistee	3	3
Mason	0	3
Muskegon	4	5
Oceana	I	1
Ottawa	3	8
Van Buren	0	2

* All national sites are also state sites and included in the state figure.

Table 13. Historic Sites Within Two Miles of Lakeshore 1975.

The predominant form of transportation used in the sand dune area is automobile traffic. Table 14 lists motor vehicle registration in 1977. Berrien and Muskegon counties had the greatest number of registered vehicles. The Federal highway system serving the lower Lake Michigan area includes Interstate 94, 1-96, 1-196, and U.S. Highways 31 and 33. Mackinac County is served by 1-75 and U.S. Highway 2.

Figure 8 - See Appendix B.

	Passenger	Total
Allegan	36,088	59,140
Berrien	91,912	136,489
Mackinac	4,510	8,001
Manistee	11,552	18,381
Mason	13,241	21,776
Muskegon	82,392	124,085
Oceana	9,515	16,407
Ottawa	76,980	119,460
Van Buren	31,018	50,096

Table 14. — Motor Vehicle Registration June 1977.

Railroad service is provided by the Chesapeake and Ohio Railroad, which serves a number of the existing mining operations.

There are seven commercial harbors in the sand dune areas: Benton Harbor; South Haven Harbor; Holland Harbor, Grand Haven Harbor; Muskegon Harbor, and interational port; Ludington Harbor and Manistee Harbor.

3. Aesthetics

The aesthetics of the dune areas along Lake Michigan has traditionally been a very important part of the social environment. It is a key element of area economics, primarily through tourism. Aesthetics has also played a part in historical land use patterns as indicated by early development of State Parks. It has probably been of less significance in demographic determinations (except secondarily) since traditionally, populations follow economic rather than aesthetic patterns.

However, the importance of this factor in the existing social environment must not be minimized. Although hard science has not irrefutably quantified the value of aesthetics, circumstantial evidence of its importance abounds.

4. Economics

The average unemployment percentage for all nine counties rose from 8.2% in 1970 to 9.15% in 1977. This is well above the 1977 National unemployment rate of 7%, and Michigan's 1978 average rate of 6.9% (See Table 15). The average weekly earnings for all nine counties in 1976 was $l77.43.

Individual county statistics vary. Allegan County matched the nation's unemployment average for 1977, with 7%. Manistee County, however, had an unemployment rate of over 6% points higher than average.

The lowest average weekly earnings in 1976 were in Oceana County, and the highest in Muskegon County. The average income per capita again shows Oceana County with the lowest figure. The highest average income per capita is in Berrien County. The nine county average was $5,243 (Table 16). The average weekly earnings suggest that the annual average yearly income would be higher than the figures indicated. This discrepancy may be attributed to persons being employed for only part of the year. These figures also do not include the population or economic impact of seasonal residents such as summer home-owners and migrant laborers.

V. POTENTIAL IMPACTS

In assessing the impact of any project proposing land change, it is necessary to consider the functional aspects of the environment or ecosystem as well as the structural or physical aspect. Functional parameters include time as a unit of measurement (or rates of flow of material or energy) and relate to those changes that may occur beyond the construction period and away from the specific site.

In many ways, functional parameters are more important to the impact assessment than are purely structural ones that indicate only the visible changes measured or predicted at one point in time and in one place. If functional parameters are known, then one can more clearly determine the real impacts of a project. Changes or damages which may occur through time after the construction (the change producing agent) is completed will provide a truer picture of total damages. Impacts on the functional parameters may create adverse changes geographically distant or at least outside of the immediate area being changed structurally.

	Avg. Employ ment	Avg. Weekly Earning	Worker Non-worker Ratio	Unemploy-ment Rate	
	1976	1976	1970	1970	1977
Allegan	10, 879	180.15	1.57	5.9	7.0
Berrien	50, 774	206. 61	1.41	5.7	9.1
Mackinac	1,884	138.34	2.09	16.5	12.8
Manistee	4,781	188.49	1.64	11.1	13.1
Mason	5,557	170.10	1.57	6.2	9.3
Muskegon	44, 590	215.51	1. 59	8.5	9.1
Oceana	2,123	127.58	1.81	8.5	9.1
Ottawa	37, 586	191.08	1. 51	6.5*	6.3*
Van Buren	9, 907	179.03	1.62	5.5**	6.5**

* Including Kent County
** Including Kalamazoo County

Table 15. Employment

	Total	Personal income	Average Income	Pre Capita
	Millions of	Dollars		
	1970	1976	1970	1976
Allegan	207.9	363.6	3,110	5,068
Berrien	639.8	1,032.2	3,902	6,003
Mackinac	27.4	50.9	2,814	4,918
Manistee	62.3	110.9	3,029	5,083
Mason	68.1	121.1	2,979	4,855
Muskegon	556.8	887.8	3,533	5,633
Oceana	52.9	92.1	2,920	4,450
Ottawa	477.5	838.6	3,720	5,896
Van Buren	186.4	327.0	3,299	5,278

Table 16. Income in the Nine County Area.

For sand dunes, the functional aspects include, for example, microclimate stabilization landward of the dune. This in turn creates an ecotone more suited for plants and animals adapted to less variable and harsh environments.

Table 17 shows the state equalized value of real and personal property. Berrien County has both the highest real property and Mackinac County has the lowest real property value and Oceana County has the lowest personal property value

	Real Property	Personal Property
Allegan	$344,083,318	$75,510,731
Berrien	1,025,586,453	171,470,609
Mackinac	94,622,261	24,224,273
Manistee	137,792,333	39,278,013
Mason	291,492,920	29,903,201
Muskegon	662,558,834	99,424,319
Oceana	112,724,040	10,452,105
Ottawa	818,257,637	90,539,026
Van Buren	314,386,036	39,121,005

Table 17. State Equalized Value by State Tax Commission.

Thus, in assessing the impacts of a sand dune mining proposal, especially in a stabilized barrier dune, the Department attempts to determine not only the percentage loss of the dune and its associated biota, but the effects on environments surrounding the barrier dune. The removal of a portion of the barrier dune may or may not impair its function of stabilizing the microclimate. The physical loss of a portion of the barrier dune may be minor compared to the loss of its functional attributes. Conversely, the physical loss of a portion of a barrier in some cases will not impair its function.

Table 18 shows Federal government involvement counties. Berrien and Muskegon counties are the greatest amount of federal money and employees.

County	1976	1977	Total Fed Employees
Allegan	62,881	63,209	165
Berrien	199,852	207,399	443
Mackinac	12,712	15,849	62
Manistee	24,078	27,572	93
Mason	26,438	28,144	90
Muskegon	289,440	315,104	432
Oceana	20,565	28,780	55
Ottawa	100,600	133,617	306
Van Buren	64,113	72,413	135

Table 18 - Federal Government Outlays Including Defense

Several parameters will effect the degree to which the functional characteristics of a dune may be altered. Among those are the position of the proposed mining operation in relation to the position of the dune, the percentage of the dune to be mined, the height and extent of a barrier dune which may reflect its abilities to alter microclimate and the degree to which mitigation measures (reclamation, buffers, stabilization, timing of cell unit plan) will prevent adverse impacts (e.g., blowouts) on adjacent or surrounding environments. Figures 9a and 9b enumerate change producing agents and suggests potential areas of impact as a summary of this section. The impacts may be structural and/or functional.

	Acres Owned or Leased by Mining Co.'s	Total Personal Income X $1,000	Tourism Income X $1,000	Farm Cash Receipts X $1,000
County	1976	1976	1978	1975
Mackinac	*2,552	50,900	97,655	1,592
Oceana	400	92,100	8,959	16,158
Berrien	908	1,032,200	113,781	51,779[1]
Mason	620	121,100	24,189	9,886
Manistee	**240	110,900	31,805	8,817
Van Buren	405	327,000	21,950	42,426[1]
Allegan	0	363,600	20,158	55,926[1]
Muskegon	504	887,800	52,411	14,515
Ottawa	620	838,600	71,225	52,470[1]
Sub Total	5,009	3,824,200	442,133	253,569
	(100% of State Total) Total Personal Income X $1,000	(6.22% of State Total)	(9.4% of State Total) X $1,000	(14.5% of State Total)
State Total	5,009	61,485	4, 700	1,751,133

* Has not yet been mined.

** Has not been mined since 1974.

1 Higher than county average.

Table 19. Tourist and Farm Income in Nine Counties.

A. PHYSICAL

1. Geology

Extraction of sand will interrupt the geological development of the dunes. The topographic results of glacial scouring and deposition will be altered. The land will be lower overall, and flatter. Additional surface water will remain where dredging operations have removed sand below the water table. Erosion potential will increase and may result in new sand deposition and movement of dunes. To a great extent, erosion problems can be mitigated. (See Section VII)

2. Hydrology

Potential for impacts to groundwater levels varies depending on the method of mining and the existing subsurface materials underlying surface sand deposits.

If sand is mined "in the dry", the water table is not intruded upon. There still remains some potential for water table fluctuation if removal of the overburden reduces pressure for the existing directional groundwater flow. Water follows the path of least resistance, and is generally controlled by gravity and the permeability of the surrounding strata. In some cases, removal of a considerable weight (tons of sand) may decrease compaction of the soils underneath, which may in turn increase their permeability. This may result in localized change in water levels or direction of flow.

Mining which does intrude upon the water table involves a potential for temporary water level fluctuation if a divide is crossed from the mining site to the area of water storage. Following cessation of mining, the water table should stabilize at its previous level.

In general, hydrologic impacts resulting from mining appear to be minimal. There is, however, a potential for secondary impact due to development, since mining reduces topographic constraints for development. This may induce increased withdrawals. However, information available at this time does not suggest that this has happened (See Section V,D.).

3. Climate

The general climate along Lake Michigan will not be effected by sand dune mining. However, considerable impacts to the microclimate may occur as a result of any change in topography or loss of vegetative cover. Changes in humidity, light, wind, and temperature of localized areas may occur. The degree of impact will depend on height and slopes of the existing area, type of vegetative cover, where and how mining will be done. These impacts are likely to be less obtrusive if the area to be mined is landward of a higher point between the site and the lake, and if the formation between them is not breached. An area of lower topographic relief with gentler slopes, existing development and sparse vegetation is subject to less dramatic microclimatic changes with mining than an area of high relief, steep slopes, rich woods and no existing development.

Lower, flatter dune areas devoid of vegetation after mining will have lower humidity, higher winds, more light and greater temperature extremes than undulating, richly wooded land on which no mining or other development has occurred.

B. TERRESTRIAL

1. Biotic Communities

For all intents and purposes, the biotic communities within the area to be mined will be eliminated. The vegetation and humus layer will be removed to accommodate mining. The animal life dependent upon the vegetative communities will not survive the loss of habitat. Migrating birds will be effected by loss of feeding and roosting sites.

As removal of vegetation occurs, changes take place around the disturbance periphery as well as in the stripped areas themselves. Increases in light, temperature, exposure to wind and evaporation along the edge of the remaining vegetation will affect not only what species will grow there, but the vigor with which they will grow. In some cases, blowouts may result from removal of vegetation if the area is close enough to the shoreline and is subject to prevailing winds.

Changes in light, temperature, humidity and exposure to wind, as well as the resulting changes in vegetation will produce changes in animal species composition of the periphery of stripped areas. Because surrounding habitat is assumed to be at carrying capacity for all species, it will not assimilate fauna displaced by vegetation removal. Those animals are presumed lost to their own populations, but may become part of other populations through predation, disease, etc. Some decrease in species diversity as well as in individuals may occur as a result of decrease in habitat. Those species with spacial requirements which cannot be met after removal of a critical amount of habitat will no longer inhabit the area.

Those plant and animal species on the U.S. and Michigan's endangered and threatened species lists which may occur in sand dune areas. on Michigan's western coastline are noted in Appendix C. Habitat destruction in these areas may contribute to the decline and eventual extinction of some endangered and threatened species. Mitigation measures can be very important in reducing these peripheral effects.

2. Community Succession

Successional development within and peripheral to mining sites will be altered to promote earlier serial stages. Within the mining site itself, succession is likely to be very slow. A certain level of soil development will be necessary to advance beyond early stages. Even though surface material is removed, stored and eventually replaced during the mining process, a relatively long period is required to develop a soil layer which will support later successional stages.

Areas peripheral to mining sites will be subject to increased light, wind and temperature extremes. The extent of impact will depend on the size and location of the site relative to surrounding topography and wind direction as well as type and extent of surrounding vegetative cover.

Mitigate measures can greatly influence the extent of impact a~ well as the time required to return an area to acceptable levels of succession.

3. Unusual Aspects of Dune Communities

Perhaps the greatest impact will be a loss of many of the unique characteristics of a forested dune complex as described in Section IV, B, 3. The modified microclimate will be less evident, resulting in changes in biotic communities. Species diversity will decrease, eliminating many of those individuals of species at the northern and southern extremes of their ranges. In some cases it could eliminate the species itself from that range. Richly diverse biotic communities resulting from several thousand years of unusual successional development will be gone. These communities include high canopies, large individual trees, a number of dune specific hybrids, atypical associations and locally abundant pockets of rare and threatened species.

Impacts of these features are the most difficult to mitigate. In a system as fragile as dunes, preserving species and especially individual plants and animals is extremely difficult when changes take place.

C. AQUATIC

1. Water Quality

In general, sand dune mining will not result in many direct adverse impacts to water quality. The location and geophysical function of sand dunes preclude major impacts to either surface or groundwater.

In some instances however, the mining and preparation of sand for sale, and the alteration of topography can result in changes in water quality and the biota associated with it. The beneficiation process provides some potential for impacting water quality. At beneficiation sites, the residual clay, unusable sand fraction and additives (frothing and/or flotation agents) are retained in lagoons or discharged to surface water. The extremely porous and permeable sands of dune areas allows for loss of process water to the groundwater. In certain cases, seepage from lagoons, additive spills and process water transport may allow penetration of the overburden by contaminants to ground or surface water.

Along Lake Michigan, or any site for that matter, the introduction of chemicals into these ponds could result in groundwater or surface water contamination. Although the commonly used additives are not considered toxic, breakdown products of beneficiation chemicals could cause taste, odor, or color problems. Constituents of specific beneficiation processes will be considered site specific information. Information on certain patented additives is included in Appendix D.

2. Biotic Communities

Waterbodies within the watershed being mined could be impacted by a change in runoff retention time, removal of vegetation, exposure of more or less readable material or shift in land use.

An alteration in the physical characteristics of the watershed (e.g., clear cutting, etc.) will cause a shift in general water chemistry in such parameters as temperature, dissolved oxygen, suspended solids, BOD, pH, etc. as well as a possible change in direction or speed of flow. Because vegetation, invertebrates and fish (as well as other animals using surface water) are dependent on these factors, any changes may result in a shift in biota, depending on the dilution factor. In the case of more fragile systems such as first quality cold water streams, such shifts may adversely impact fish resources.

D. SOCIAL

Social impact evaluation is extremely difficult to quantify because, as pointed out in the study for Assessing the Environmental, Aesthetic, Social and Economic Impact of Sand Dune Mining, evaluation requires that choices be made through the comparison of unlike variables and because “a satisfactory medium of exchange which can be used to compare social utilities for non-market values is not currently available.”

Some values approach nearly universal appeal or are so widely adhered to that they are safe evaluative criteria. Examples of such agreed upon values include; health, income, jobs, safety, housing, nourishment, education, recreation, and many other quality of life dimensions. Yet, while few persons would prefer sickness to health, there is no consensus on exact relative rankings for such commonly held values. Only the direction of these impacts--positive or negative--can be indicated with certainty. “The problem of social impact assessment is not so much what we are doing to the environment; it is what we are doing to ourselves through the medium of environment by technological misapplications.” CC. P. Wolf, 1974, P.3)

1. Demographics

Sand dune mining is not expected to significantly impact demographics of the communities where mining occurs, unless important economic or land use impacts are associated with them. Since fewer than 400 people are employed by sand mining companies in Michigan, cessation, continuation or expansion of sand dune mining should have little impact on the immediate community demographics.

However, Michigan foundries, the major user of dune sand, employ 51,653 people in firms which are often geographically close to sand sources. Some secondary impact on area demographics could be experienced through a change in foundry sources of raw materials.

2. Land Use Patterns

Some impacts to land use patterns may result from sand dune mining. The predominant use of public land in the nine county area is recreational. Some private land is recreational and serves (along with the public land) area tourism. The largest single use of private land in these counties (excepting Mackinac) is farming. See Table 20.

If changes in microclimate occur in areas which are now farm or recreation lands, some changes may occur in use patterns. Microclimate changes may include increased wind and deposition of sand inland, which may effect agricultural production. Changes in humidity are also a potential problem for farmers.

Recreational land use may change somewhat as a result of nearby mining if microclimate changes are experienced. Wind and sand blowing, as well as visual and noise disturbances, may make adjacent areas less desirable for recreational purposes.

Potential land use impacts are presumed to diminish with distance from the point of primary ecological impact. Because sand dune mining occurs on relatively small specialized areas of land, any changes in land use are likely to be localized.

Correlation analyses from material in Table 20 indicate that county wide, no significant relationship exist between number of acres mined and acres of farmland or between acres mined and acres of public recreation land. The only statistically significant relationship apparent county wide is an inverse relationship between number of farm acres and number of recreation acres (r’m’-0.86, at 95% confidence level). No cause, effect or the lack of same can be construed from these data.

