

**MAJOR REHABILITATION EVALUATION REPORT
GRAND MARIAS HARBOR, MICHIGAN
SECTION D – PILE DIKE BREAKWATER
OCTOBER 2003**

1. STUDY AUTHORITY

Section 104 (c), Small Navigation Projects, of the Water Resource Development Act of 1996 includes the following language:

Section 104. Small Navigation Projects

The Secretary shall conduct a study for each of the following projects and, if the Secretary determines that the project is feasible, may carry out the project under section 107 of the River and Harbor Act of 1960 (33 U.S.C. 577):

(c) Grand Marais Harbor Breakwater, Michigan – Project for navigation, Grand Marais Harbor breakwater, Michigan.

Operations and Maintenance, General, funds were appropriated in FY 2002 to conduct a major rehabilitation reevaluation of a breakwater at Grand Marais, Michigan. The appropriation language for this study was as follows: “*Grand Marais, Michigan – The Committee has provided \$ 200,000 to conduct a major rehabilitation reevaluation of the harbor project at Grand Marais, Michigan*”.

a) Federal Navigation Project

The River and Harbor Act, approved 14 June 1880, authorized the Federal Navigation Project at Grand Marais, Michigan. The Act provided for the construction of two parallel timber crib jetties, 500 feet apart. The construction of the jetties was initiated in 1883 and completed in 1903. The jetties extend into Lake Superior to the 20-foot depth contour. The River and Harbor Act was amended to include enclosing the harbor by constructing a 5,770-foot long timber pile breakwater. The breakwater or “pile dike” was constructed during the period 1895 to 1897. The outer 744 feet of the east pier was rebuilt with a reinforced concrete superstructure in 1950-51. The River and Harbor Act of 17 May 1950 provided for an 802-foot extension of the existing west pier consisting of rock and sand-filled steel sheet piling cells.

Pike Dike

The pile dike is identified as Section D of the navigation structures and was originally constructed (See Appendix A, Plate 3) of close-driven circular timber piles at an angle of 30 degrees. Stone reinforcement on the harbor side and a vertical piling provide support for the dike. The top width of the dike was 10-feet and its height was 4-feet above International Great Lakes Datum (1955) for Lake Superior, elevation 600-feet above Mean Water Level at Father Point, Quebec. The existing pile dike is in ruins and no longer functions as it was intended, which was to dissipate wave energy in order to reduce shoaling in the harbor. The last maintenance performed on the Pile Dike was in 1943. Since then the dike has deteriorated and has virtually disappeared. All that remains is an indeterminate amount of stone below water level. The timber has also disappeared with nothing visible above water.

Jetties

The navigation structures consist of 2 concrete and steel sheet pile jetties which form a channel providing safe entry to the natural harbor of Grand Marais. Grand Marais serves as a harbor-of-refuge. The east jetty is 1,695 feet long and the west jetty is 2,714 feet long. The existing harbor is complete except for widening the inner portion of the channel between the jetties to 500 feet. The project depth between the jetties is 18 feet (inner channel) and 20 feet (outer channel). The channel is maintained to 15 feet (inner channel) and 17 feet (outer channel). The east and west jetties were rehabilitated from 1969 to 1973.

Maintenance Dredging

The Federal navigation channel at Grand Marais, Michigan was last dredged in 1973 by the Dredge Hains, a hopper dredge. The quantity of dredged material (63,100 cubic yards) was placed in open water.

b) Major Rehabilitation Studies

Guidance for Major Rehabilitation Studies is provided in:

- *ER 1105-2-100, Planning Guidance Notebook, 22 April 2000;*
- *EP 1130-2-500, Project Operation Partners and Support (Work Management Guidance and Procedures), 27 December 1996;*
- *ER 1130-2-500, Project Operations Partners and Support (Work Management Policies), 27 December 1996.*

2. STUDY PURPOSE

The purpose of a major rehabilitation study is to establish the engineering condition of a structure and determine the need for reliability or efficiency improvements. The structure to be evaluated is a 5,770-foot long timber pile breakwater or "pile dike" identified as Section D of the navigation structures. The remainder of the Federal navigation project at Grand Marais has been maintained and is considered to be operating as intended.

Rehabilitation of a major project feature of a Corps operated and maintained facility is intended to improve the reliability of an existing structure and result in the deferral of capital expenditures to replace the structure. Rehabilitation would be considered if it could significantly extend the physical life of the project feature and can be economically justified by benefit-cost analysis. In order to consider rehabilitation of a Corps structure as an efficiency improvement, it must be shown that the operation of a major project component would be enhanced.

