13636

W.P.

COASTAL
INFORMATION CENTER

Let's protect our earth

NEW JERSEY

DEPARTMENT OF ENVIRONMENTAL PROTECTION

OFFICE OF COASTAL ZONE MANAGEMENT

HD
9506
.U63
H47
1977

New Jersey. Dept. of Environmental Protection

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

COASTAL ZONE
INFORMATION CENTER

Upland Mineral Resources and the Coast:

A Staff Working Paper

Kenneth J. Hess

U.S. DEPARTMENT OF COMMERCE NOAA
COASTAL SERVICES CENTER
2234 SOUTH HOBSON AVENUE
CHARLESTON, SC 29405-2413

January 1977

HD9506.U63 H47 1977
9623604
MAR 13 1997

Property of CSC Library

New Jersey Department of Environmental Protection
Division of Marine Services
Office of Coastal Zone Management
P.O. Box 1889
Trenton, New Jersey 08625

Note: This staff working paper is one of a series of Issue and Policy Alternative Papers presenting facts, analyses, and conceptual policy alternatives on coastal resources and coastal land and water uses. The purpose of this draft document is to stimulate discussion and comments that will assist preparation of the management program for the New Jersey coastal zone. This report was prepared in part with financial assistance under the federal Coastal Zone Management Act, P.L. 92-583.

Comments, criticism, additions, and suggestions are welcome and should be addressed to the New Jersey Office of Coastal Zone Management.

Contents

Page

Introduction..... 1.

I. Issue..... 3.

II. Policy Alternatives..... 4.

III. Mineral Characteristics..... 7.

IV. Analysis..... 13.

Appendices

A. Tables..... 19.

B. Sources..... 25.

Introduction

Mining operations have the potential for environmental degradation. The two major impacts of mining are landscape devastation and surface water pollution. Such impacts on the environment have been common in those areas lacking local ordinances to control the operations. An understanding of these impacts has lead to the prohibition, through zoning, of mineral extraction in many areas of the state. As a result, the minerals which are suitable for mining become economically valueless if they cannot be used. The source of supply for the various minerals also becomes somewhat restricted, not only by prohibiting regulations and ordinances, but also by development which has covered over mineral deposits.

This paper is intended to discuss the issues related to upland mineral resources and present alternatives for alleviating the problems. The first section of the paper clarifies the issues as they exist in New Jersey's coastal plain. The second section presents the policy alternatives.

Section III describes the types of upland mineral resources which exist, their uses, and their significance to the state's economy.

Section IV analyzes the causes and effects of the issues mentioned in Section I.

The text is followed by two appendices. Appendix A consists of a number of tables which help to support the text. Appendix B is a bibliography of all references used in the formulation of this paper.

Issue

The basis of the upland mineral resources problem is the potential that mining operations have for degrading the environment. Impacts on the environment have been common in those areas lacking local ordinances to control the operations. The two major impacts of mining are the destruction of the visual and ecological landscape and the pollution of surface waters.

The large acreage requirement for most mining operations is the primary factor influencing landscape devastation. In order to extract the materials from the earth most efficiently, it is generally necessary to raze all surface obstacles such as trees and shrubs. Such elimination of cover material over a large area not only impacts on the visual landscape, but on the ecological interactions of the area as well.

The second environmental impact of mining operations is the pollution of surface waters. Rivers and streams running through or adjacent to devegetated mining areas are susceptible to receiving eroded sediments from the operation site. Increased sediment loads in surface waters affect the turbidity of the waters and may affect the normal functions of fish and other aquatic species.

Because these environmental problems caused by mining exist, another type of problem associated with upland mineral resources is introduced. A fear of similar occurences of environmental degradation often prevents mining operations

from taking place in some areas where it would otherwise be economically feasible to do so. In a sense then, there is a decline in potential mineral supplies and a loss of economic opportunity within the state since these areas cannot be developed to their fullest extent.

The source of supply for the various minerals also becomes somewhat restricted by development which has covered over some of the mineral-rich areas. Obviously, the expense that would be involved in utilizing these areas for mining purposes is enormous, thereby making operations highly impractical. The minerals underlying the development then, become non-usable. The impact of such occurrences becomes particularly significant when minerals that are somewhat limited in geographic scope are involved. In the case of the New Jersey coastal plain, ilmenite is the primary mineral restricted by development.