State Park use in dune areas was examined to allow a more localized view of potential impacts to recreation. Table 12 indicates visitor use in all State Parks which are within the nine county area and within two miles of Lake Michigan. Several parameters which may effect the number of visitors per acre were examined in correlation analyses. These include amount of park development (as for picnic area, beach, etc.), amount of water frontage, distance from a major road and distance from the nearest mining site. The only statistically significant correlation is between visitors per acre and amount of developed area, rin0.97 at 95% confidence level.

While other, less significant relationships may be present, no relationship is apparent between visitor use and distance from a mining site (r'~0.08). Again, cause and effect or lack of it cannot be assigned based on these data.

One factor which could be expected to effect visitor use is population. The majority of round trips to State Parks (62% according to the 1974 State Recreation Plan) are of 60 miles or less. Therefore, those parks with population centers within 30 miles could be expected to experience higher visitor use than those more isolated parks.

Land use impacts may occur on the mining site itself. Four depleted mining sites were examined to determine present use. Information on these sites is given in Table 21. The first site, a 240 acre tract in the city of Manistee has been zoned light industrial since cessation of mining five years ago.

Another site, Pigeon Hill on Muskegon Lake has not been mined since 1967. This area is currently zoned for single family residences. Although housing exists around the perimeter, the site itself, including Muskegon Lake frontage, is vacant. No services to the area (water, sewage, electricity, etc.) currently exist. However, the mining company still owns the site and plans for the area are not known. Two other depleted sites are currently within State Park ownership; a 444 acre parcel within Port Crescent State Park and a 30.8 acre parcel within Warren Dunes State Park.

3. Aesthetics

Aesthetic impacts must be considered an important but very subjective aspect of social impacts. Included in aesthetic impacts are those mining activities which assault the senses - sight, hearing, smell, and taste. Impacts to smell and taste may occur if byproducts of the beneficiation process migrate to water supplies, or if airborn pollutants from machinery and vehicles increase sufficiently. By far the most common objections are to visual and noise impacts.

Noise is considered to be any sound that may produce an undesired physiological effect in an individual and that may interfere with the social ends of an individual or group. The EPA has established 55 decibels as a reasonable average noise level for residential areas. As outdoor noise levels increase above this point, they are increasingly likely to interfere with speech communication, sleep, relaxation, and privacy, and result in community manifestations of annoyance. Table 22, allows comparison of common sound levels to Table 23, sound levels associated with sand mining. See also Figure 10.

Site	Location	Acres	Year Sold	Approx. $ / Acre	Current Use	Years Since Mined
Manistee	T 21N, R 17W, Sec 1 & 2	240	1970 (80 Acres)	*		05
Pigeon Hill	T 10N, R 17W, Sec. 28	72	N. A.			12
Port Crescent	T 18N, R 12E, Sec. 9	444	1976	3,400 (Lake Front)	Park	45
Warren Dunes	T 06S, R 2OW, Sec. 35	30.8	1968	812 (No Lake Front)	Park	17

* Deed indicates 80 acres sold for $l0.00 plus other valuable considerations.

Table 21. Depleted Mining Sites.

Sand dune mining operations create conditions of high ambient noise levels through the operation of heavy equipment during the mining, processing, and transport phases of the operations. The operation of a loader or heavy truck may produce an intermittent noise level approaching 100 decibels at 100 feet, and an average in excess of 75 decibels, particularly if inadequately muffled or maintained. This condition may be exacerbated if equipment is operated during hours other than the normal working hours (typically, 8:00 a.m. 5:00 p.m.), if the site is located adjacent to a residential area, and/or if transport is routed through residential areas. The majority of the sand dune mining operations propose long-term activities in or adjacent to areas suitable for or undergoing residential development, requiring consideration of noise abatement procedures where impact is determined to be excessive.

Sound levels will be influenced to some extent by atmospheric conditions. The following decibel levels were recorded without noting all possible conditions which may have affected the readings. It was done to gather a general idea of sound levels associated with sand mining.

Readings were taken at a Berrien County site, with a Bruel and Kjaer Sound level meter type 213H on June 27, 1979, between 11:30 a.m. and 1:30 p.m. There was a slight (about 15 m.p.h.) wind, clear sky and the temperature was 78^{0}F.

One of the primary functions of the dunes is in their aesthetic appeal to both local residents and tourists. That appeal is basically visual. Mining of dune areas destroys that visual appeal. Any mining in wooded dunes may destroy those unusual aspects of dune communities described in V, B, 3. Introduction of mining machinery along with removal of vegetation and leveling of topographic relief replaces a known appealing vista with one considered unappealing. Although some lessening of impact may occur through mitigation such as visual buffers and revegetation, aesthetic impacts and the attendant controversy remains largely unresolved.

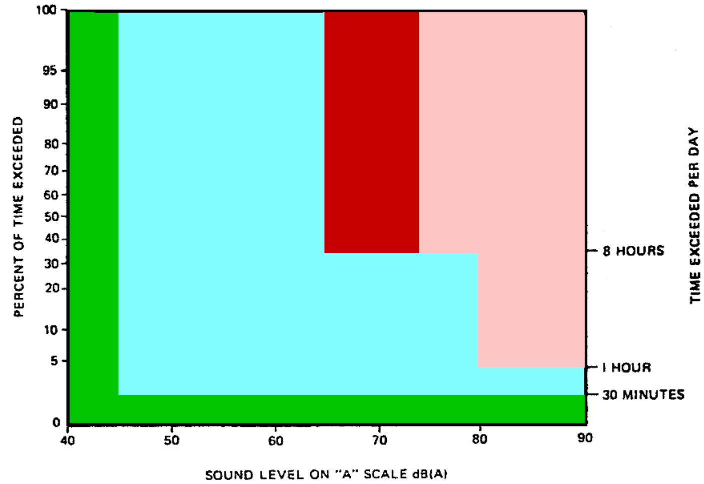
SPL, dBA	EXAMPLE
0	Threshold of hearing

10	
20	Studio for sound pictures
30	Studio for speech broadcasting
40	Very quiet room
50	Residence -
60	Conventional speech
70	Street traffic at 100 feet.
74	Passing automobile at 20 feet.
80	Light trucks at 20 feet.
90	Subway at 20 feet.
100	Looms in textile mill
110	Loud motorcycle at 20 feet.
120	Peak level from rock and roll band
140	Jet plane on the ground at 20 feet.

Table 22. Recognized Sources of Noise in our Daily Experience.

	Position of Meter	DBA
1.	Office site approximately 200 yds. from plant machinery.	58-60
2.	Operating payloader - approximately 50 yds.	80
3.	50 yds. from processing plant.	70-75
4.	50 yds. from bulldozer operating.	70-75
5.	30 yds. from processing plant.	70-75
6.	Immediately adjacent to processing plant.	87
7.	25 yds. downwind of processing plant.	70-74
8.	25 yds. upwind of processing plant.	62-64
9.	100 yds. upwind of processing plant.	55-60
10.	At gate of processing plant site.	45-50
11.	At gate of mining site (hydraulic jet mining).	50
12.	25 yds. from holding tank.	60
13.	At jet stream.	80
14.	25 yds. from jet stream.	72
15.	3 ft. from water pump in drain paralleling road at 5 ft.	73
16.	Sand truck (empty) accelerating from corner at 10 m.p.h. from I yd. away.	94
17.	25 yds. from 1-94.	75-80
18.	At shore of small inland lake in area.	50-52

Table 23. Sound Levels Associated With Mining.



green – acceptable
blue – normally acceptable
red – normally unacceptable
pink – unacceptable

Source New York State Department of Environmental Conservation, 1973

Figure 10 - Noise criteria.

County	Company	Site	# Employed
Berrien	Martin Marietta	Bridgman North	23
	Martin Marietta	Bridgman South	+35
	Martin Marietta	Nadeau	1
	Manley Brothers	Gulliver-Peters	*114
	Manley Brothers	Garage	*
Mason	Sargent Sand	Sargent Sand	31
Muskegon	Nugent Sand	Nugent Sand	+50
	CWC-Textron	Sherman Blvd.	
	CWC- Textron	Lake Harbor Road	10
Oceana	Hart Packing	Hart Packing	+12
Ottawa	Construction Aggregates	Ferrysburg	35
	Standard Sand	Standard Sand	+6
Van Buren	Manley Brothers	Busse	
	Manley Brothers	Rose	
	Manley Brothers	Nadeau	
Total			317

* Figure is for all five Manley Brothers operations in both Berrien and Van Buren.

Table 24. Full Time Employees in Sand Dune Mining Along Lake Michigan.

4. Economics

Potential impacts include both positive and negative effects on local and state economics. Foundries employ more than 40,000 people in Michigan and their sales within the State are greater than one billion dollars per year. A large proportion of these sales is to automobile manufacturers. Although the number of employees of sand dune mining operations is relatively small, (Table 24), secondary gains to the economy through the foundry and automotive industries (among others) are relatively large.

Tax rates (Table 25) of sand dune mining townships were compared with lakeshore townships without mining operations. The average taxation rate per $1,000 in townships with mining operations (~39.63) is slightly lower than the average taxation rate per $1,000 in townships without mining (~4l.43). It appears then, that the presence of mining within a township ordinarily will not negatively impact (and may positively impact) the local tax base.

No economic impact is indicated when comparing county personal income with the number of acres owned or leased by mining companies (Table 1).

BERRIEN COUNTY	
Benton	$46. 65
Hagar*	$39. 81
Lake**	$22.16
Lincoln*	$43.40
New Buffalo	$38.14
St. Joseph	$49.54
MASON COUNTY	
Hamlln*	$28.94
Pere Marquette	$28.94
MUSKEGON COUNTY	
Norton Shores**	$51.28
Fruitland	$42.86
OCEANA COUNTY	
Benona	$34.64
Golden*	$37.05
OTTAWA COUNTY	
Grand Haven*	$38.10
Park	$44.54
Port Sheldon	$39.60
Spring Lake*	$44.36
VAN BUREN COUNTY	
Covert*	$51.58
South Haven	$47.96

* Township with one mining operation.
** Townships with two mining operations.

Table 25. Township Tax Rates Per $1,000 in 1978.

An impact to agricultural crops may result from changes in microclimate brought about by mining. However, no county wide impact is evident by comparing farm cash receipts of the nine counties with the number of acres owned or leased by mining companies (Table 19). The greatest farm cash receipts appear to be in the counties at the southern extreme of Lake Michigan, irrespective of mining acreage within the counties.

Because the tourist industry and sand mining industry compete in part for the same resource, some impact to tourism may occur as a result of mining. There are more than 10,600 tourist related jobs within the nine county area. Income derived from those jobs is indicated in

Table 19. A significant correlation exists between number of acres owned by mining companies and tourist income within the county (r =.77 including Mackinac County or r=.75 excluding it. Exclusion seems appropriate since no mining has yet occurred on the Mackinac site.) This correlation may exist because the resource which attracts mining also attracts tourism. On a county wide basis, no impact is apparent. If county wide impacts occur to the tourist industry, they are obscured by unknown factors. However, localized impacts, within sight and hearing of mining activities may be felt by the tourist industry.

A major concern has been expressed regarding possible diminished property values resulting from mining activities. While no studies have been undertaken to verify these impacts, discussions with land appraisers in the Lake Michigan area indicate that property values may be effected under certain circumstances. If the mining operation is in close proximity to the reality in question, that is, close enough to be visible or audible from a residential property, that closeness may affect the property marketability. Additional truck traffic may be perceived as both a safety as well as a noise problem, which may also effect marketability.

Table 26 indicates recently bought or optioned Lake Michigan properties and their relative dollar values as well as their distance from the closest mining site.

County Where Located	u/Foot of Frontage on Lake Michigan	Front s/Acre	Ratio of Nearest Mining Foot :Acre	Distance From Site in Miles
Manistee	87	1,302	15:1	
Mason	116	1,106	10:1	3.5
Manistee	105	3,686	35:1	0
Muskego n	400	1,373	3 1/2:1	10
Muskego n	290	6,184	21:1	2
Ottawa	182	5,936	36:1	4.5

Table 26. Lake Michigan Properties Bought or Optioned within the Last Six Years.

VI ALTERNATIVES TO SAND DUNE MINING

Finding alternatives to dune mining for industrial sand uses is an important goal for the people of Michigan. Some information is now available but much more needs to be understood. Additional information as well as economic incentives for use of feasible alternatives are needed. Otherwise, no practical development of those alternatives will occur.

There are four identifiable alternatives to the utilization of dune sand for industrial use. These alternatives are as follows: (1) dredge sands acquired from Great Lakes bottom lands, (2) sands obtained from inland deposits, (3) reclamation and recycling, (4) technological advances of the foundry industry.

In view of the fact that the foundry industry is the major consumer of this resource, it is prudent to focus on those alternatives which would allow this industry to continue to function. It is recognized that alternative sources of sand do exist; however, the major stumbling blocks thus far have been economic.

Michigan's industrial sand extraction operations are shown in Figure 11. Included are mining of dune sand, lake dredging, inland sand and sandstone.

A. OFF-SHORE DREDGING

Sargent Dredging Corporation has extracted sand from the Saginaw Bay since 1932. The DNR recently studied this operation to determine 1-possible destruction of fish and aquatic life habitat, 2-elimination of potential spawning grounds and 3-degradation of water quality. The results of this study are included in Appendix E.

A yearly average of nearly 600)000 cubic yards of materials is dredged by the U.S. Army Corps of Engineers in the Lake Michigan sand dune region for purposes of navigation. See Figure 12. Potential offshore sand deposits are shown in Figure 13.

Disposal of these dredge spoils, predominantly consisting of sand, depends on their quality. Contaminated materials are confined in sealed, diked disposal facilities, and uncontaminated materials are generally used for erosion control, beach nourishment or open lake disposal.

Use of dredge spoils could prevent the “loss” from dumping in deep water areas, as well as prevent further degradation of the sand dunes.

Studies could be undertaken to determine whether the quality of the Corps dredged sand is suitable for casting and whether mildly contaminated sand could be used in casting operations. Testing for contamination is done regularly by the EPA but there are no specific tests which are pertinent to use of the material in casting for auto parts.

This alternative will be considered in the upcoming Department study of alternate sources of casting materials for industry. The Economic and Environmental Assessment of Offshore Sand Mining makes certain conclusions regarding the feasibility of this method as a supplement and/or replacement for dune mining.

The Assessment concluded that economically, the offshore dredging of sand in Lake Michigan is feasible given existing market conditions and potential operating Costs. Should traditional sources of industrial and construction sand - most notably the dunes of the western coast of Michigan - become either depleted or unavailable for any reason (such as land-use shifts or management actions), the exploitation of offshore sources becomes economically even more feasible. The above mentioned study suggests that a greater data base is necessary than is now available. However, it tentatively concludes that offshore mining in 30 to 100 feet of water would produce clean sand with low clay and silt content, low benthic populations and would not interfere with the littoral drift of the nearshore area. Mining in deeper water would increase percentages of clay, thus increasing potential for toxic chemical resuspension and more fertile benthic habitat. Mining in water less than 30 feet deep could adversely effect the longshore processes and could accelerate erosion.

Means are now available to determine composition, acid demand and angularity of off-shore reserves. One sample study including off-shore sand between White Lake and Grand Haven is summarized below. (Table 27.) Composition appears to be of a lower quartz content than dune sands.

Mineral	Mean	Range	
		High	Low
Quartz (SiO_2)	80.3	87.0	58.1
Albite ($NaAl\ Si_3O_8$)	6.2	14.9	1.7
Microcline ($KalSi_3O_8$)	6.3	8.8	
Calcite ($CaCO_3$)	2.2	20.5	
Dolomite [$CaMg(CO_3)_2$]	5.6	22.7	0.9

Table 27. Percent Composition-Offshore Core Samples from Lake Michigan

Most of the samples fall within the range allowable for low-temperature castings, but none of the samples contained the 96% or better required for high-temperature castings for the foundry industry. Class sand requires higher quantities of silica than are available in these samples (up to 99%).

Grain size is another important characteristic. The sand from these cores generally meets this criteria although the ranges are fairly narrow and skewed slightly to the coarse end of the size range.

The acid demand value (ADV, Table 28) provides the foundry with some insight as to the quantity of catalyst required for binder. Unfortunately, the ADV is not uniform within a deposit or between deposits. This lack of uniformity generally requires that some beneficiation be accomplished by the producer. This not only makes the ADVs more uniform, but also reduces the ADVs so that they are close to 0 (which is the optimum value).

These values are very high so that beneficiation of the sand would be required.

pH	Mean	Range	
		High	Low
3	35.95	63.33	12.50
5	34.57	61.33	11.50
7	33.51	59.83	11.00

Table 28. Acid Demand Values (ADV).

Therefore, although this sand is not ideal sand for all industrial uses, it can be generally concluded that the offshore reserves between White Lake and Grand Haven, Michigan are suitable for many industrial uses. Some beneficiation may be necessary to reduce the ADV and albite content.

B. INLAND SAND

Other alternate sources of sand are inland dunes, glacial outwash and sandstone. Sand from inland dunes closely resembles the coastal dune sands and therefore, are believed to be a prime potential alternative industrial sand source. Some increase in contaminants is evident, necessitating beneficiation of sands from this source.

Heavy concentrations of inland dune deposits occur in three very general areas: (1) western lower Michigan, particularly around the Muskegon area; (2) the Saginaw Bay area and (3) the eastern Upper Peninsula. These three areas are considered to be the most promising, largely because of greater concentrations of sand.