3. LOCATION AND DESCRIPTION

a) Location

Grand Marais Harbor is a natural deep water harbor located in Alger County, Michigan on the southern shore of Lake Superior about 93 miles west of Sault Ste. Marie and 75 miles east of Marquette, Michigan. The embayment at Grand Marais is comprised of a relatively deep basin on the west side (West Bay) extending into a shallow, marshy region of the east side (East Bay). The bay is about 2 miles long and one-half mile wide. See Appendix A, Plates 1 and 2, respectively, for a location/vicinity map and for the existing plan view of Grand Marais Harbor of Refuge.

b) Non-Federal Sponsor

Burt Township, Alger County, Michigan has expressed an interest in becoming a cost sharing partner in the reconstruction of a breakwater type structure to replace Section D at Grand Marais, Michigan Harbor of Refuge.

c) Congressional Districts

The study area lies within the jurisdiction of the 1st Congressional District, MI. (Congressman Bart Stupak) and U.S. Senators Carl Levin and Debbie Stabenow.

4. PRIOR REPORTS AND EXISTING PROJECTS

a) Reviewed Reports

1) *Grand Marais Harbor, Michigan Reconnaissance Report on Reducing Future Maintenance, November 1978*, prepared by the U.S. Army Corps of Engineers, Detroit District. This study evaluated alternatives to reduce increasing maintenance costs and developed a plan to reduce future maintenance costs. It was determined that deterioration of the pile dike had resulted in the doubling of the accretion rate in West Bay and increased erosion of the lake bottom offshore of the pile dike, which may threaten the stability of the East Pier. The recommended mitigation plan for reducing future project maintenance consisted of the construction of a segmented rubble mound breakwater with four segments and an opening of 200 feet between the segments. The recommended breakwater, if constructed, would extend 1,600 feet southeast from the south end of the East Pier.

2) *Section III, Final Environmental Impact Statement on Shore Damage, Grand Marais Harbor, Michigan, July 1980*, prepared by the U.S. Army Corps of Engineers, Detroit District. This study evaluated shore erosion damage. The study concluded that the Federal structures have contributed a very small portion of the shoreline erosion. This study concluded that about 67 percent of the erosion within the harbor would have occurred had not the navigation structures been constructed. The following plans were evaluated.

Non-Structural:

No Mitigation Action
Shoreland Regulation

Structural:

Restore bay to pre-project conditions
Construct a continuous revetment
Construct protective beaches
Establish sand-bypass program
Construct detached breakwater (replace pile dike)
Headland protection

A non-structural mitigation plan (Shoreland Regulation) was recommended and based on a lack of economic justification for structural alternatives. The non-structural recommendation was also based on a determination that the majority (67%) of erosion was classified as ambient. The Shoreland Regulation plan included the following points:

- Assist non-Federal agencies in establishing shoreline regulations;
- Establish erosion monitoring process;
- Develop a public information program;
- Utilize clean dredged material for beach nourishment;
- Insure future projects consider erosion mitigation works.

3) *Grand Marais Harbor Rehabilitation Design Alternatives, Final Report, 1 December 2000*, prepared for the Michigan Sea Grant College Program by Dr. Guy Meadows, Director, Ocean Engineering Lab, Department of Naval Architecture and Marine Engineering, University of Michigan. The goal of this study was to provide viable and long-term solutions to address the needs and uses of Grand Marais Harbor. This report evaluated the impacts of the blocking of along shore sediment flow from west to east by the existing west jetty. The report concluded that the west jetty acts as a wave barrier for storm waves approaching from the northwest and decreases the wave energy attack on the shoreline for a distance of about one mile to the east. This distance was determined to be dependent upon the actual incident wave direction and period. Beyond this area, the littoral drift was locally maximized with a potential for high erosion impacts. With regard to littoral transport, the report concluded that the material eroded from Lonesome Point and other areas is transported into West Bay and along the shoreline seaward of East Bay. This has resulted in deposition of material along the bay perimeter, as well as in deeper shoals.

Extensive field data was collected, including: hydrographic surveys, random access surveys, aerial photography, sediment collection and testing, and underwater inspection. Modeling of near shore processes was also accomplished.

The alternatives evaluated included those presented in the U.S. Army Corps of Engineers, Detroit District, reported entitled: *Section 111, Final Environmental Impact Statement on Shore Damage, Grand Marais Harbor, Michigan, July 1980*,

- No Mitigation Action;
- Shoreland Regulation;
- Restoration to pre-project conditions;
- Construction of a continuous revetment;
- Construction of protective beaches;
- Establishment of a sand-bypassing program;
- Construction of a detached breakwater (replace pile dike);
- Construct groin field;
- Headland protection.

Three (3) of the alternatives were evaluated in detail, those being no mitigation action, establishing a sand-bypassing program, and reconstruction of all or a portion of the original pile dike breakwater. The report concluded that reconstruction of Section D at 15-degree or 55-degree angles to the shoreline was the most practical and cost-effective solution to reduce the ongoing erosion and accretion processes.