Policy Alternatives

The mining of upland mineral resources could be included in a comprehensive coastal zone management strategy. The objective would be to promote the mining industry to the greatest extent possible while retaining harmony with the existing environment. There are several policy alternatives which could be implemented toward this end.

1. Mining could be encouraged in those regions which are presently being mined. Generally, mining operations locate

in accordance with areas of economic suitability. It is plausible that other sites within the mining region would also offer high levels of mineral potential. The encouragement of additional mining development in these existing regions would allow the use of the state's mineral reserves for economic purposes without transforming the overall quality of the environment.

2. Mining could be encouraged in those regions which exhibit economic suitability and potential for future urban development. Those regions which contain high levels of a particular mineral resource but are presently not being mined would be encouraged for mining if urban and residential development seems likely in the future. Such a policy would allow for the extraction of the minerals before development makes such mining economically infeasible. Upon termination of the operation, the land would be adapted for residential or other use.

3. Mining could be discouraged in those regions which would be detrimentally affected in other aspects. Such regions would include those which are tourist-oriented, environmentally sensitive, historically valuable, or contain rare or endangered species of plants and animals.

4. Buffer zones could be required in those areas which are adjacent to roadways. Such zones of natural vegetation would prevent visual blight from roadways during the actual operation phase of the mines.

5. Buffer zones could be required in those areas which are adjacent to surface water bodies. Such zones of natural vegetation would aid in the prevention of sediment pollution of surface waters since they would tend to collect eroded sediments from the mining site before they enter the waters.

6. The total land area which is cleared for mining at any one time could be restricted. Such a policy would reduce the amount of unnecessary visual and ecological destruction that could occur at a mining site at a time.

7. Reclamation or written agreements that the exposed mining areas will be put to useful purpose upon land conveyance could be required before any other areas may be cleared. This requirement would hold for a designated percentage of the exposed area rather than the entire area in order to allow working space. Efforts at reclamation would include contouring, seeding, sodding, tree planting or transfer, pond development in the case of dredging operations, or other suitable methods.

8. Reclamation or written agreements that the exposed mining areas will be put to useful purpose upon land conveyance could be required before the operation may be officially terminated. Failure to do so would result in fines or similar punishment. Efforts at reclamation would include contouring, seeding, sodding, tree planting or transfer, pond development in the case of dredging operations, or other suitable methods.

9. A tax break could be provided to mining corporations for the portion of the property which is not presently exposed. Since active mining can only effectively be done in those areas stripped of topsoil and ground cover, the mandatory vegetated or reclaimed areas would be taxed at a lower rate if that land is not presently being put to some economic use.

Mineral Characteristics

New Jersey is fairly limited in its variety of upland mineral resources in comparison to many other states. This fact becomes even more evident in the state's coastal plain where commercial mining operations are essentially limited to the extraction and production of sand and gravel, clays, ilmenite, and glauconite. Sand and gravel has the greatest demand of all the coastal minerals since the construction industry is highly dependent on these materials. The demand for clays, ilmenite and glauconite, however, are not as extensive since the uses of these minerals are much more limited. Nevertheless, all four mineral resource types contribute to New Jersey's overall economy.

Sand and gravel production in New Jersey totalled 17,924,000 short tons* in 1974, ranking the state 17th among all the states in total quantity. The $47,292,000 value of

*Short tons, as opposed to long tons, are equal to standard tons of 2000 pounds each.

production, on the other hand, gives the state a 7th ranking in terms of total value. The availability of sand and gravel in the coastal plain is widespread since it is composed almost entirely of unconsolidated sediments deposited during the Cretaceous, Tertiary, and Quaternary periods of geological time. In fact, a major portion of all sand and gravel mined in the state is taken from the coastal plain. As of September 1976, 57 of the state's 87 sand and gravel operations are located in the counties of the coastal plain.

Sand and gravel can basically be used for either of two purposes: construction or industry. By far, the largest percentage of all sand and gravel produced in the state is used for construction purposes. The sands in this category may be of various sizes and often contain hydrous iron or other minerals which act as impurities. Most of these sands and gravels are processed and used for making concrete products such as cement blocks, bricks, and pipes, or used in non-residential and residential construction, bituminous paving, and highway and bridge construction. Other processed aggregate uses include roadbase and subbase materials, construction of dams, waterworks, airports, and other miscellaneous items, and fill. As unprocessed aggregate, the major uses are as fill and roadbase and subbase materials.