The inland dune areas are all characterized by having little relief, being moderately to poorly drained, and occurring generally at low elevations. The above features are consistent with the fact that these same areas were covered after the retreat of the last glacier by the ancestral Great Lakes. The dunes developed along the beaches and lake deposits which formed throughout these areas during the various stages of fluctuating lake levels. None of the inland dunes are as large as the present coastal dunes, primarily because the present lake levels have been relatively constant for a much longer period of time than any of the older higher levels. Glacial outwash deposits cover- an extensive area in Michigan. The properties of these deposits are much more varied than inland dune and range from clean fine sand to sandy clay to “dirty” gravel.

Surface exposures of sandstone are very limited in Michigan due to the extensive glacial cover, and of the sandstones which are exposed, most do not appear to be suitable for industrial sand uses. The known exception is the Sylvania Sandstone which outcrops in Wayne and Monroe counties and is quarried near Rockwood in Wayne County. This is an exceptionally silica pure, friable sandstone and is used only in the manufacture of glass. Other industry sources which should be mentioned are olivine, zircon and chromite, none of which are economically feasible as a replacement for dune sand in todays Michigan market. The primary reason for this is transportation cost.

Olivine is a mineral composed of iron and magnesium chemically combined with silica. The composition varies between iron-rich and high magnesium content. Forsterite, the magnesium-rich variety of olivine, is the only one with sufficient refractoriness to be usable as a foundry material. Forsterite fuses at 3316^{0}F. It can be used in producing stainless steel castings because it is not attacked by manganese oxide which is associated with the process. In Sweden, olivine sands have displaced silica sand for all types of casting, and in Great Britain every effort is being made to convert to the use of zircon, chromite, and olivine.

Zircon sand is composed of grains of almost pure zirconium silicate. This material is used because of high refractoriness (fuses at 3676^{0}F), good thermal expansion properties, and higher heat conductivity which promotes more rapid chilling of the castings. Deposits are found primarily in Australia.

Chromite is effective in casting stainless steel. It has good chilling properties, does not combine chemically with molten metal and is more resistant to metal penetration than either silica or zircon, thereby producing smoother surface finishes.

C. RECLAMATION AND RECYCLING

Foundries are one of the few industries that use sand without consuming it in the manufacturing process. Thus, foundries have an opportunity to recycle the sand as well as the problem of eventual disposal.

Sand used in the formation of casting molds and cores can be recycled until it becomes unusable through agglomeration or excessive coating of deleterious materials. Sand recycling technology has been advanced in recent years by the development of methods of cleaning and recovering sand particles.

A primary objective of reclamation, for the foundry industry, is to reduce the operating costs of providing high quality sand for casting. Two factors must be considered in determining the economic feasibility of reusing sand: I. The properties of materials (sand plus binder) to be reclaimed and; 2. What the product is to be used for. Initial outlay as well as operating costs will depend on those considerations.

Simple reclamation systems are based on the recovery of a single system sand -- that is, a sand system using only one binder. If more than one binder, or more than one size and shape of sand are used, complexities and costs rise.

The chemical and physical properties of the sand and how they may change in the reclamation process must be investigated. Since each may have to be treated differently, it is necessary to determine what components are present and in what quantities before the equipment can be designed.

Sand reclamation systems fall into three basic processes: 1. Thermal reclamation, 2. Wet reclamation, 3. Dry or mechanical reclamation.

In concept, the thermal process is simple. The granular used sand is burned in a furnace long enough to reduce the organic coating to a vapor. The sand then should be as pure as it was when it entered the system, slightly discolored, but with little evidence of carbon on the grain itself.

Incomplete combustion leaves carbon in the grooves of the grain, as can be observed through a microscope. This carbon residue generally is the result of shortening the time the sand is in the combustion chamber. Under the right conditions, it is difficult to tell the difference between a new sand and a thermally reclaimed sand, except for a slightly darker color in the reclaimed sand.

In general, the combustion chamber reaches temperatures from 1,200^0 to l,700^{0}F, depending on the furnace and the type of sand in process. Currently two types of furnaces are in use, the open hearth or Herreschoff type and the newer, fluidized bed type. With both, dry, granulated sand enters a preconditioning chamber operating at 600^0 to l,000^{0}F, depending on the furnace. The sand either is dropped to the heart of the furnace, where the temperature reaches the l,700^{0}F level, as in the Herreschoff furnace, or is transferred to the main combustion chamber for complete burning of the organic binder. Sand then is collected, cooled, and stored for reuse.

Thermal reclaimers can be adapted to reclaim all types of mixtures of bonded sand with the exception of inorganic silicate-bonded sand. The most common mixture is an organic bonded core sand and a clay bonded molding sand. The intense heat of the thermal reactor will burn the organics and dehydrate any clay entrained with the sand.

Thermal reclaimers deliver sand with essentially zero organic residual, as pure as new sand, but much more stable. Dimensional tests on cores made with both reclaimed and new sand prove that castings are within the tolerance more often with reclaimed sand than with new sand. These systems have very little sand loss; usually, only system losses occur.

Thermal systems use a lot of energy, however. Theoretically, a sand with a high enough organic residue could operate without additional fuel, except for the startup requirements. This is not quite the situation in practice. One never can be totally sure that the sand feed always will have the minimum organic residue. Usually natural gas is used as the fuel, although oil is readily adaptable. Thought has been given to the use of powdered coal as a substitute fuel, too.

As the sands to be reclaimed become more and more complex, thermal reclaimers of sorts will play important roles in the total recovery of sand if foundries continue to operate as they do today. If energy reserves are too limited for this procedure, better control of separate sand systems will be necessary to simplify reclamation systems.

Care must be taken when thermal reclamation is considered because of the potential chemical change that can occur within the grain. Depending on the source of new sand, this effect could have adverse reactions on the ADV of the returned sand, causing an original sand with low ADV to return as a reclaimed sand with high ADV.

Perhaps the first large-scale systems to be considered were wet systems. They were developed because it was desirable to recover and clean all traces of clay from the sand grains so that the sand could be reused in cores. These systems were developed for large core operations -- automotive for example -- and were in capacities of 25 to 40 tons per hour.

The equipment processed the sand in much the same way that a laboratory clay wash test would be made, but on a large scale. When water is agitated with the sand, clays become saturated, losing bonding capability, and lift off the sand grains. Similarly, burned organic residue of binders or additives come free of the grains and are separated from the cleaned sand. The sand is dried, screened, and returned to storage.

Although a high-quality sand is produced, the system has drawbacks. The agitators are high-wear items, and the problem of disposal of the sludge becomes difficult as the volume of sand increases. Foundries using this process generally maintain settling ponds where the sludge can settle and be removed periodically. The water either is recycled or is treated before disposal to prevent undesirable leachates from entering waterways or public water systems.

Perhaps eight or ten major systems based on the wet system are in operation, although not of recent vintage. This type of reclamation is expensive, not only because of the necessity to treat large volumes of sand and water, but also because of problems in disposal of contaminated wash water.

It further is ineffective in treating the organic no-bake or resin-type core binders, which are insoluble in water. Acceptance of shell resin-coated sands, hot box resins, and resins that require no heat for settling for use in cores is making these systems obsolete because of the expense of maintenance and operation. Water does nothing to these water-insoluble resins. Another means must be used to treat and reclaim such sands.

In the last few years, some experimental work has been done with wet reclaimers in the reclamation of silicate-bonded sand. Sodium silicate binders never really have come into wide acceptance in the United States, partly because of difficulty of reclaiming sand so bonded, but OSHA problems seem to be creating awakened interest.

This type of binder never enters a complete reaction, it does not become inert, but always remains active. As a result, the binder layer is flexible, not brittle, and mechanical systems cannot remove enough residual silicate for effective re-use of the sand.

Subsequent silicate coatings therefore build until there is slippage between the layers, preventing use of the sand to make cores with integrity. Mechanical systems can reintroduce only about 50-60% of the reclaimed sand to the system before the rebonding fails or the casting surface tends to deteriorate because of the buildup of alkali (Na_2O) in the sand.

Small wet reclaimers are being used because the silicate binders are water soluble. Mixtures of used to new sand in the order of 90% to 10% are claimed for these experimental systems. These units are smaller, in the 3 to 5 tons per hour range. Again, drawbacks seem to center on treatment of wash water and sludge.

Several dry or mechanical methods are used, some in combination with other systems. Early reclamation systems purchased as a package primarily were crushing systems in which the sand lumps were reduced to grains and reused with new sand to make up for losses. Little consideration was given to the shape of the grain as it came from the reclaimer or how that shape would change during rebonding with the organic binders. More recently, additional reconditioning of the sand is accomplished through the addition of classifiers and scrubbers.

Without such steps, residual organics built up on the grain until strength of the rebonded sand failed, and then perhaps a large volume of new sand was added to the system. The problem then went away immediately when the residual organics, as measured by the loss-on-ignition test, were diluted by the new sand. This cycle continued because the inert cured binder that remained on the sand was not controlled.

Because the pneumatic scrubber had been used extensively in steel foundries to remove dehydrated clays and other contaminants, it naturally was put to use to scrubbing the organic residue. This adaption proved that there was a reduction of organic residues on the sand grain, and dry scrubbing was achieved . The amount of residual organics left on the grain depended on the energy expended. The cleaner the sand required, the longer the grain had to remain in the cell.

In this process sand is entrained with the airstream and pushed against an impingement cap. The grain goes through a sand-on-sand scrubbing and a sand-on-metal impingement. The deflector plate either passes the grains on or holds them in the cell for additional cleaning, depending on the plate angle.

Flow rates depend on the cleanliness desired, and this unit will deliver high quality sand at a rate of 800 to 1,000 lb. per hour per cell or lower quality sand at a rate of up to 4,000 lb. per hour per cell. Capacity of the pneumatic scrubber depends on the number of cells in the system and the air velocity developed by the fan.

A further development of a scrubber is a mechanical/centrifugal device. In this application, a motor-driven impeller replaces the pneumatic tube. Sand is fed to the center of an impeller that spins off the sand grains, hurling them at an impingement ring for sand-on-metal impact. Sand thrown off the impeller meets and scrubs sand cascading from the impingement ring. While this action is occurring, air is drawn through the sand mass, removing the small particulate from the sand, be it either organic binder flakes or dried clay.

An advantage of this scrubber is that lower horsepower performs effective scrubbing. Quality of the sand coming from a reclamation system that includes a scrubber is substantially higher than that of sand produced when a crusher or lump reducer is used alone.

Steps in reclamation involve: 1. Removal of the casting from the sand. 2. Granulation of lumps. Crushing is not the best approach. Vibratory machines into which lumps and loose sand are fed are more effective because they do not powder the sand. Good castings cannot be poured with lumps at the mold interface. 3. Cooling the sand. Regardless of which binder system is used, there is an optimum temperature at which the sand will develop the best qualities in the core or mold. 4. Scrubbing the grains. Positive scrubbing of sand grains controls contaminants in the system. In no-bake sand reclamation, the scrubbing device controls the buildup of organic residual. Whether mechanical, centrifugal, or pneumatic, the scrubber should have a predictability as to the amount of contaminant it can remove from a reclaimed sand. It is this predictability of binder or clay removal that makes an effective reclaimer. The equipment system must deliver the same screen distribution that was available when the sand first entered the casting operation. Control of agglomerates and fines is necessary to make the process effective. Reclamation of 95% of the sand wastes money if the sand returned is 50% fines. 5. Classification①

Recycling is still not often economically advantageous for foundries manufacturing automobile components. The cost of recycling one ton of sand often exceeds the purchase price by 2 1/2 times; and the cost of disposal amounts to less than one-half of the purchase price. Increasing environmental awareness, concern for resource depletion, and opportunities to reduce costs and increase quality serve as incentives to continue research in sand recycling.

① Marvinney, A.A. 1979 Reclaiming foundry sands. Foundry Management and Technology, Cleveland, Ohio, August, 1979 pp. 26-40. Portions reprinted with permission.

Results of a survey of foundries using dune sand support the feasibility of recycling. Nearly 50 percent of these foundries employed recycling in their operation. They recycled the same sand an average of 7.5 times.

Dune mining operators hold an estimated recoverable reserve of 256,765,000 tons from both active and inactive sites. Based on demand figures, the estimated recoverable reserves will be depleted between the years 2000 and 2010.

A number of factors will ultimately affect future demand for dune sand. The U.S. Bureau of Mines reports that the trend in casting appears to be toward favoring use of molding materials which are more heat resistant than silica sand and use of permanent molds made of high temperature ceramics. Advances in recycling technology have potential for decreasing demand for sand by foundries. Changes in the automobile industry, as dictated by the national energy situation, will undoubtedly have an impact on dune sand consumption. Smaller engines and the increasing use of plastics and other light-weight materials in automobiles may curtail demand for dune sand used in casting. Feasible resources will be further explored in the study required by Act 222, Sec. 3Ce). As previously mentioned, this study is in negotiation stages now and should be initiated within the 1980 fiscal year.

VII MITIGATION

Effects of mining, especially within a barrier dune, can be lessened by consideration of the functional aspects of the particular portion under application. If, in the Department's judgment, a portion of a barrier dune can be mined without impairing dune function, such mining may be permitted.

Reclamation is the key to mitigating many impacts of mining. Angle of slope and stabilization of the dune are crucial elements in restoring a somewhat fixed aesthetically acceptable land form.

Recommended reclamation procedures have been developed by condensing informational materials provided by the Soil Conservation Service. These are included in Appendix F. All mining plans submitted by permit applicants must include a schedule of reclamation. No new cell beyond the three allowed may be prepared for mining until satisfactory reclamation of one of the current cells has occurred. The usual plan includes initial stabilization with grass, followed in two years by plantings of trees.

A. PHYSICAL

1. Geology

Topographic and erosion impacts such as blowouts will be reduced by stabilization of one of three operating cell units prior to movement into another cell unit. Stabilization will be accomplished through grading, planting and mulching. Effectiveness can be augmented by placement of snow fencing leeward of disturbed areas. Ikwever, changes in existing geological formations will occur.

2. Hydrology

The primary concern of fluctuating water levels regards potential impacts to local wells and recreational surface waters. These impacts can be minimized by consideration of the following information during development of mining plans: 1) groundwater table map; 2) permeability of material; 3) location, depth, static level and pump setting of wells in the area and, 4) existing surface waters.

If determination is made that a likelihood of impact to private or public water sources will occur, the permit applicant will be required to change the plans to accommodate existing use of the resources.

3. Climate

Those impacts to area microclimate may be lessened by providing for wind screens in the form of vegetation and snow fencing. In cases where forested dunes are disturbed, microclimate impacts will be difficult to mitigate. Changes will be less severe in areas that have already been subject to human or natural disturbance.

1. Biotic Communities

The extent to which the effects of land disturbance are felt within the plant and animal communities in areas peripheral to mining can be somewhat reduced by early stabilization. Although impacts will still occur, the distance over which they occur may be reduced by effective stabilization. Those protected plants which are in areas scheduled for devegetation may require removal to other areas. In these cases, a qualified botanist flags all plants, acquires a collecting permit from the Department of Natural Resources, and transfers those plants to more protected area or park lands.

If critical habitat for a protected animal species is found to be included in the cell unit plan, that plan will be altered to exclude the habitat considered critical.

2. Community Succession

Late serial stages are not always preferred. In most cases, a preferred stage is the result of other goals involving Wildlife management, timber harvest, recreation needs, etc. Later serial stages will develop in time if areas are undisturbed. Mitigation measures, such as tree plantings, will probably have little effect on successional development. However, if dunes are stabilized with grasses quickly after disturbance, this will initiate serial development more quickly than would otherwise occur.

3. Unusual Aspects of Dune Communities

For those areas which are highly unusual, avoidance appears to be the only effective mitigation. Acceptable cell unit plans will omit those areas which the Department feels are highly unique and valuable biologically.

C. AQUATIC

1. Water Quality

Impacts may be considerably reduced by lining lagoons with bentonite or clay. Some seepage will still occur through transport and spillage of process water, but the impact will be considerably less.

2. Biotic Communities

These impacts can be considerably reduced by maintaining a buffer zone of vegetation along the water perimeter and by grading so that runoff will not directly enter the surface water, but will percolate through as groundwater. Determination of groundwater flow and watershed characteristics will also help to minimize impacts. Again, stabilization of disturbed areas will reduce impacts.

1. Land Use Patterns

Impacts to land use patterns which are undesirable may be minimized by planning (prior to mining) for secondary use of the site. Impacts to land use adjacent to sites may be reduced by maintaining visual buffers and by reducing the noise of operations.

2. Aesthetics

Auditory and visual impacts can be considerably reduced in the following ways:

There are basically three approaches to noise abatement which can be applied to reduce the noise emissions from mining sites.

Site Restrictions - (achievement of noise reduction by requiring a modification of the time, place, or method of operation of a particular source). Methods available range from prohibition of operation within a specified distance from a residence to a requirement that major activities take place only during normal working hours. Other methods which may be appropriate in a given set of circumstances include: (a) vegetation or other natural shielding between the site and residential areas. Given the long-term nature of sand dune mining, this may be one of the most appropriate and effective methods. (b) truck rerouting; essentially, the avoidance of residential areas by trucks either transporting sand or returning empty. (c) equipment relocation; this involves the relocation of loading, processing, and other concentrated noise centers to points behind natural barriers or further away from residential areas.