4) *Grand Marias, Michigan Shoreline Monitoring Report, January 1993*, prepared by the U.S. Army Corps of Engineers, Detroit District. The purpose of this report was to reassess the erosion situation at Grand Marias, estimate the shoaling rate in the vicinity of the Federal navigation channel, and recommend solutions to the problems associated with accretion within the harbor. Local concerns included accretion at the west end of the bay, shoaling of West Bay, erosion of the south shore of the bay, and unsafe wave conditions in West Bay. Two (2) alternatives were recommended for mitigating accretion along the west shoreline of West Bay. The first alternative was to periodically dredge material from the marina vicinity. The second alternative was to construct a groin that would block the alongshore transport of sand and be located south of the marina.

This report also concluded the following:

- The Bay and coastline still are readjusting to the change in condition following the demise of Section D;
- Shoaling in the west basin would continue at an unknown rate between 1,000 - 25,000 cubic yards per year;
- The erosion at Kahle Park and Lonesome Point would continue;
- The offshore area east of the jetties would continue to deepen and the offshore contours would move landward until an equilibrium profile is reached. This would result in waves with higher energy within the bay.

5. PROJECT HISTORY¹

a) Pre-Project Conditions

Grand Marais was once an inland lake, isolated from Lake Superior except for a channel, which served as an outlet for the Sucker River. The wave climate over time eroded material from the shoreline in the vicinity of Grand Marias Harbor and eventually eroded away the land separating the inland lake from Lake Superior. Two spits formed, one on the east side (Lonesome Point) and one on the west, which has continued to erode since the mid-1800's.

During the period 1880 to 1920 the logging industry located at Grand Marais reached its peak, and the harbor was important to the shipment of logs to markets on the south shores of the Great Lakes. However, by 1915 a large extent of the pine and hardwood forests had been clear-cut and the last sawmill was closed.

¹ *Grand Marais, Michigan Shoreline Monitoring Report, January 1993*

b) Post-Project Conditions

Construction of the Federal navigation project induced changes in the local littoral processes, with an accompanying change in the existing configuration of the bay. Two jetties were cut through the west spit, interrupting normal alongshore transport. An accretion fillet formed on the west side of the west jetty. The fillet as of 1993 extended over 1,000 feet lake-ward of the pre-project shoreline and over one mile to the west. The tip of the west spit, cut off by the jetties, created Gull Island. The pile dike was completed in 1897 to provide protection from wave action within the bay for the logging industry. During the period when the dike was in good condition, waves diffracted through the channel, eroding the south shoreline directly across the bay from the entrance channel and on the north shore at Coast Guard Point. After 1939, the pile dike began to slowly deteriorate. By the mid-1950's the dike was in need of repair, but no economic justification could be found for the repairs since the termination of the logging industry. The dike had almost completely disintegrated by 1960; however, Gull Island was still in place, with little change, in 1962.

Deterioration of the dike gradually exposed the bay to waves from Lake Superior, resulting in increased wave action within the bay and increased accretion along the south shore. Material, which had been deposited in the vicinity of the dike and material, which formed Gull Island and Lonesome Point, began to redistribute within the bay. The available soundings show a dramatic recession of the offshore contours in the vicinity of the pile dike. Several million cubic yards of material that had accumulated landward and lakeward of the pile dike began to move landward into the bay. The movement of this material has resulted in the increased filling of the eastern half of West Bay and the landward movement and disappearance of Gull Island.

Prior to 1960, the eastern half of West Bay was roughly 50 feet deep. Gull Island was a large island 10 to 15 feet above the water surface at the western end of the dike. Following the demise of the pile dike, Gull Island began to rapidly erode and move southward toward the shoreline. By 1973, Gull Island was no longer visible. The deepest part of the eastern half of West Bay was rapidly reduced to a narrow basin that had completely filled in by 1991. The material that filled in the eastern half of West Bay came from Gull Island. The material that had accumulated around the pile dike came from the collapse of Lonesome Point.

During the early 1980's, the shoreline west of the jetties and the west accretion fillet appeared to be stable. The shoreline along West Bay, south of the jetties, was generally unchanged except for a reach of shoreline about 1,200 feet long which had accreted 30 to 60 feet. Further east along the south shore of West Bay the trend changed to erosion. A 2,000-foot reach of shoreline just west of Kahle Road had eroded 40 to 70 feet. There did not appear to be any erosion of the bluff along the south shore of West Bay during this period. The shoreline east of Kahle Road showed no significant change. A small spit of sand had formed just northeast of the mouth of the Sucker River. The Lonesome Point spit had grown about 50 feet westward. The shoreline for roughly 2,000 feet east of Lonesome Point had receded 20 to 40 feet and the bluff had receded about 10 feet. Further east, the shoreline and bluff show no measurable change during this period. The air photos, however, show a bare bluff face along the entire east shoreline with many fallen trees visible laying on the bluff face and toe. This is indicative of a bluff experiencing active erosion.

c) Period 1982 to 1992

Between 1982 and 1992 the coastline in the vicinity of Grand Marais continued to readjust to conditions following the demise of the pile dike. The rate of readjustment appeared to be slowing down as the available sources of material were used up and the coastline east of the harbor came into alignment perpendicular to the predominate wave direction.