Industrial sands are often fine in size and lack the impurities of construction sands. These sands are used in the making of glass, molding, and pottery, for blasting, grinding, polishing, and filtering, and various other uses.

Glass sands, which are principally found in Cumberland County, are fairly pure and white and contain mostly quartz. These sands are ground up, heated, and melted into glass. The color and type of glass produced depends on the degree of sand purity: optical glass is produced from the highest quality sands, followed by flintglass, sheetglass, green glass, and amber glass, respectively. Approximately 18 percent of the work force in Cumberland County is employed by the glass manufacturing industry, thus indicating the importance of clean sands to the area.

Clay production in New Jersey's coastal area is much less significant than sand and gravel production, although still important. In 1974, a total of 103,676 short tons with a value of $524,210 was produced. The state ranked in the bottom half of both categories in comparison to the other states.

The two types of clay which are mined in New Jersey are common clay and fire clay. About 65 percent of the clay total is comprised of the common clay variety. This clay is used exclusively in the production of building brick and is defined as a clay which is "sufficiently plastic to permit ready mold and vitrification below 1100°C." Also included with common clay in the making of brick is shale which is a "consolidated sedimentary rock composed chiefly of clay minerals laminated and indurated while buried under other sediments."

Fire clay, on the other hand is defined as a "detrital material, either plastic or rocklike, containing low percentages of iron oxide, lime, magnesia, and alkalies to enable material to withstand temperatures of 1500°C or higher." Because of its physical properties, fire clay in New Jersey is used for fire brick and block, refractory mortar, and sealing.

The third major mineral which is mined in New Jersey's coastal plain is ilmenite. This mineral is an ore which contains principally titanium dioxide (TiO_2). The importance of TiO_2 is in its use as paint pigment, although it is also used in the making of paper, rubber, and leather. Although actual TiO_2 is a white powdery substance, the ilmenite ore from which it must be extracted is a black or grayish color.

The major ilmenite ore bodies having economic potential are situated in the vicinity of Lakehurst in Manchester and Jackson Townships, Ocean County. The total potentially economic reserves in this area are estimated to be greater than 15,000 acres, although much of this area will probably never be mined. The average heavy mineral concentration of these sands is in excess of 3 percent for depths down to about 25 feet, although the ore may exceed 80 feet in some locations.

Throughout the ilmenite province, the ore tends to form a discontinuous irregular pattern which varies in ore content from place to place, but viewed as a whole, the region averages out to greater than 3 percent. The discontinuous

pattern of the ore, however, requires extensive drilling operations in order to locate the best sites. There are presently two large companies extracting ilmenite on a large scale in this area, but a third company also owns land and has completed its preliminary drilling tests to determine the feasibility of beginning operations.

Smaller areas of ilmenite ore are located near Browns Mills and Medford Lakes, both in Burlington County. The Medford Lakes deposit contains even less continuous heavy mineral concentrations than exists near Lakehurst. No mining has yet occurred in either of these two regions.

The last mineral type in New Jersey's coastal plain which is of any commercial significance is glauconite. This mineral is green to dark green in color, consisting of a hydrous iron potassium silicate with varying amounts of other elements. It is contained in a sediment commonly known as greensand. Other materials such as quartz, mica, pyrite, some heavy minerals, and calcium carbonate may also comprise greensand. The glauconite is separated from these other materials, washed, and treated so that it may be sold.

The demand for greensand, at present, is very limited. It had traditionally been used as a fertilizer and soil conditioner due to its potash content, but the introduction of artificial fertilizers with adjustable nutrient ratios and the high extraction costs of greensand led to a decline

of this material for agricultural purposes. Greensand is still recommended, however, as a mulch or soil additive for home and garden use.

The major use of greensand today is as a water softening agent. Due to the high ion exchange capacity of glauconite, magnesium, calcium, and other ions present in water may be removed. Sodium ions are released in their place. Despite this use of greensand, the overall demand is low.

New Jersey has the distinction of being the only state which currently mines greensand on a commercial basis. Although greensand formations extend across New Jersey from the Raritan Bay area to Delaware Bay near Salem, only one operation is currently mining the material. This operation, located near Sewell in Gloucester County, essentially supplies many areas of the country with greensand where its use is applicable.

One final mineral type which exists in the coastal planning area but not in the coastal plain is stone. The major type of stone produced is crushed stone, as opposed to dimension stone. This stone is blasted in a quarry and cut into various sizes. Most of the output is used as aggregate for highway and building construction, but some is also used for jetties and other uses.