Equipment Noise Control - (where equipment is not permitted to produce noise levels in excess of specified limits). This approach is generally effective in producing immediate noise reductions when the overall level is not severe, though is of increasingly limited application the greater the reduction in noise desired. Methods for reducing equipment noise include:

(a) Requirement of adequate muffling devices, both for engine emissions and moving parts;

(b) Proper maintenance, fastening, and lubrication particularly of chain, shielding, and other vibrating parts can significantly reduce noise levels;

(c) Reduction of rates of speed, particularly of engines and of transport equipment, may serve as a means to reduce noise. An appropriate use of this method is the reduction of speed limits during passage through residential areas.

Personnel Training (operators and supervisors are made more aware of the noise problem, and are instructed in methods such as those mentioned, to reduce noise levels in the community). This may be one of the most cost-effective, yet most often neglected, noise abatement measures. These same measures may be taken to reduce machinery induced airborn pollutants.

Several Department procedures are geared to mitigating visual impacts of mining.

(a) Grading markers are placed (with a Department representative present) to conform to natural contours. This is to eliminate a straight cut, or boxy effect on remaining slopes;

(b) If there is existing woody vegetation in a buffer zone, it must be left intact. This provides a visual screen to mining activities and is less expensive to the mining company than a replanting and mulching program. However, in areas where no visual barrier now exists, it may be years before that buffer zone will have sufficient woody vegetation to provide a satisfactory visual screen;

(c) Visual aesthetics are given consideration in permit application review. Delineating of cell units may be revised to ameliorate a potentially important visual impact.

3. Economic

Sand dune mining may create a negative impact on local tourist industries. Conversely, a positive impact may be experienced by Michigan foundry and auto industries.

The administration of Act 222 itself should help to lessen impacts on tourism. Controls which were not present prior to implementation of Act 222 will prevent some of the unregulated mining which has occurred in some cases in the past.

A major impact to Michigan’s economy could occur if all sand dune mining were to stop before some other economically feasible alternative to dune sand is available to the foundry and auto industries. It is hoped that in the near future (partially through a study initiated by the Department) feasible alternatives will gain increasing acceptance and will thus reduce the need to mine dune s.

A great deal of public controversy has been present over sand dune mining. Act 222 is itself a result of emotional fervor over the loss of dunes to mining.

The controversy centers around two major issues: 1. Concerns regarding loss of aesthetic appeal, and 2. safety concerns. While aesthetics are undoubtedly the primary issue, and many other objections would dissolve with the satisfactory resolution of that issue, it is most difficult to assess the impact of the loss of an aesthetically important entity. However, Act 222 requires that consideration be given to aesthetics in administering the program.

The most often vocalized issues of aesthetics are: 1. The depletion of a unique resource (primarily visual), and 2. noise involved in operation and traffic (auditory). The unique resource is considered the dune itself, not necessarily its constituent parts. The topography appears to be crucial. Observations indicate a relationship exists between height and expanse of the dune and the public opposition which accompanies proposed mining.

Along with height and expanse of the dune are the unusual vegetative combinations and resultant fauna of dune ecosystems, especially wooded dunes. Although many people do not know what happens to the fauna of a mined area, they do understand that the vegetation is destroyed. Revegetation, even with trees, is unsatisfactory to many because of the loss of height of the dune and the resultant level appearance. In addition, while some vegetation and fauna may not be unique, old, mature hardwoods are not replaced in a short period of time even with the best reclamation program.

Concern over noise of operations is the other major component of aesthetic issues. This involves the operation of equipment on the mining site and transporting of sand from the site. Mining operations in many cases occur around the clock. Sounds associated with mining which seem tolerable during daytime hours may be less tolerable at night.

Both aesthetic issues and safety concerns are vocalized most often. Traffic also appears to be a major part) and in addition, there is concern over the possibility of injury or death to children playing in mined areas due to air pockets in disrupted sand and instability of trees where roots have been cut.

Public hearings are held prior to issuance of each permit. In one such meeting which generated much public opposition, the following reasons for opposition to sand dune mining were given: Comments are listed in order of decreasing frequency.

1.	The dunes are unique and beautiful.
2.	The environmental impact statement is deficient.
3.	Traffic increase will create safety and noise problems.
4.	Mining will completely deplete a resource.
5.	The proximity of mining disrupts life as “I” want to experience it.
6.	Dunes should have a different use, like recreation.
7.	The studies required by Act 222 have not been completed.
8.	Blowing sand is a nuisance.
9.	Barrier dunes protect the inland areas.
10.	It causes water pollution.
11.	It causes water level changes.
12.	The animals will be gone.
13.	The DNR has inadequate policing powers to insure the conditions of the ETS.

Numbers 2, 7, and 13 of these comments may actually be aesthetic grounds. Numbers 1, 4, 5, 6, 12 and part of appeals to aesthetic concerns. Numbers 3, 8, 9, 10 and 11 involved beyond, but in many cases including aesthetic values.

It is not entirely understood what part opposition represents, although one study extent of opposition has been conducted for objections on 13 are open have factors of the population the vocal geared to understanding the one site.

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APPENDIX A - Selected Tables

Company	(IF ANY)	COUNTY	Township	(I)	1	2	3	SAND USES
Auto Specialties	Thunder Mt.	Van Buren	Covert	I	± 132.8	0		
Construction Agg.	Ferrysburg	Ottawa	Spring Lake	A	320	90	Dry	Molding
Cwc Textron	Sherman Blvd.	Muskegon	Norton Shores	A	85	30	Dry	Molding Glass Blast
Cwc Textron	Lk. Harbor Rd.	Muskegon	Norton Shores	A	19	19	Dry	Molding Glass Blast
Hart Pkg.	Oceana Golden			A	400	280	Dry	Molding
Martin-Marietta	Bridgman S.	Berrien	Lake	A	253	144	Dry	Glass Molding
Martin-Marietta	Bridgman N.	Berrien	Lake	A	210	87	Dry	Glass Molding
Martin-Marietta	Nadeau	Berrien	Hagar	A	265	165	Dry	Glass Molding
Manley Brothers	Gulliver- Peters	Berrien	Lake & Lincoln	A	144	93.1	Hyd.*,	Molding, Furnace, Engine
Manley Brothers	Garage	Berrien	Lake	A	36	9.68	Dry	Molding, Furnace, Engine
Manley Brothers	Rose Pit	Van Buren	Covert	A	55	44.58	Dry & Dredge	Molding, Furnace, Engine
Manley Brothers	Nadeau Pit	Van Buren	Covert	A	180	160.96	Dry	Molding, Furnace, Engine
Manley Brothers	Busse	Van Buren	Covert	A	37	36.4	Dry	Molding, Furnace, Engine
Nugent		Muskegon	Muskegon	A	400	+ 250	Dry & Dredge	Molding, Engine, Blast
Sand Prod. Corp.		Mackinac	Moran	I	± 1,552			A
Sargent Sand Co.		Mason	Hamlin	A	20	534	Dry & Dredge	Engine, Metallurgical
Standard Sand Co.		Ottawa	Grand Haven	A	3OO	130	Dry	Molding, Engine

1. Number of Acres Owned or Leased
2. Number of Acres Planned for Mining
3. Methods

* High velocity stream of water sprayed on sand to create slurry.

Table 1. Mining Operations under Jurisdiction of Act 222.

	AGE (1975)							
	0-17		18-64		65+		Total	
	M	F	M	F	M	F	M	F
Allegan	12,265	11,803	18,730	19,039	4,081	4,310	35,076	35,152
Berrien	29,498	28,386	44,284	46,598	6,807	9,682	80,589	84,666
Mackinac	1,832	1,762	2,630	2,940	965	1,040	5,427	5,742
Manistee	3,508	3,376	5,592	5,588	1,742	1,968	10,842	10,932
Mason	4,126	3,970	7,650	7,613	1,056	1,257	12,832	12,840
Muskegon	28,333	27,266	42,014	45,421	6,002	8,476	76,349	81,163
Oceana	3,869	3,723	5,618	5,772	894	1,094	10,381	10,589
Ottawa	26,948	25,933	38,079	38,246	4,606	6,096	69,633	70,275
Van Buren	10,746	10,342	17,445	17,247	3,159	3,661	31,350	31,250

Table 8. Age and Sex of Residents within the Nine County Area 1975 data.

Race / Sex 1970

	White		Black		Indian		Other		TSS
	M	F	M	F	M	F	M	F	
Allegan	32,040	32,807	566	522	126	106	208	236	1,085
Berrien	70,814	73,989	8,705	9,578	144	158	238	249	1,404
Mackinac	4,648	4,800	2	4	88	96	8	14	400
Manistee	9,692	10,161	47	29	68	52	22	23	400
Mason	11,036	11,347	66	44	46	50	9	14	400
Muskegon	68,134	71,765	7,987	8,735	221	251	156	177	2,221
Oceana	8,720	8,946	24 i	29	34	46	1	94	400
Ottawa	62,758	64,562	180	173	88	102	137	181	2,757
Van Buren	25,317	25,893	2,143	2,313	~ 92	113	159	143	599

TSS - Total Spanish speaking population

Table 9. Race/Sex Distribution within the Nine County Area.

County	Park-Year Established	Size (Acres)	Visitors 1978	Visitors Per Acre	% of Area Developed ‘	Visitor Capacity	Feet of Shoreline	Approx. Miles From Major ‘Road	Approx. Distance From Nearest Mining Site
Berrien	Warren Dunes 1949*	1,502	2,322,652	881	2.6	9,204	6,000	0	2
Mackinac	Straits 1924	180	357,435	1,986	18.9	2,888	1,500	0	25
Manistee	Orchard Beach 1921	200	103,566	518	10.4	1,420	2,800	0	20
Ma son	Ludington 1927	4,154	810,252	195	1.1	3,168	A’ 50,000	0	adjacent
Muskegon	Duck Lake 1974	610	52,482	86	0	NA	9,24p	5	8
Muskegon	Muskegon 1923	1,225	486,770	433	7.7	5,204	26,O0~0	0	2
Muskegon	Hoffmaster 1962	1,043	376,625	361	5.0	2,677	14,400	2.5	5
Oceana	Mears 1920	50	375,024	7,500	37.5	1,516	1,800	0	6
Oceana	Silver Lake 1920	2,686	764,870	285	1.0	3,548	25,500	0	adjacent
Ottawa	Holland 1926	143	1,695,926	11,860	42.7	4,320	2,500	9	17
Ottawa	Grand Haven 1920	48	761,250	15,859	56.25	3,544	4,350	4	2
Van Buren	Van Buren 1964	326	272, 781	837	7.4	2,900	2,900	0	2

* 30.8 Acres purchased in 1968 from Martin Marietta Corporation. Table 12.

Table 12. State Park Use.

County	Acres in County	Owned or Leased By Mining Company		Farmland 1969		Total Published Recreation Land	
		Acres	%Co. Total	Acres	% Co. Total	Acres	% Co. Total
Mackinac	648, 960	1,552*	0.24	28,479	4.4	340, 014	52.37
Oceana	343,040	400	0.12	131,414	38	52,426	25.27
Berrien	371,200	908	0.25	215,867	58	1,654	0.45
Mason	313,600	620	0.20	95, 760	30.5	63, 762	20.34
Manistee	353,920	240 **	0.07	68, 319	19.3	88, 032	24.87
(not in series)							
Van Buren	385,920	405	0.11	225, 042	58.3	904	.23
Allegan	528,640	0	0	275,652	52.1	44, 901	8.50
Muskegon	320, 640	540	0.16	71, 556	22.3	22,828	7.11
Ottawa	360,320	620	0.17	176, ~62	49	2,532	0.7
Totals	3,626,240	5,009	0.14	1,288, 751	35.5	617,053	17
			of state total		of state total		of state total

* Has not yet been mined.
* Has not been mined since 1974.

Table 20. Major Land Use in Nine Counties.

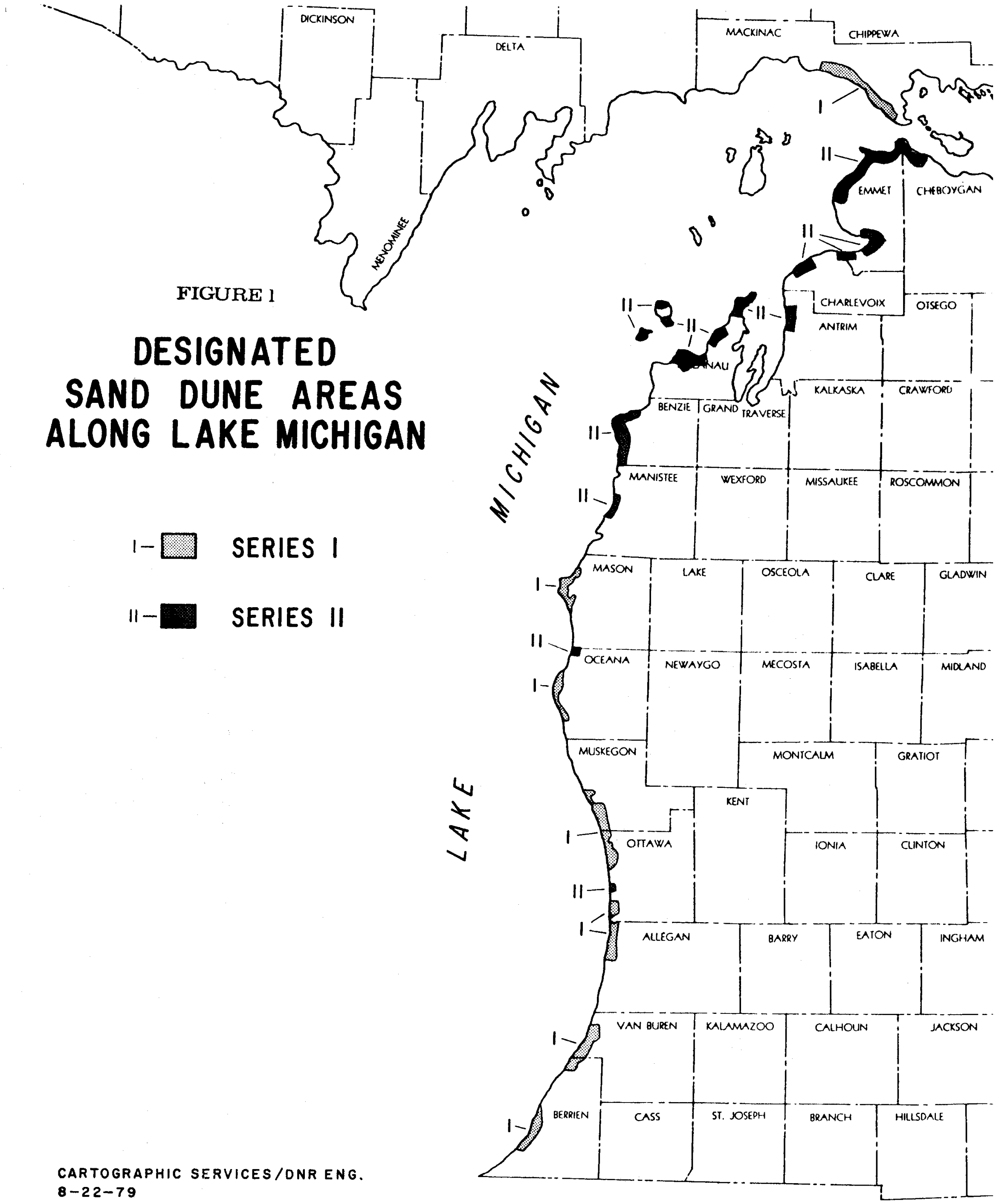
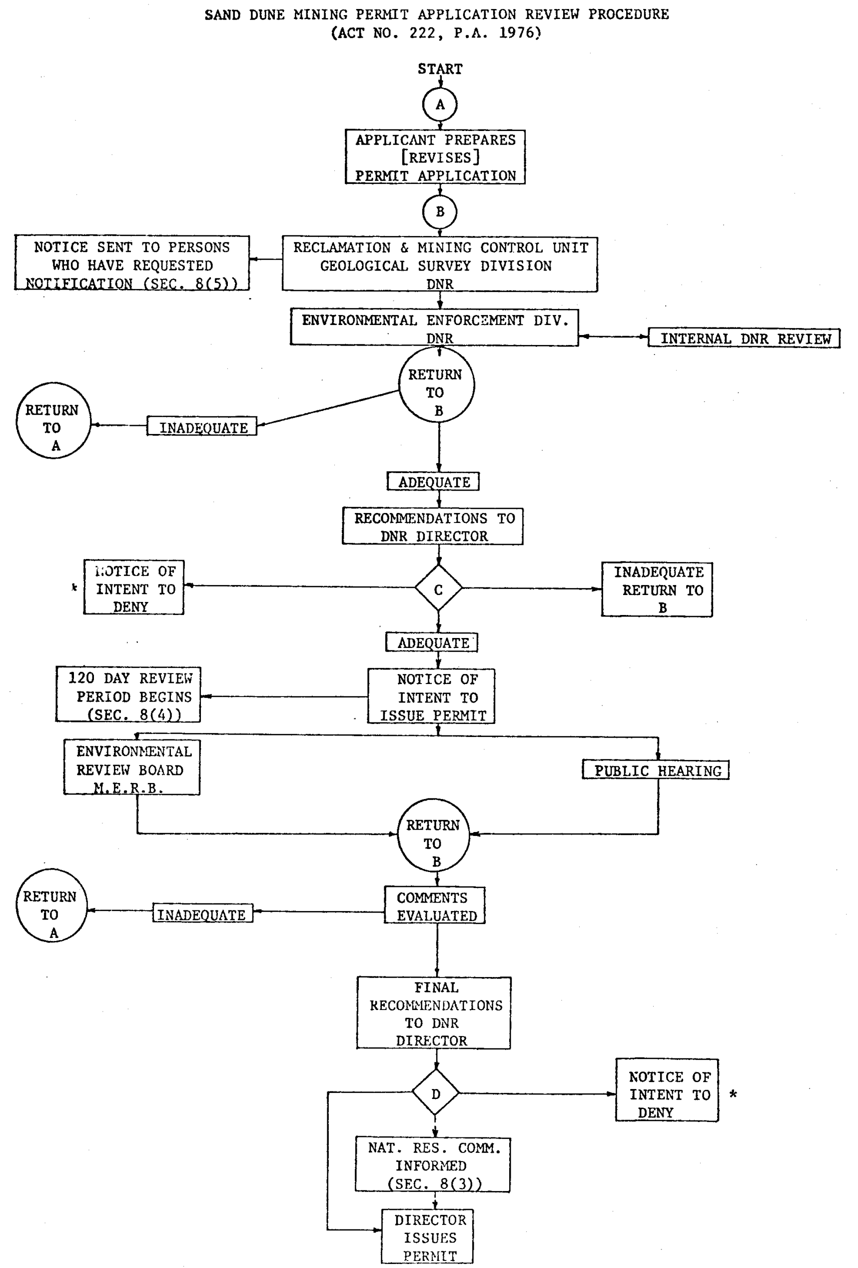


Figure 1. Designated Sand Dune Areas along Lake Michigan.



* Applicant is entitled to contest Departments decision in accordance with the provisions of the Administrative Procedures Act (Act No. 306, P.A. 1969, as amended).

FIGURE 2 PERMIT REVIEW PROCEDURE

Figure 2. Permit Review Procedures

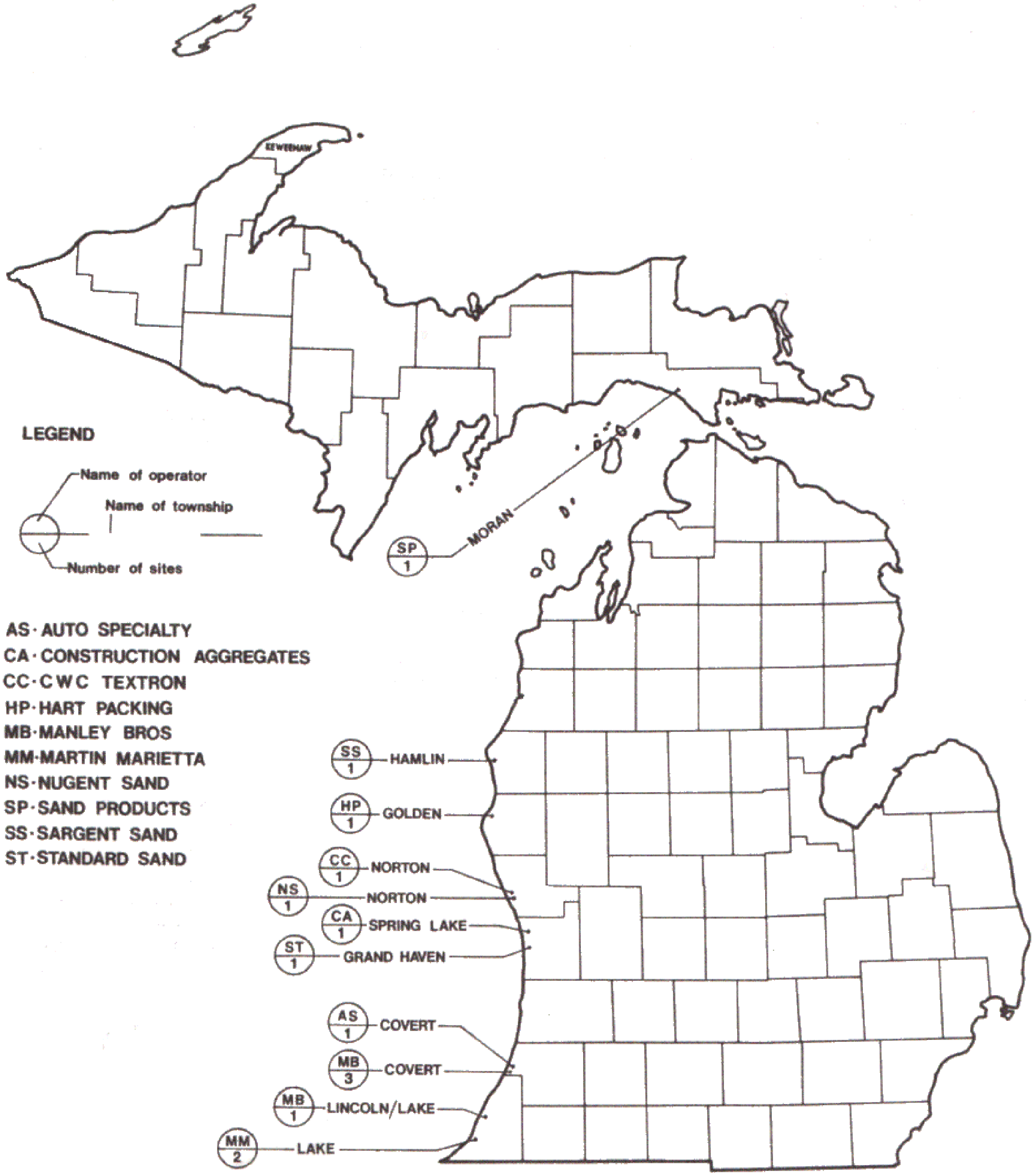


Figure 3. Location, Operators' Names and Number of Sites of Sand Dune Mining in Michigan.

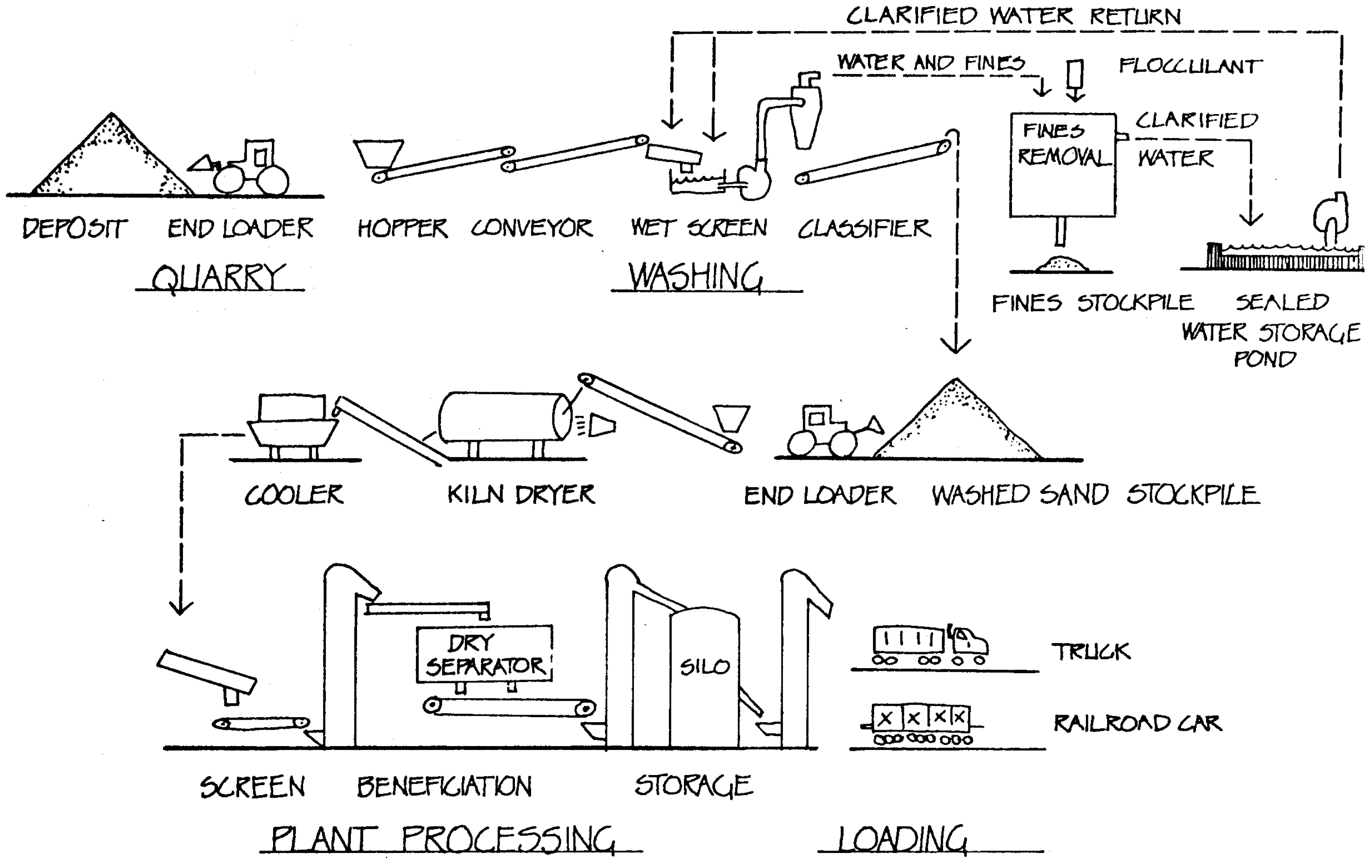


FIGURE 5

SAND PLANT FLOW DIAGRAM

NOTE: THIS IS AN EXAMPLE OF THE STEPS THAT CAN BE TAKEN IN THE PROCESSING OF SAND. DEPENDING ON LOCATION, SAND QUALITY AND USER NEEDS CERTAIN STEPS MAY BE OMITTED.

Figure 5. Sand Plant Flow Diagram

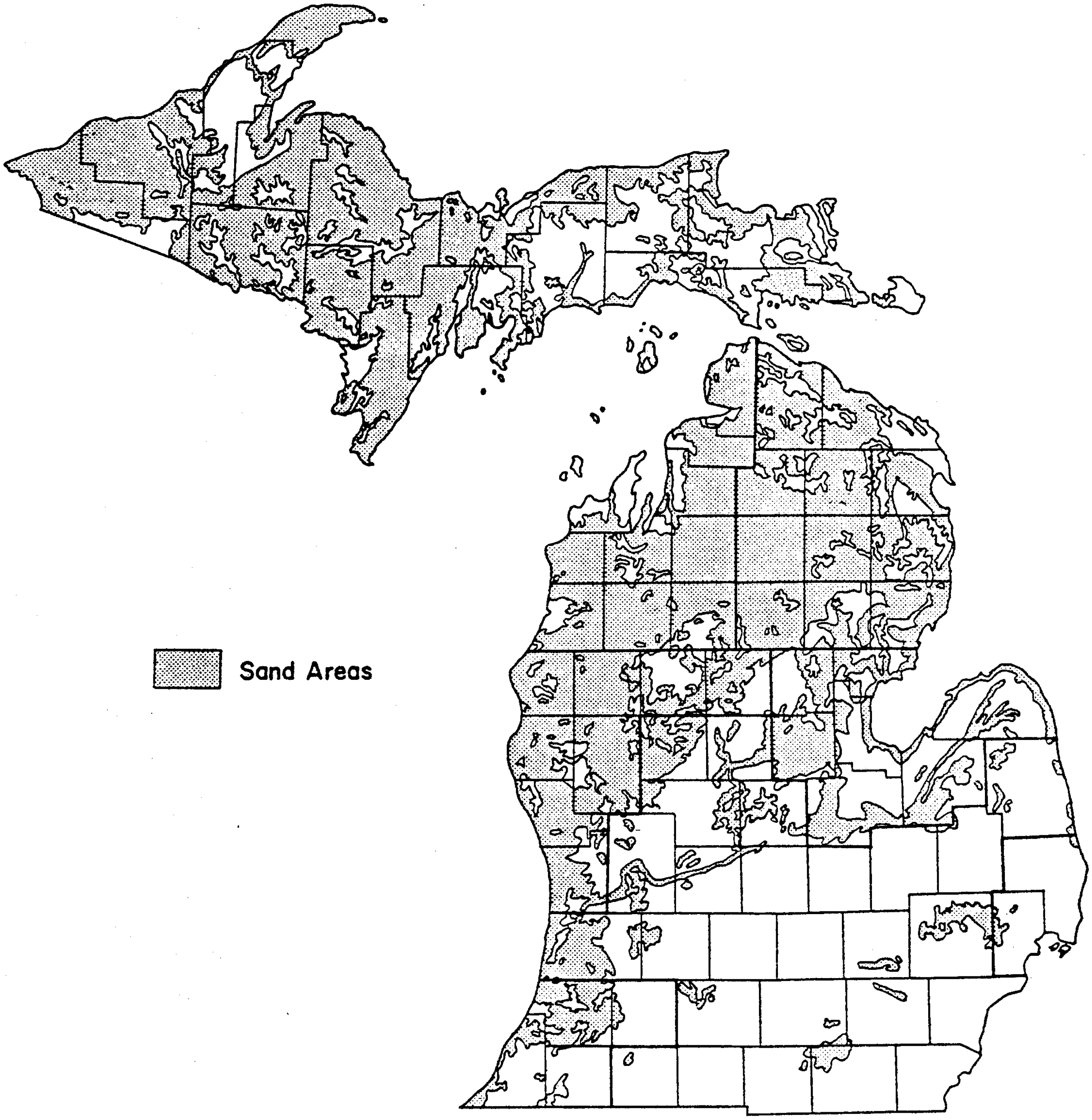


FIGURE 6 SAND COVER IN MICHIGAN

Drawn by G. A. Wilson, 12-11-78
from a map by Christine Anderson
Institute of Mineral Research
Michigan Technological University

Figure 6. Sand Cover in Michigan.

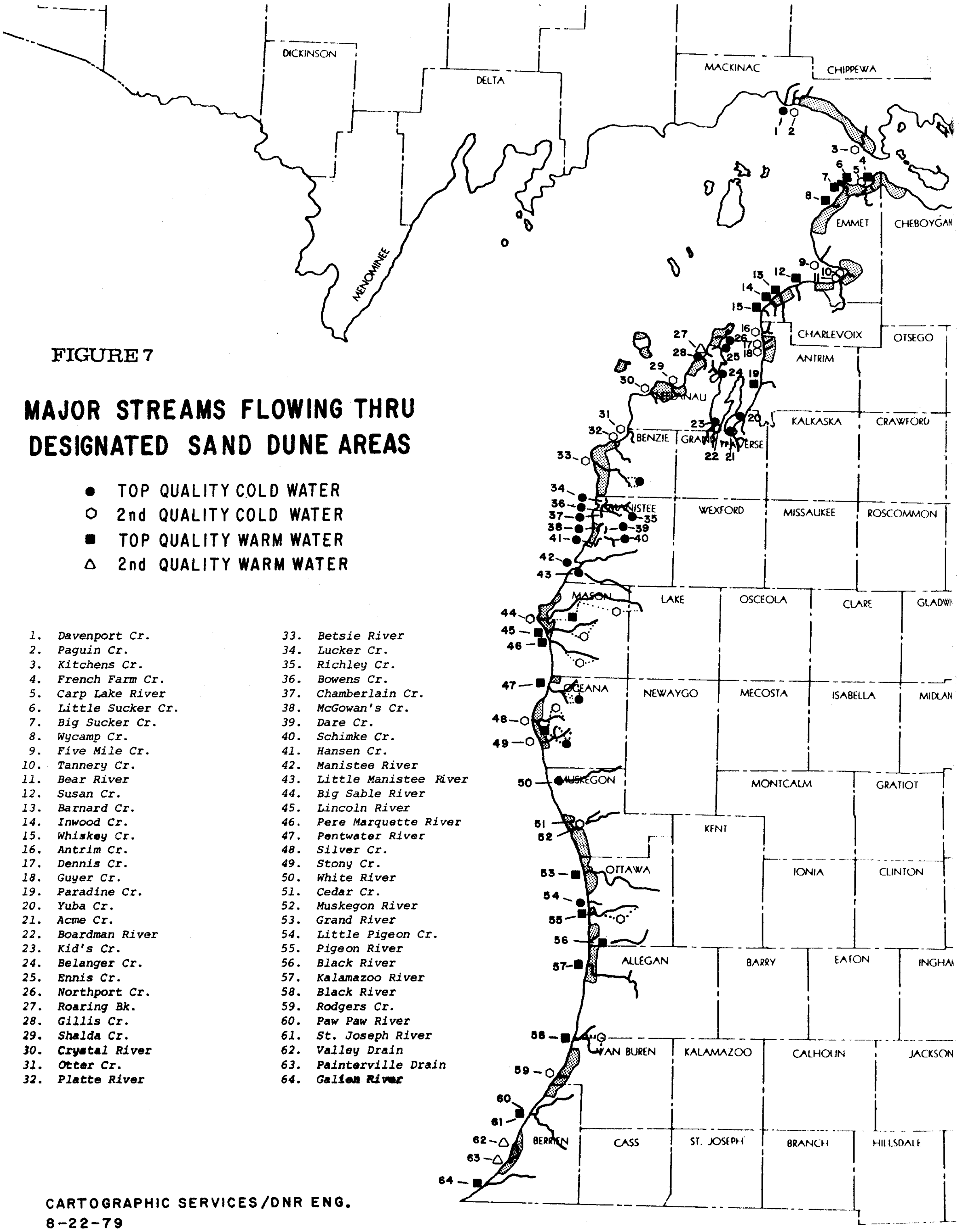


Figure 7. Major Streams Flowing Through Designated Sand Dune Areas.