The variety of stone mined in the Northeast Region and Mercer County is traprock. Large ridges of traprock are

scattered throughout the Piedmont Plain. The traprock consists of basalt and diabase. Both of these rocks are igneous in nature, but the former was surface cooled and the latter was cooled underground. These rocks are quarried and crushed for use. In 1973, the quantity of crushed traprock stone produced in New Jersey totalled 12,191,000 short tons. The total value was $34,688,000.

Analysis

The two major types of upland mining operations in the coastal plain are dry pit and wet pit. Dry pit operations are essentially those which take place above the water table. Sediments are generally removed from the surface of such pits by using power shovels, scraper wagons, or front-end loaders. Wet pit operations, on the other hand, are those which take place below the water table. These operations require the use of dredges or draglines to extract the sediments from the groundwater ponds. After the sediments have been removed from the soil surface, regardless of whether the surface is above or below the water table, they are cleaned and sorted at the adjacent plant.

Both methods require total removal of surface vegetation and topsoil in order to expose the sediments for easy extraction. At this point, the area becomes an eyesore as it is transformed into a desert of sand. Dry pits have the potential for an even greater degree of visual blight as operations continue.

The sediments are extracted from increasing depths as upper layers are eliminated. As a result, the surface becomes depressed and irregular in shape.

The large acreages which generally characterize surface mining operations augment the problem even more. Many operations may have as much as several hundred or in excess of 1000 acres stripped at any one time. In those areas lacking local public controls over mining facilities, the land is often left permanently scarred even after the operations have been abandonned. Often, the stripped sites are used for landfilling when the mining has been completed.

Fortunately, many municipalities now require that the visual damage initiated by a mining operation be ameliorated upon termination. The two existing ilmenite operations, for instance, are in the process of returning topsoil and contouring many acres in which mining has been completed. They are experimenting with various species of vegetation which will adapt to the soils. Even so, the time required before a truly attractive area develops is great and the return to a total climax situation will be difficult.

Vegetation removal not only impacts on the visual landscape, but on the ecological landscape as well. Death or migration of animals from cleared areas to surrounding vegetated areas normally accompany land clearing. Such an impact would be particularly significant if the dead or displaced animals are considered to be rare or endangered.

Similarly, the plants themselves, which must be removed may contain certain valuable species. The existence of such plants and animals should therefore, be determined before beginning a mining operation.

The second major environmental impact of upland resources mining is the degradation of water quality. Pollution is mainly in the form of sedimentation caused by erosion of unvegetated mining sites. The mills and gullies which exist at many of these sites are evidence of such erosion. The sediments are carried by runoff into the nearby surface waters.

Although surface water sediment loads in the coastal plain are among the lowest in the state, they can cause severe problems in localized areas. A direct impact of sedimentation is the increase in water turbidity. Food perception of fish may thus be impaired, and feeding and breeding grounds may be ecologically altered.

No data which specifically relates erosion at mining sites to increased sediment loads in surface waters of New Jersey's coastal zone are presently available. The overall significance or insignificance of surface mining operations on sedimentation is therefore difficult to determine. However, the characteristics of the mining industry do seem to indicate its potential as a polluter.

An understanding of these environmental impacts of surface mining creates, in turn, a problem of a different type. Because of the damage to the environment which surface mining operations are capable of doing, municipalities often zone out mining even in areas where economic potential is high. Such an occurrence is particularly associated with the proposed operations of construction minerals (i.e. sand and gravel and clay). As a result, many sources of valuable minerals are, in a sense, wasted.

Municipal ordinances that prevent the development of mineral reserves can be particularly significant when the potential sites contain high quantities of gravel. Since gravel is scarce throughout the state, it is necessary to develop all economically and environmentally suitable supply sources. For example, the demand for gravel may increase in the Atlantic City area since the recently-passed casino gambling referendum is expected to promote new construction. If additional gravel sites are not opened in the near future, alternative sources outside the state may be required. Obviously, the costs associated with such outside supplies would be phenomenal. The large availability of sand, on the other hand, presents no immediate problems to the construction industry in New Jersey.

Another cause of diminishing mineral supplies is the development which has occurred in mineral-rich regions. Once again, a problem is created when the extent of the

mineral supply is limited initially. Development in an area increases the value of land in that area, thereby pricing the land outside the range which most mining companies would be willing to pay. Generally, residential and other types of development are undertaken with little regard for the existence of mineral reserves or in total ignorance of such existence.

Ilmenite is one mineral type in New Jersey that has had its supply restricted by development. Although substantial areas of high ilmenite concentration still do exist, areas west of Laurelton and east of Lakewood in Ocean County have been rendered economically infeasible because of residential development. It is doubtful, however, that this restriction on the ilmenite supply will significantly affect future production of the mineral.

Basically, an analysis of the mining industry from a state or regional perspective rather than a local perspective is needed. Too often, decisions concerning mining operations which are made entirely at the local level tend to neglect the larger good which they might serve. If the development of a mineral source will benefit the coastal area or state in general, the source probably should be developed as long as irreparable damage to the environment can be prevented. State intervention and planning of mineral resources would provide for a more efficient and less environmentally-damaging mining industry.

The promotion of mining in New Jersey may also be reviewed in terms of employment generated. Though direct employment in mining is very low in the state, representing less than one percent of all covered employment, other industries which depend on the minerals extracted do generate many jobs. These industries include building construction and glass making.

Appendix A

Tables

Table 1

Value of Mineral Production for 1972 in New Jersey Coastal Counties

Region	County	Value in Thousand Dollars	Minerals Produced in Order of Value
Northeast	Bergen	1,267	Sand and gravel
	Essex	W	Stone
	Hudson	1,678	Stone
	Passaic	7,599	Stone; Sand and Gravel
	Union	W	Stone
North Shore	Middlesex	2,023	Sand and gravel;clays
	Monmouth	1,273	Sand and gravel
Central Shore	Ocean	7,208	Sand and gravel;Ilmenite
South Shore	Atlantic	373	Sand and gravel
	Cape May	W	Magnesium (plant-produced); Sand and gravel
Delaware Bay	Cumberland	15,051	Sand and gravel; clays
	Salem	-	-
Delaware River	Gloucester	546	Sand and gravel; Greensand
	Camden	1,605	Sand and gravel;clays
	Burlington	W	Sand and gravel;clays
	Mercer	W	Stone
Total for Known Operations		38.623	
Estimated Total for Concealed Operations		10,386	
Total Value		49,009	

W: Withheld to avoid disclosing individual company confidential data.

No production was reported in Salem County. Estimated total for concealed operations includes all W values existing for the coastal counties and all gen stone values for the entire state. From available information, it was impossible to separate the value of gem stones from W values.

Source: Wininger, 1973

Table 2

Number of Mining Operations

in New Jersey Coastal Counties in 1976

Region	County	Sand & Gravel	Clay	Ilmenite	Glauconite	Stone
Northeast	Bergen	2				
	Essex					2
	Hudson					1
	Passaic	6				6
	Union					1
North Shore	Middlesex	5	2			
	Monmouth	4				
Central Shore	Ocean	10		2		
South Shore	Atlantic	4				
	Cape May	5				
Delaware Bay	Cumberland	12	1			
	Salem					
Delaware River	Gloucester	7			1	
	Camden	6				
	Burlington	4				
	Mercer					2

Source: United States Department of the Interior, September 13, 1976.

Table 3

Uses of Sand and Gravel Mined in New Jersey in 1974

Sand and Gravel Use	Project Funding Source	Quantity in Thousand Short Tons	Value in Thousand Dollars
A. Construction			
1. Nonresidential and Residential Construction	Commercial	3,773	7,564
	Public	W	W
2. Highway and Bridge Construction	Commercial	908	2,026
	Public	345	698
3. Other Construction (Dams, Waterworks, Airports, etc.)	Commercial	392	881
	Public	W	W
4. Concrete Products (Cement Blocks, Bricks, Pipe, etc)	Commercial	4,137	10,881
	Public	51	127
5. Bituminous Paving (Asphalt and Tar Paving)	Commercial	1,183	2,626
	Public	540	988
6. Roadbase and Subbase	Commercial	521	1,281
	Public	229	470
7. Fill	Commercial	217	328
	Public	0	0
8. Other	Commercial	45	101
	Public	42	69
9. Unprocessed Sand and Gravel (Fill)	Commercial	1,938	1,522
	Public	0	0
10. Unprocessed Sand and Gravel (Roadbase and Subbase)	Commercial	308	321
	Public	0	0
B. Industrial		3,247	17,272
C. Total for Known Operations		17,876	47,155

W: Withheld to avoid disclosing individual company confidential data.