FIGURE 8

NUMBER OF NATIONAL AND STATE HISTORIC SITES WITHIN TWO MILES OF LAKE MICHIGAN

Figure 8. Number of National and State Historic Sites within Two Miles of Lake Michigan.

	Potential Areas of Impact **A**. Geology - - **B**. Hydrology - - **C**. Micro Climate - - **D.** Terrestrial Biotic Communities - - **E**. Groundwater Quality - - **F**. Surface Water Quality - - **G**. Aquatic Biotic Communities - - **H**. Land Use Patterns - - **I**. Safety - - **J**. Aesthetics - - **K**. Economics										
Change Producing Agents Associated with Mining	A	B	C	D	E	F	G	H	I	J	K
Site and Structural Design											
Processing Plant	High	NVP	High	NVP	NVP	NVP	Low	High	High	High	High
Accessory Building and Vehicles	High	NVP	High	NVP	NVP	NVP	Low	High	High	High	High
Antennas, Towers, Stacks and Conveyors	NVP	Low	NVP	Low	Low	Low	Low	High	High	High	High
Roadways and Paved Surfaces	High	NVP	High	High	High	Low	NVP	High	High	High	High
Storage Areas	High	NVP	High	NVP	NVP	Low	Low	Low	NVP	NVP	NVP
Utility Lines and Corridors	NVP	NVP	NVP	Low	Low	Low	NVP	Low	NVP	High	High
Fencing	Low	Low	NVP	Low	Low	Low	Low	Low	High	NVP	High
Lighting Systems	Low	Low	NVP	Low	Low	Low	Low	Low	High	NVP	High
Sound (Public Address) System	Low	Low	Low	Low	Low	Low	Low	Low	NVP	NVP	High
Site Preparation and Facility Construction											
Clear/Stripping	NVP	NVP	High	High	NVP	NVP	NVP	High	NVP	High	NVP
Excavating	High	High	High	High	NVP	NVP	NVP	High	High	High	High
Transport of Equipment and Materials	NVP	Low	Low	NVP	NVP	Low	Low	NVP	High	High	High
Erection of Plant and Accessory Structures	High	NVP	High	High	NVP	NVP	Low	NVP	High	High	High
Installation of Utilities	NVP	Low	NVP	NVP	NVP	NVP	Low	NVP	High	NVP	High
Operations											
Overburden Stockpile Storage	NVP	NVP	NVP	NVP	NVP	NVP	Low	NVP	NVP	NVP	NVP
Waste Sand Storage	High	NVP	NVP	NVP	NVP	NVP	NVP	NVP	NVP	NVP	NVP
Fines and Contaminant Dump	NVP	NVP	Low	NVP	High	High	NVP	NVP	NVP	NVP	NVP
Mobile and Stationary Equipment Operation	High	NVP	Low	High	NVP	NVP	NVP	NVP	High	High	High
Clamshell Extraction	High	High	NVP	High	NVP	NVP	NVP	NVP	High	High	High
Dredging	High	High	NVP	NVP	High	NVP	High	NVP	High	High	High
Dewatering	NVP	High	Low	NVP	NVP	High	NVP	Low	NVP	High	High
Washing Sand	Low	NVP	Low	Low	NVP	NVP	Low	Low	NVP	High	High
Drying Sand	Low	Low	Low	Low	Low	Low	Low	Low	NVP	NVP	NVP
Rail Transport	Low	Low	Low	Low	Low	Low	Low	NVP	High	NVP	High
Truck Transport	Low	Low	Low	Low	Low	Low	Low	NVP	High	NVP	High
Ship Transport	Low	Low	Low	Low	Low	Low	Low	NVP	High	High	High
Reclamation											
Buffer Planting	High	NVP	High	High	Low	Low	Low	High	Low	High	High
Regrading	High	NVP	High	High	NVP	Low	Low	High	High	High	High
Soil Restoration	High	NVP	NVP	High	NVP	NVP	Low	High	Low	NVP	High
Revegetation	High	High	High	High	NVP	NVP	Low	High	Low	High	High
Redevelopment											
Selected Land Use	High	NVP	NVP	High	NVP	NVP	NVP	High	NVP	High	High
Site Plan/Development	High	NVP	NVP	High	NVP	NVP	NVP	High	NVP	High	High

High probability [High] Not very predictable - depends on location and activity [NVP] Low probability [Low]

Figure 9. General Summary of Primary Impacts

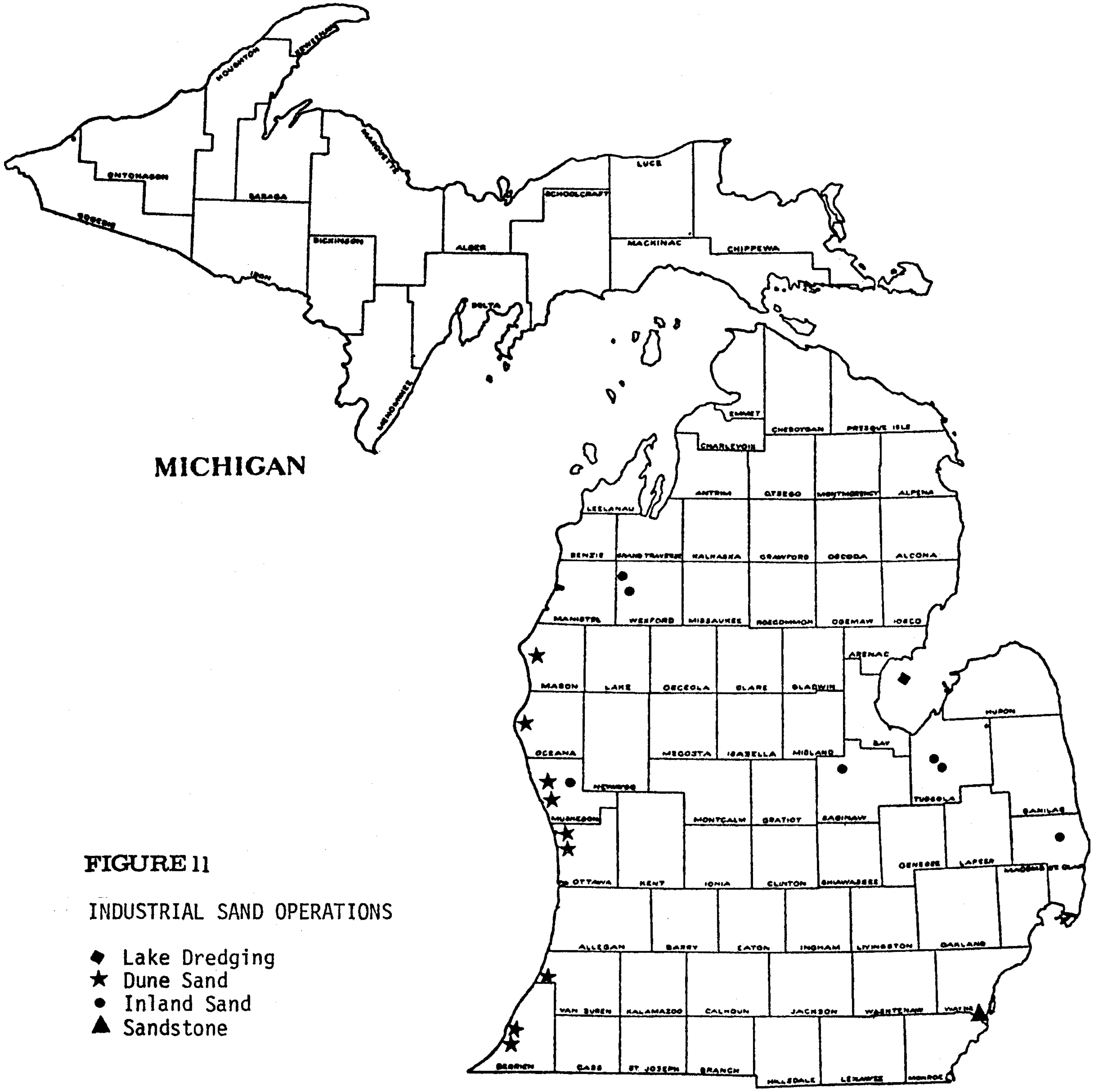


Figure 11. Industrial Sand Operations.

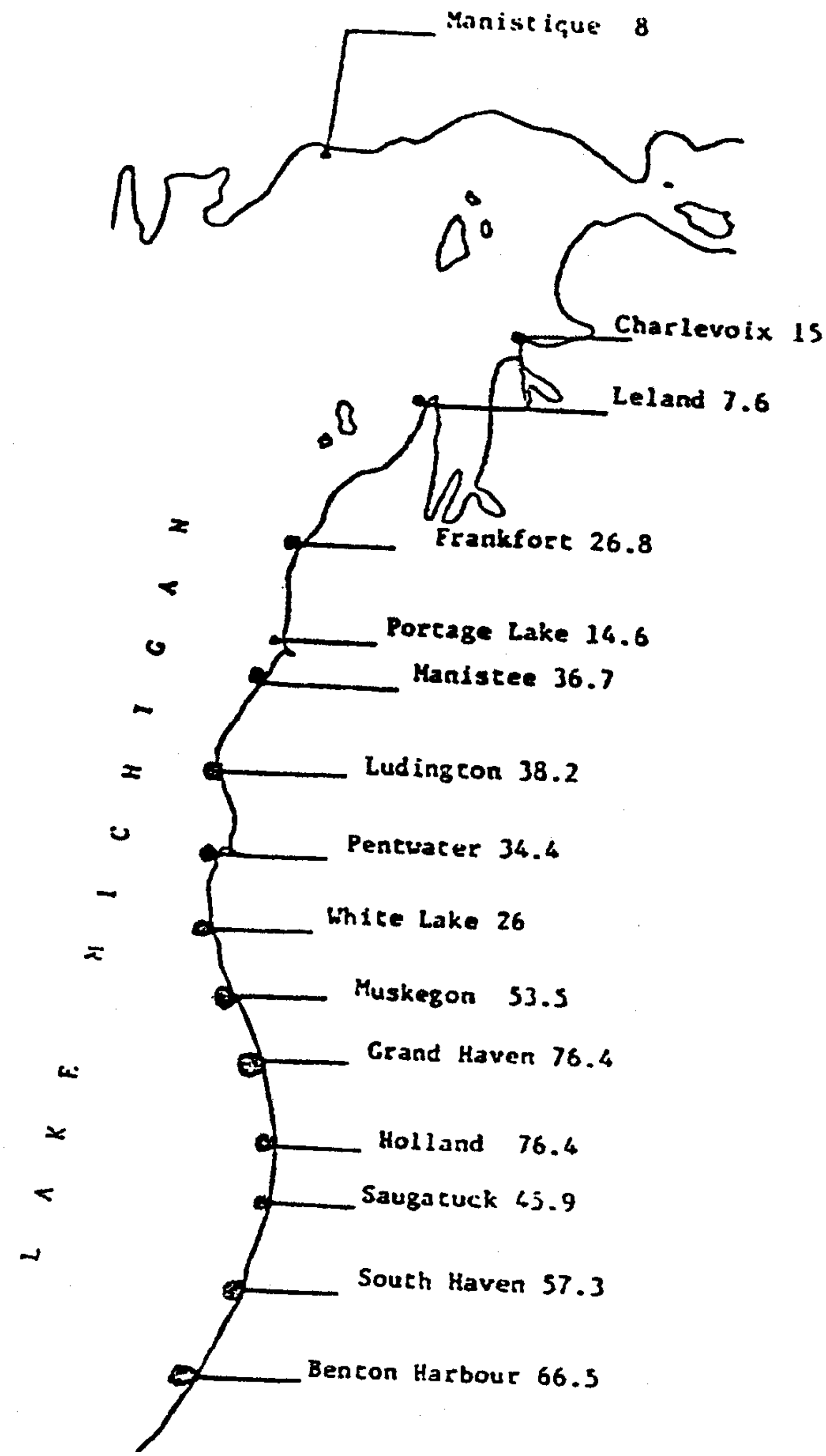


Figure 12. Lake Michigan Corp. of Engineer Dredging Activities.

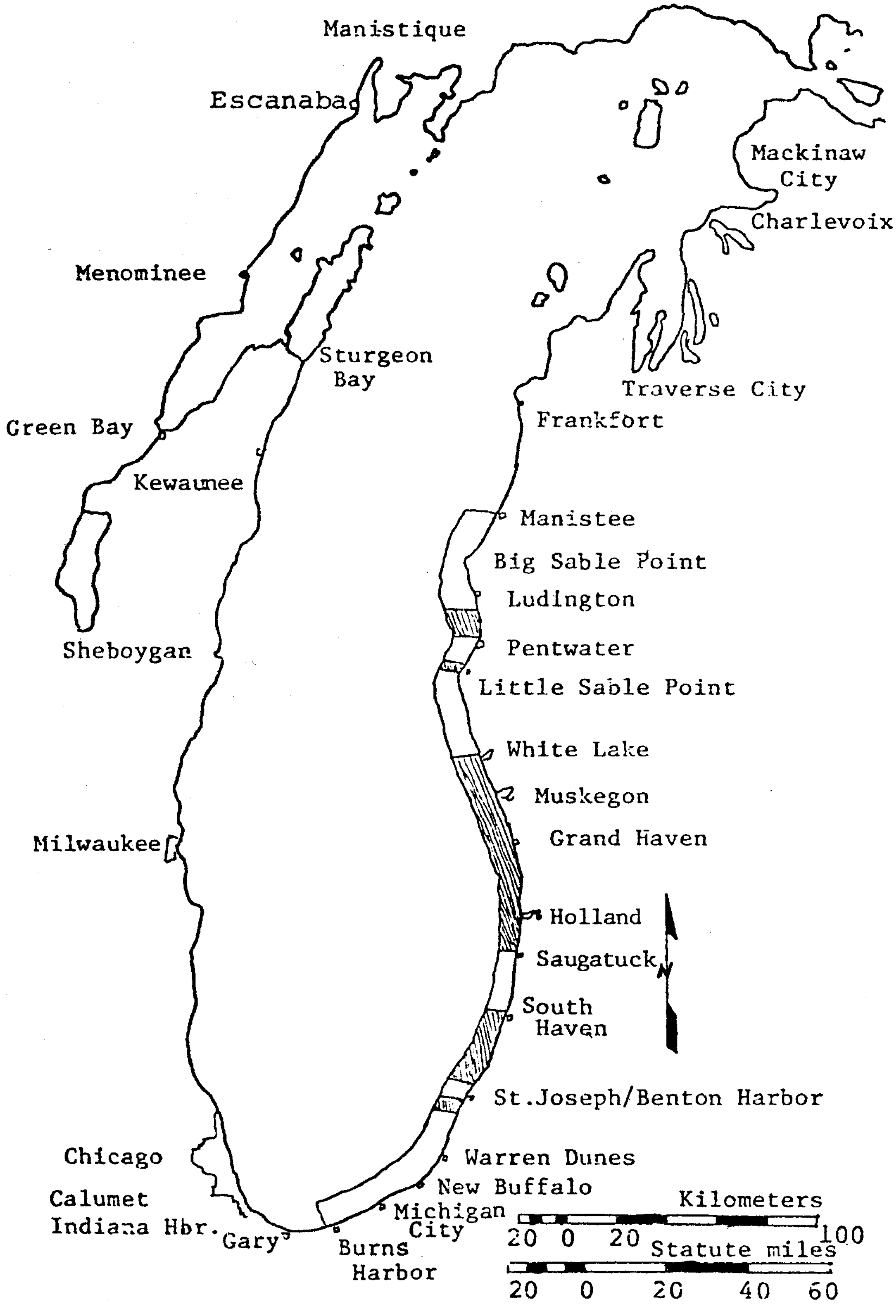


Figure 13. Potential Offshore Sand Deposits in Eastern Lake Michigan.

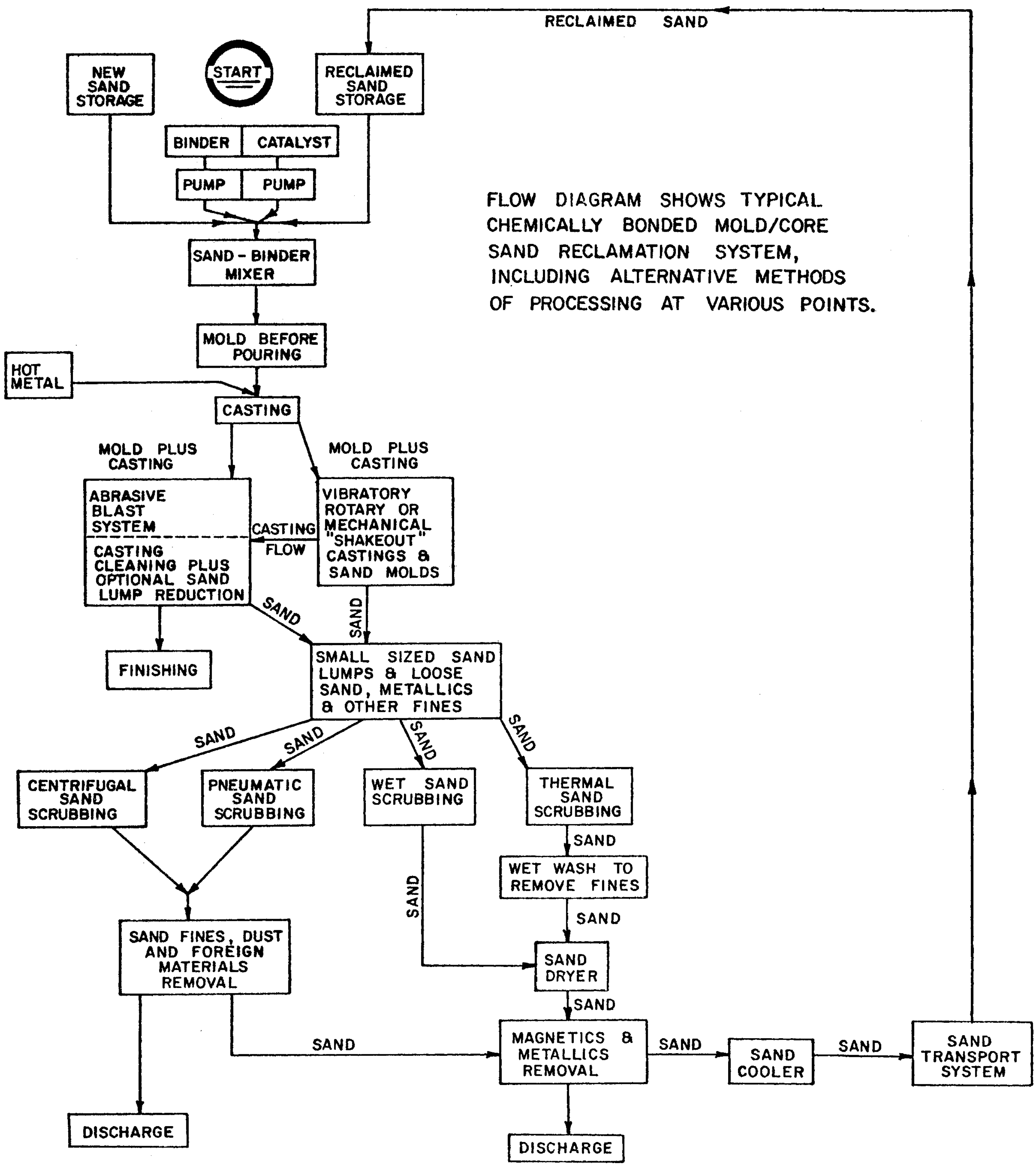


Figure 14. Flow Diagram of Sand Reclamation System

Plate 1.. Sleeping Bear Dunes National Lakeshore – A Perched Parabolic Dune

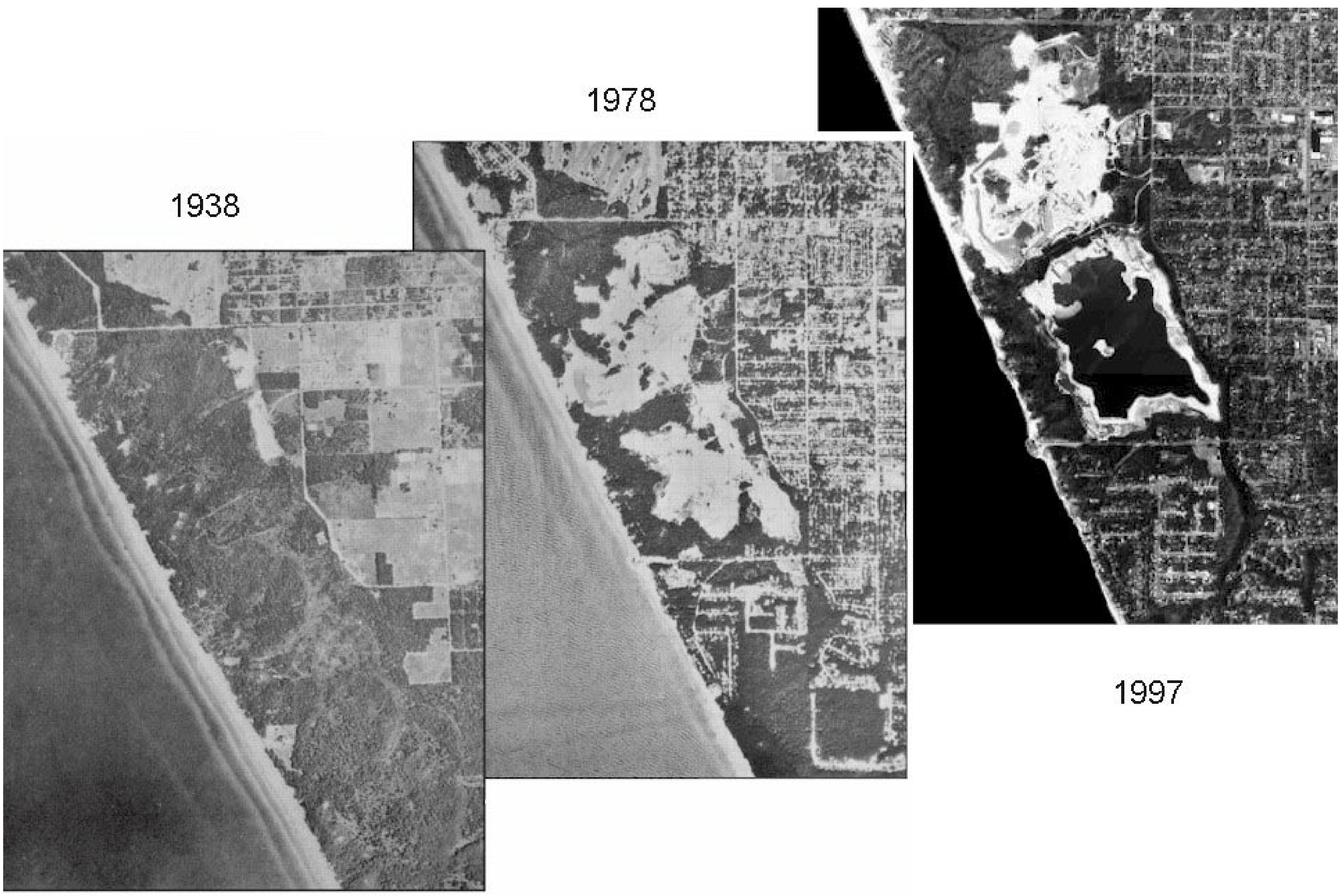


Plate 2.. 1938, 1978 & 1997 Air Photographs of Sand Mining in Muskegon County.

APPENDIX C - Terrestrial and Aquatic Species

The following animal lists include those likely to be found along the east coast of Lake Michigan in dune areas. In the absence of current detailed studies which include all dune areas along the coast, some species may be unintentionally omitted from the lists. Conversely, some may be included, but are no longer found in these areas. Those listed on either the Michigan or U.S. Endangered or Threatened lists are indicated with an *. The Cranbrook Study, when completed, is expected to give a current and authoritative evaluation of plant systems along Lake Michigan dunes. In addition, the Michigan Natural Areas Council Reconnaissance, Site and Other Reports includes 9 reports from the areas involved in sand mining. They are: #12 Cathead Bay Area, Leelanau County, #30 Hoffmaster State Park, Muskegon and Ottawa Counties, #36 Ludington State Park, Mason County, #41 and 42 Muskegon State Park, Muskegon County, #64, 65, and 66 Sleeping Bear Dunes, Leelanau County, #76 Warren Dunes, Berrien County. These reports give general features as well as plant species for the indicated areas. Mammals which may be found in dune areas along the east coast of Lake Michigan include the following:

Mammals

Opossum
Eastern Mole
Starnose Mole
Masked Shrew
Shorttail Shrew
Little Brown Myotis
*Indiana Myotis
Silver-haired Bat
Big Brown Bat
Red Bat
Hoary Boat
Raccoon
Longtail Weasel
Least Weasel
Mink
Striped Skunk
Red Fox
Thirteen-lined Ground Squirrel
Eastern Chipmunk
Red Squirrel
Eastern Fox Squirrel
Southern Flying Squirrel
Deer Mouse
White-footed Mouse
*Southern Bog Lemming
Meadow Vole
*Pine Vole
Muskrat
Norway Rat
House Mouse
Meadow Jumping Mouse
Eastern Cottontail
Whitetail Deer
Woodchuck

residents include the following:

Birds

Common Loon
Red-throated Loon
Horned Grebe
Pied-billed Grebe
Brown Pelican (accidental)
*Double-crested Cormorant
Great Blue Heron
Green Heron
Cattle Egret
Common Egret
Black-crowned Night Heron
Yellow-crowned Night Heron
Least Bittern
American Bittern
Mute Swan
Whistling Swan
Canada Goose
Snow Goose
Mallard
Black Duck
Gadwall
Pin tail
Green-winged Teal
Cinnamon Teal (accidental)
American Widgeon
Shoveler
Wood Duck
Redhead
Ring-necked Duck
Canvasback
Greater Scaup
Lessner Scaup
Common Goldeneye
Bufflehead
Oldsquaw
Harlequin Duck
White-winged Scoter
Surf Scoter
Ruddy Duck
Hooded Merganser
Common Merganser
Red-Breasted Merganser
Turkey Vulture
Goshawk
Sharp-shinned Hawk
*Coopers Hawk
Red-tailed Hawk
*Red.shouldered Hawk
Broad-winged Hawk
Rough-legged Hawk
*Bald Eagle
*Marsh Hawk
*Osprey
*Peregrine Falcon
Pigeon Hawk
Sparrow Hawk
Ring-necked Pheasant
Wild Turkey
Sandhill Crane
Virginia Rail
Sara
Common Gallinule
American Coot
American Avocet
Killdeer
*Piping Plover
Black-bellied Plover
Golden Plover
American Woodcock
Common Snipe
Upland Plover
Spotted Sandpiper
Ruddy Turnstone
Salltary Sandpiper
Wilson's Phalarope
Willet
Greater Yellowlegs
Lesser Yellowlegs
Baird's Sandpiper
White-rumped Sandpiper
Least Sandpiper
Pectoral Sandpiper
Dunlin
Semipalmated Sandpiper
Sanderling
Parasitic Jaeger
Greater Blackbacked Gull
Glancous Gull
Herring Gull
Ring-billed Gull
Laughing Gull
Franklin' Gull
Bonaparte's Gull
Little Gull
Forster's Tern
*Common Tern
*Caspian Tern
Black Tern
Rock Dove
Mourning Dove
Yellow-billed Cuckoo
Black-billed Cuckoo
Screech Owl
Great Horned Owl
Snowy Owl
Barred Owl
Long-eared Owl
Short-eared Owl
Whip-poor-will
Common Nighthawk
Chimney Swift
Ruby-throated Hummingbird
Belted Kingfisher
Yellow-shafted Flicker
Pileated Woodpecker
Red-bell led Woodpecker
Red-headed Woodpecker
Yellow-bell led Sapsucker
Hairy Woodpecker
Downy Woodpecker
Eastern Kingbird
Great Crested Flycatcher
Eastern Phoebe
Yellow-bellied Flycatcher
Acadian Flycatcher
Traill 's Flycatcher
Least Flycatcher
Eastern Wood Pewee
Olive-sided Flycatcher
Horned Lark
Tree Swallow
Bank Swallow
Rough-winged Swallow
Barn Swallow
Cliff Swallow
Purple Martin
Blue Jay

Northern Raven
Common Crow
Black-capped Chickadee
Tufted Titmouse
White-breasted Nuthatch
Red-breasted Nuthatch
Brown Creeper
House Wren
Winter Wren
Carolina Wren
Long-billed Marsh Wren
Short-billed Marsh Wren
Mockingbird
Catbird
Brown Thrasher
Robin
Wood Thrush
Hermit Thrush
Swainson's Thrush
Gray-cheeked Thrush
Veery
Eastern Bluebird
Townsends Solitaire
Blue-gray Gnatcher
Golden-crowned Kinglet
Ruby-crowned Kinglet
Cedar Waxwing
Water Pipit
Starling
White-eyed Vireo
Northern Shrike
Bell's Vireo
Yellow-throated Vireo
Solitary Vireo
Red-eyed Vireo
Philadelphia Vireo
Warbling Vireo
Black-and-white Warbler
Prothonotary Warbler
Worm-eating Warbler
Golden-winged Warbler
Blue-winged Warbler
Tennessee Warbler
Orange-crowned Warbler•
Nashville Warbler
Parula Warbler
Yellow Warbler
Magnolia Warbler
Cape May Warbler
Black-throated Blue Warbler
Yellow rumped warbler
Black-throated Green Warbler
Cerulean Warbler
Blackburnlan Warbler
Chestnut-sided Warbler
Bay-breasted Warbler
Blackpoll Warbler
Pine Warbler
Prairie Warbler
Palm Warbler
Ovenbird (accidental)
Northern Waterthrush
Louisiana Waterthrush
Kentucky Warbler
Connecticut Warbler
Mourning Warbler
Yellowthroat
Yellow-breasted Chat
Hooded Warbler
Wilson's Warbler
Golden Eagle
Canada Warbler
American Redstart
House Sparrow
Bobolink
Eastern Meadowlark
Red-winged Blackbird
Orchard Oriole
Northern Oriole
Rusty Blackbird
Common Grackle
Brown-headed Cowbird
Scarlet Tanager
Summer Tanager
Cardinal
Rose-breasted Grosbeak
Indigo Bunting
Evening Grosbeak
Purple Finch
Pine Grosbeck
Common Redpoll
Pine Siskin
American Goldfinch
RedCrossbill
White-winged Crossbill
Rufous-sided Towhee
Savannah Sparrow
Grasshopper Sparrow
Henslow's Sparrow
Slate-colored Junco
Tree Sparrow
Chipping Sparrow
Clay-colored Sparrow
Field Sparrow
Harris' Sparrow
White-crowned Sparrow
White-throa ted Sparrow
Fox Sparrow
Lincoln's Sparrow
Swamp Sparrow
Song Sparrow
Snow Bunting

Amphibians and reptiles

which are likely to be found in dune areas along the east coast of Lake Michigan include the following:

Red-backed Salamander
Eastern Tiger Salamander
Spotted Salamander
Red-spotted Newt
American Toad
Fowler's Toad
Cricket Frog
Spring Peeper
Gray Tree Frog
Western Chorus Frog
Bullfrog
Green Frog
North American Leopard Frog
Pickerel Frog
Snapping Turtle
Spotted Turtle
*Eastern Box Turtle
Map Turtle
Painted Turtle
Blanding's Turtle
Spiny Soft-shelled Turtle
Common North American Water Snake
Queen Snake
Brown Snake
Eastern Garter Snake
Eastern Ribbon Snake
Eastern Hognosed Snake
Blue Racer
*Black Rat Snake Milk Snake
Eastern Massasauga

Fish Species Michigan. The fish species of this second largest of the Great Lakes are indicated below. It Is presumed that many of the same species will inhabit nearby rivers during part or all of their life cycles.