Source: Pajalich, 1974.

Table 4

Sources of Sand and Gravel Mined in New Jersey in 1974

Source	Quantity in Thousand Short Tons	Value in Thousand Dollars	Number of Operations
Dry Pit on Land	9,620	24,681	48
Wet Pit on Land	5,857	17,543	18
Non-Navigable Riverbed	0	0	0
Navigable Riverbed	W	W	1
Lake	W	W	1
Total for Known Operations	15,477	42,224	68

W: Withheld to avoid disclosing individual company confidential data.

Based only on the 68 operations which completed the 1974 supplemental form distributed by Bureau of Mines.

Source: Pajalich, 1974.

Table 5

Methods of Mining Sand and Gravel in New Jersey in 1974

Mining Method	Quantity in Thousand Short Tons	Value in Thousand Dollars	Number of Operations
Dredge	5,543	20,436	24
Dragline	4,566	11,471	7
Shovel	908	2,131	6
Front-end Loader	4,292	7,604	29
Other	W	1,088	2
Total for Known Operations	15,309	42,730	68

W: Withheld to avoid disclosing individual company confidential data.

Based only on the 68 operations which completed the 1974 supplemental form distributed by Bureau of Mines.

Source: Pajalich, 1974.

Appendix B

Sources

References

American Smelting and Refining Company, "Asarco: Manchester," pamphlet.

Bospian, Walter, Glidden-Durkee Division of SCM Corporation. Jackson, New Jersey. Interview, October 8, 1976.

Flawn, Peter T., Mineral Resources, Chicago: Rand McNally & Company, 1966.

Kebblish, William. United States Department of the Interior, Bureau of Mines. Letter to David N. Kinsey, Office of Coastal Zone Management, New Jersey Department of Environmental Protection. October 8, 1976.

Drake, Harold J. "Preprint from the 1973 Bureau of Mines Minerals Yearbook: Stone," United States Department of the Interior Bureau of Mines.

Kummel, Henry B. Bulletin 50: The Geology of New Jersey. Trenton: New Jersey Department of Conservation and Development, 1940.

Lord, John. American Smelting and Refining Company, Manchester, New Jersey. Interview, October 8, 1976.

Markewicz, Frank J., "Ilmenite Deposits of the New Jersey Coastal Plain" in Seymour Subitzky, ed., Geology of Selected Areas in New Jersey and Eastern Pennsylvania, New Brunswick: Rutgers University Press, 1969.

Markewicz, Frank J., Office of Special Services, New Jersey Department of Environmental Protection. Interviews. October, 1976.

Markewicz, Frank J. and William Lodding, "Glauconite", in Stanley J. Lefond, ed., Industrial Minerals and Rocks, American Institute of Mining, 1975.

Murray, Dr. Raymond. Rutgers University Geology Department, New Brunswick, New Jersey. Interview, October 1976.

New Jersey Department of Environmental Protection, Opinion No. 16, Decision by the Commissioner Conditionally Approving CAFRA Permit Application CA 74-11-070, Pennsylvania Glass Sand Corporation, April 15, 1975.

Pajalich, Walter, "Preprint from the 1974 Bureau Of Mines Minerals Yearbook: Sand and Gravel," United States Department of the Interior, Bureau of Mines.

Southard, Les. Brick-Wall Corporation, Lakehurst, New Jersey. Interview, October 8, 1976.

United States Department of the Interior, Bureau of Mines. Compilation of Industries Establishments in New Jersey, September 13, 1976.

United States Department of the Interior, Bureau of Mines. "Mineral Industry Surveys: Clays in 1974," December 12, 1975.

Wessel, F.W., "Preprint from the 1974 Bureau of Mines Minerals Yearbook: Titanium," United States Department of the Interior, Bureau of Mines.

Wilkenson, A.S. and J.E. Comeforo. Some New Jersey Glass Sands, New Brunswick: Rutgers University Press, 1948.

Wininger, Donald C., "Preprint from the 1973 Bureau of Mines Minerals Yearbook: The Mineral Industry of New Jersey," United States Department of the Interior, Bureau of Mines, 1975.

COASTAL ZONE
INFORMATION CENTER

NOAA COASTAL SERVICES CENTER LIBRARY
3 6668 00002 7062