Fish Species

Alewife Rainbow smelt
*Bloater
Yellow perch
Slimy sculpin
Spottail shiner
Trout perch
White sucker
Longnose sucker
Lake trout
Lake whitefish
Coho salmon
Chinook salmon
Rainbow trout
Carp
Bluegill
Brook trout
Brown trout
Burbo
Emerald shiner
Gizzard shad
Lake chub
Largemoth bass
Longnose dace
Ninespine stickleback
Northern pike
Round whitefish
Shorthead redhorse
Sinallmouth bass
Tiger trout
Black bullhead
Black crappie
Central mudminnow
Channel catfish *Cisco* spp. (some)
Fathead minnow
Freshwater drum
Golden shiner
Goldfish
Green sunfish
Spotted sucker
Johnny darter
Lake herring
Pumpkinseed
Rock bass
White bass
White crappie
Wall eye
Bluntnose minnow
Brook stickleback
Blacknose dace
Warmouth
Northern hog sucker
Tadpole madtom
Quillback
Bowl In
Atlantic salmon
Blacknose shiner
Brown bullhead
Common shiner
Creek chub
Log perch
Longnose gar

Mooneye	Yellow bullhead	Pugnose minnow	Fourhorned scul pin
Mottled sculpin	Chestnut lamprey	Spoonhead sculpin	Lepomis hybrid
Pirate perch	Sea lamprey	Silvery minnow	
River-chub	Brook silverside hales spp.	Golden trout	
Stoneroller	Silver lamprey	Grass pickerel	

Threatened and Endangered Plant Species

The following threatened and endangered plant species may be found in sand dune areas included in the Series I designation:

Lycopodium Appressum	MI .-T
Tradescantia bracteata (Spiderwort)	MI -T
Fuirena squarrosa (Umbrella-grass)	MI -T
Eleocharis melandcarpa	MI -T
Psilocarya scirpoides (Bald Rush)	MI-I
Scleria reticularis	MI-I
Potamogeton capillaceus	MI-I
Polygonum careyi	MI -T
Geum triflorum	MI -T
Valerianella chenopodifolia	MI -T
Trilliurn recurvatum	MI -T
Trillium sessile (Toadshade)	MI -T
Carex Crus-corvi	MI -I
Carex seorsa	MI -T
Gentiana saponaria (Soapwort Dentian)	MI-E
Lycopodiuh xhabereri	MI-T
Cypripedium candidum (White lady slipper)	MI-I, US-T
Habenaria ciliaris (Orange fringed orchid)	MI -T
Habenaria leucophaea (Prairie fringed orchid)	MI-T, US-I
Isotria medeoloides (Smaller whorled pogon i a)	MI-E, US-E
Tipularia discoloh (Cranefly orchid)	MI -T
Dlarrhena americana	MI-I
Triplasis purfurea (Sand grass)	MI-I
Uniola latifolia (Wild oats)	MI -T
Zizania Aquatica (Wild rice)	MI-I
Zizania aquatica (Wild rice)	MI-I
Eryngium yuccifolium (Rattlesnake Master or Button-Snake)	MI -T
Aristolochia serpentaria (Virginia snakeroot)	MI -T
Cirsium pitcheri (Pitcher's thistle)	US-I
Coreopsis palmata	MI-I, MI-T
Sllphium integrifolium	MI-I, US-I
Silphium laciniatum (Rosinweed or compass plant)	MI -T
Silphium perfoliatum (Cup plant)	MI-T
Cuscuta olomerata	MI -T
Baptisia leucantha (White or Prairie False Indigo)	MI -T
Gymnocladus dioica (Kentucky coffee tree)	MI -T
Castenea dentata (American chestnut)	MI-E
Sabatia angularis (Rose-pink)	MI-I
Hibiscus palustris (Swamp rose-mallow)	MI-I
Ludwigia alternifolia (Seedbox)	MI-I
Polemonium reptans (Jacob's ladder)	MI-I
Populus Heterophylla (Swamp or black cottonwood)	MI -T
Trillium undulatum (Painted trillium)	MI -T
Aesculus glabra (Ohio buckeye)	MI -T

Potamogeton hillii	MI -T
Agropyron dasys tachyum	MI-I
Orchis rotundifolia (Round leaved orchid)	MI-I
Potamogeton confervoides	MI-I
Dryopteris felix (Male fern)	MI-I
Iris lacustris (Dwarf lake iris)	MI-I, US-I
Juncus stygius	MI-I
Habenaria unalascensis (Alaska orchid)	MI-I
Ruppia maritima (Ditch grass)	MI-I
Erigeron hyssopifol ius	MI-I
Solidago houghtonii (Houghton's goldenrod)	MI-I, US-I
lanacetum huronese, Lake Huron Tansy	MI-I
Arrnoracia aquatica (Lake-cress)	MI-I
Draba arabisans	MI-I
Pterospora andromedea (Pine drops)	MI-I
Pinguicula vulgaris (Butterwort)	MI-T
Mimulus glabratus (Monkey flower)	MI-T, US-T
Calypso Bulbosa (Calypso or Fairy Slipper	MI-I
Cypripedium arietinum (Ram's Head lady slipper)	MI-rare, US-I
Eleocharis atropurpurea	MI-I
Hemicarpa micrantha	MI-I
Scirpus hallii	MI - E
Habenaria flava (Tubercleo orchid)	MI-rare, US-I
Iriphora trianthophora (Nodding pogonia Three birds orch)	MI-I
Asclepias hiriella	MI-I
Cirsium hillii (Hill's thistle)	MI -T
Solidago reinota	MI-I
Opuntia fragilis (Fragile prickly-pear)	MI-E
Orobanche fasciculata (Broom rape)	MI-I
Eleocharic trichostata	MI-PR Ext.
Panax quinquefolius (Ginseng)	MI-I, US-I
Mertensia virginica (Bluebells)	MI-I
Poa paludigena	MI-rare, US-I
Lycopodium sp.	MI -E
Woodwardia areolata (Netted chain fern)	MI-Pr, Ext.
Acleria pauciflora	MI-I
Juncus scirpoides	MI-I
Aristida tuberculosa	MI-Pr., Ext.
Potamogeton lateralis	MI-Pr., Ext.
Aster sericeus	MI-I
Helianthus microcephalus (Small wood sunflower)	MI-I
Petalostemon purpureum (Red prairie clover)	MI -E

APPENDIX D – Guide to Identifying Areas of Particular Concern

AREAS OF NATURAL HAZARD

HIGH RISK EROSION AREAS.

An area exhibiting at least two of the following characteristics s considered a potential high-risk erosion area:

A. Vegetation removal (25% or more)
B. Narrow beach
C. Slumping bank
D. Turbidity of adjacent waters
E. Damaged erosion control structure
F. Damaged land structure
G. Protective works present
H. Unusual angle of response of the bluff material

- Using historic and recent aerial photography, average annual bluff recession can be measured for those areas identified as potential high risk erosion areas. If it is determined that bluffs are receiving at an average rate of at least one foot per year, the area is considered a high risk erosion area.

FLOOD HAZARD AREAS

- The area is within the 100-year floodplain of the Great Lakes. Based on engineering studies conducted by federal rid state agencies and local units of government. In general, special flood risk areas should include those areas designated by the Federal Insurance Administrator

SENSITIVE AREAS

ECOLOGICALLY SENSITIVE AREAS

Marshes lakeward or landward at the ordinary high water mark with the following values.

A. Production, brood rearing, feeding. resting or migration habitat ‘or waterfowl and/or other migratory birds.
B. A traditional waterfowl hunting area.
C. A habitat supporting a significant furbearer population.
D. Significant fisheries for important sport and/or commercial species are spawning and-or nursery areas toe important species
E. Significant fisheries through management or potential as significant spawning and/or nursery areas of important species
F. Support for unusual. threatened or endangered plant species, or unusual aggregations of species.
G. Function as a breakwater by absorbing wave energy and retaining rising floodwaters.

Areas of the upland along the shoreline that have any or all of the following values.

A. A staging or stop over point tot migratory birds.
B. A gull or tern nesting colony or heron rookery.
D. An eagle or osprey nest.
C. Valuable habitat or deer, furbearers, hawks owls. game birds. song birds and/or threatened or endangered animal species.
E. Support unusual, threatened or endangered plant species or unusual aggregations of species.

Open water areas from the water’s edge to a depth of 25 fathoms with the following values:

A. Traditionally important sport and/or commercial fishing areas where important species concentrate, or known spawning or nursery areas for important fish species.

B. Potentially valuable luring areas where management efforts are Currently underway to develop the fishery, or potentially good spawning nursery areas for lake trout or other expanding fish populations

C. Valuable fish habitat areas not now providing a sizable fishery and not currently under management, but with significant fishery values for future development

D. Submerged aquatic plants important to waterfowl

NATURAL AREAS

Guidelines established by the Michigan Wilderness and Natural Areas Advisory Board can be used to identify special natural areas throughout Michigan's coastal area.

Have retained, have re-established or can readily re-established natural character

- Possess one or more of the following characteristics:
  - A. Biotic. geological, physiographic or paleontological features of scientific or educational value
  - B. Outstanding opportunities for scenic pleasures. enjoyable contact with nature or wilderness type of experiences (solitude, exploration and challenge)
- In addition, the area should exhibit characteristics listed under one of the following categories

Wilderness Areas

A. Large size, has .3,000 or more acres of state land or is an island of any size.

B. Primitive, generally appears to have been affected primarily by forces of nature with the imprint of man's work substantially unnoticeable.

C. Wilderness Recreation has outstanding opportunities for solitude or a primitive and unconfined type of recreation.

D. Notable natural features, contains ecological, geological or other features of scientific, scenic or historical value.

Wild Areas

A. Size: is less than 3,000 acres of land.

B. Wilderness or nature observation type of recreation has outstanding opportunities for (1) personal exploration. (2) challenge. or (3) contact with natural features of the landscape and its biological community

C. Wilderness-like: possess one or more of the characteristics of a wilderness area

Research Natural Areas

A. Educational or scientific natural area retained or re-established natural character, or has unusual flora and fauna or biotic, geological, or other similar features of vegetation or scientific value, but it need not be undisturbed.

B. Verified by scientists: identified and verified through research and study by qualified Observers.

C. May be sub-unit: may be coextensive with or part of a wilderness area or wild area

Nature Study Areas

A. Must have essentially the same characteristics as a research natural area

B. Adaptive to development and use of facilities for conservation, education and nature study or much more intensive use than research natural areas

Managed Natural Areas

A. Same as for research natural areas

B. An ecosystem that is maintained at a chosen state of development or is brought to a desired stage of development by the use of cultural techniques or controls. These controls are known to favor the maintenance or the development of a particular biological community or may be designed to preserve or restore a desired plant or wildlife species.

SAND DUNE AREAS

Sand dune areas are defined as those geomorphic features composed primarily of unconsolidated sand, whether wind blown or of other origin Sand dunes can be considered special areas when:

- The dune area meets the guidelines for an "ecologically sensitive" or "natural' area.
- The integrity of the dune area is threatened by uncontrolled recreational use
- The integrity of the dune area is threatened by mining activity.

- The dune area is in need of reclamation due to removal of sand and/or vegetation.

ISLANDS

Islands can be considered special areas when:

- The entire island and/or littoral area meets the guidelines 'or an "ecologically sensitive" or 'natural' area.

AREAS FULFILLING RECREATIONAL & CULTURAL NEEDS

RECREATION AREAS

Special recreation areas include

- Existing shoreland recreation areas and facilities
- Sites that have been identified for acquisition and development by local, state or federal agencies.
- Other areas with high recreation potential

HISTORIC AND ARCHAEOLOGICAL SITES

Guidelines are a combination of those used for identifying National and State Register sites and those established in the Department of Natural Resources "Report on Special Environments'. Special historic and archaeological areas are those sites, structures, objects or districts that:

- Are connected with an event resulting in significant contributions to the pattern of history or prehistory.
- Are associated with an important phase of growth or decline of a local society or movement.
- Are associated with lives of historically significant person
- Embody distinctive characteristics or type, period or method of construction.
- Represent the work of a master
- Are part of the Great Lakes bottomland containing shipwrecks
- Are a grouping of structures which individually are not unique but when they are taken together, represent a certain historic scene or way of life

AREAS OF INTENSIVE OR CONFLICTING USE

COASTAL LAKES, RIVER MOUTHS AND BAYS

The special coastal lake, river mouth or bay should be a land/water area experiencing serious conflicts among two or more of the following

- Valuable fish or wildlife habitat
- Recreational booting use
- Recreational use for fishing and/or swimming.
- Supporting or with the potential to support commercial "aviation".
- Local water quality impaired by intensive development and/or discharge

URBAN AREAS

Special urban areas are those parcels of land which are

- Vacant and adjacent to the Great Lakes or connecting waterway
- Occupied by structure in need of rehabilitation or redevelopment.
- Occupied by structures that no longer contribute significantly to the tax base of the community
- Occupied by uses that do not require or are not enhanced by a shore location

And located within or in close proximity to:

1. Urbanized areas (defined by the Bureau of Census as central cities of 50 000 or more and surrounding closely settled territory) adjacent to the Great Lakes or a connecting waterway
2. Urban areas of 2,500 inhabitants incorporated as cities or villages adjacent to the Great Lakes or a connecting waterway

AREAS OF NATURAL ECONOMIC POTENTIAL

MINERAL RESOURCE AREAS

Consideration of the following factors will determine special mineral resource areas.

- Demand for the mineral on a local, state or international level
- Quality of the deposit
- Quantity of the deposit.
- Minability.
- Amenability to concentration and processing
- Availability of water, energy supplies, economical transport and other mineral commodities necessary n processing.

ENERGY RESOURCE AREAS

Consideration of the following will determine special energy resource areas

- Local, state, or national need for energy
- Proximity to load centers.
- Fuel delivery access and mode.
- Site suitability.
- Ability of adjacent land use to absorb impacts

Facilities for energy resource areas include:

A. Electric generating facilities (fossil and nuclear)
B. Coal transfer facilities.
C. Gas or oil facilities

AGRICULTURAL AREAS.

Special agricultural areas fall into the categories of prime, unique and critical agricultural lands Definitions for prime and unique lands have been adopted from Soil Conservation Service, USDA qualitative definitions for these categories.

- Those prime agricultural lands currently used (or available for use) for the production of food and fiber where the moisture, with characteristics and growing season produce a sustained high yield of crops.
- Those unique agricultural lands combining soil quality. Location growing seasons and moisture supply to produce high quality and high yield specialty crops i.e. cherries, blueberries, beans, etc.
- Critical agricultural lands in immediate danger of being placed into other uses Increasing populations may require that even those agricultural lands which are marginally productive be utilized to meet future demands.

PRIME INDUSTRIAL AREAS

The following guidelines identify special prime industrial areas

- Industrial development compatible with existing zoning and land use.
- Easily accessible modes of transportation (water transport in particular)
- Adequate utility systems (i e. sewer, water) presently available
- Site of adequate depth to accommodate plant operations such that increasing site size with artificial fill is not necessary.
- Industrial operations and appearance compatible with the coastal environment

WATER TRANSPORTATION AREAS

Special water transportation areas include

- Ports and related facilities associated with waterborne transportation.
- Docking and mooring areas
- Loading facilities.
- Ferry routes and landings.

- Shipping channels.
- Other land and water facilities related to waterborne transportation

AREAS FOR PRESERVATION AND/OR RESTORATION

Areas for Preservation and/or Restoration are the highest priority and most special areas in the above categories.

The areas must be of regional or statewide interest, and exhibit the following characteristics:

- High aesthetic, recreational, ecological or conservation value.
- High quality physical or functional characteristics.
- Unique characteristics which are uncommon and occur in very limited areas of the shoreland.
- Threat of irreversible harm and urgent need for management action.
- Problems or opportunities in the area beyond the financial or regulatory capability of local units of government.

APPENDIX E - Recommended Reclamation & Stabilization Practices for Sand Dunes

The delicate ecosystems of sand dunes are frequency altered by the actions of man and nature. Mining, off-road vehicles, pedestrian traffic and wind and water are some of the human and natural agents disturbing Michigan's sand dune environments. To stabilize these areas, it is necessary to prepare a reclamation plan that identifies the critical areas of concern. The following material has been gathered to help in the sound preparation of reclamation activities. If used as a guideline this information will help Initiate the stabilization of sand dunes.

Proper reclamation will protect adjacent properties from blowing sand and sloughing, re-establish permanent vegetation and restore affected areas to an acceptable aesthetic level.

Reclamation develops in three phases:

1. Grading and Sloping
2. Initial Revegetation
3. Secondary Revegetation

Phase I. Grading and Sloping

-- All slopes should be graded to a slope not greater than 2:1 (two feet horizontal to one-foot vertical).

-- Topsoil that is stockpiled during mining operations should be spread over graded surfaces 2-4" thick.

Phase 2. Initial Revegetation

Initial revegetation requires that dune grass be established in affected areas for initial stilling of sands. When established, dune grass provides a favorable environment that encourages other native species of dune vegetation and increases the productivity of the "A" horizon or organic layer of soil.

1. Fertilizing

1. Fertilizing is necessary because of the sterile nature of sand.

-- 500 lbs./acre of l2-12-l2* or comparable fertilizer or 800 lbs./acre of 10-10-10* will be acceptable volumes and types of fertilizer.

-- Where possible use fertilizer high in nitrogen and low in phosphorous dependent on soil's needs.

-- Because o~ concern over water quality, fertilizer should not be applied all at once.

-- Apply fertilizer every two months starting in April at doses of 50 lbs./acre.

-- An application rate of 60 lbs./acre/quarter year is also acceptable.

*Phosphorous, nitrogen, potassium

2. Planting

-- Start planting on the windward side.

-- Plant during cool temperatures (early spring or fall).

-- Select hardy plants 2-3’ high.

-- Some species of dune grass include:

Marram grass or American beachgrass (*Ammophila breviligulata*) Recommended

American dune grass (*Elymus mollis*)

Prairie sand reed (*Calamovilfa longifolla*)

-- Plant 2-3 clumps (a single stem with roots attached) 6-10” deep.

-- Sand should be firm and moist around roots with no air pockets near base of plants.

-- Clumps producing seed heads should not be used as they will die after the seed matures.

-- Space clumps 18” x 18” (about 20,000 clumps/acre) where wind velocities and sand movement are high.

- A spacing of 24” x 24” (about 11,000 clumps/acre) may be used In areas not directly exposed to strong winds.

-- For partial planting of large areas, plant 2 or 3 rows with 18” x 18” spacing every 40 feet.
(This will require only 2,500 clumps per acre but will need more time to stabilize the sand.)

- Use a regular square or diamond pattern.

- A narrow tile spade or planting bar may be used for planting.

3. Mulching.

Mulching Is especially important to slope planting. Mulch protects against rain and wind as well as reduces loss of moisture during extended dry periods. Because of the unstable nature of slopes, mulch Is desirable.

A wide variety of mulches can be used. Common materials and anchoring methods are listed below:

Mulch Materials	Anchoring Methods
Hay or Straw (11/2 - 2 tons per acre)	Peg and twine network; punched into slope with spade
Jute Netting	Staked according to manufacturer’s specifications
Plastic Netting	Staked according to manufacturer’s specifications
Glass Fiber	Follow manufacturing specifications

Phase 3. Secondary Revegetation.

Phase three would occur once beachgrass is established and surface sand movement has been reduced. Adapted trees and grasses may be planted at this time. Native species are recommended.

Below is a list of known dune grass suppliers.

Manistee Soil Conservation District, Box 275, Onekana, MI 49675
Mason-Lake Soil Conservation District, 102 E. 5th Street, Scottvllle, MI 49454
Muskegon Soil Conservation District, Room 207 - Federal Building, Muskegon, MI 49443
Allen BeVries, 14835 Barry, Holland, MI 49423
Van’s Pines, Inc., West Olive, MI 49460
County Extension Director, Sterling, Arenac County,