The coastline at Lonesome Point continued to recede. The spit continued its collapse into the bay. Into the mid-1980's a spit was present at Lonesome Point extending across the bay. During this period, Lonesome Point no longer existed as a spit. Further east, the recession rate was roughly 180 feet over this period, or an average of 20.0 feet per year.

Further west, at Kahle Park, the shoreline continued to erode, but at a slower rate per year. From 1983 to 1984, the shoreline receded roughly 78 feet. From 1984 to 1987, the shoreline receded roughly 126 feet. From 1987 to 1992, the shoreline receded roughly 141 feet. Kahle Park has receded roughly 345 feet from 1983 to 1992, or about 38 feet per year on the average. Along the south shore of the bay, a comparison of shoreline positions showed that the beach is wider in 1992 than at any time during the prior 10 years. However, it was noted that this area has been quite dynamic in the past, alternating between period of accretion and erosion.

The shoreline in the vicinity of Carpenter Creek continued to accrete during this time period. This area had experienced erosion in the recent past; however, the large volume of material being carried along the south shoreline of the bay had reversed this trend, at least temporarily.

The material carried along the south shore towards the west continued to accumulate at the west end of the bay. From 1982 to 1992, the shoreline had expanded roughly 67 feet, or an average of 6.7 feet per year.

d) History of Maintenance and Rehabilitation

Major expenditures consisted of \$ 632,293 during 1960-1962 for an 802-foot extension to the west jetty and a cost of \$ 699,403 during 1969-73 for rehabilitation of the timber crib jetty structures. The cribs were capped with a concrete cover and reinforced where necessary with vertical piling.

The last maintenance performed on the pile dike consisted of the placement of 2,193 tons of stone reinforcement in 1938 and 3,400 tons in 1943. In 1950, field inspections revealed that the breakwater was deteriorating. Project reports for the next 20 years noted that repairs were necessary but that repairs could not be economically justified. The breakwater had almost entirely disintegrated by 1960.

<u>Date</u>	<u>Construction and Rehabilitation History</u>
1883-1885	Construction of 700-foot long portions of the east and west piers progressed during this time. It was a timber crib structure with a 20.5-foot width and was built on a stone blanket. Stone protection also was included in construction.
1885-1903	A 1,112-foot long portion of the west pier (a timber crib structure) was constructed during this period. It was 24.5 feet wide. The structure was built on a stone mattress and riprap was placed along the sides for toe protection.
1892	The inner 250-foot long portion of the east pier and 100-foot long portion of the west pier were completed. These were wood-pile structures filled with sand and stone. They were 12.5 feet wide with crest elevation of +6 feet above low water datum. Stone was placed on the channel side of the structures.
1893-1903	The outer 745-foot long portion of the east pier was constructed during this period. This was a 24-foot wide stone-filled timber crib structure. It was built on stone, and riprap was placed on each side of the structure.

- 1895-1897 A 5,770-foot long timber-pile dike (Section D) was constructed during this time. It was installed at an elevation of +4 feet above low water datum.
- 1905-1907 Stone reinforcement was added along the timber-pile dike built during 1895-97. The stone crest was 10-feet wide at an elevation of +4 feet above low water datum.
- 1914 Timber crib structures on the west pier were repaired. Crib walls were repaired with tie rods, and 425 tons of crib-fill stone was installed in the outer 500-foot portion of the pier.
- 1936-1942 Repairs were made to the east and west piers. These included replacing decaying, broken, or missing deck planking and replenishing crib-fill stone.
- 1950-1951 A concrete cap (superstructure) was installed on the east pier. The cap extended to an elevation of +6 feet above low water datum.
- 1960-1962 Construction of an 802-foot long cellular sheet-pile breakwater extension was completed at the lake-ward end of the west pier. The lake-ward 307 feet of the structure was constructed with 58.9-foot diameter cells, and the remaining portion was built with 46.1-foot diameter cells. The cells were filled with dredged fill material and capped with 3-ton cover stone. The crest elevation of the structure was +8 feet above low water datum. Riprap stone was placed around the toe of the cells.
- 1969-1973 Portions of the east and west piers were capped with concrete. The new superstructures extended to elevation of +7 feet above low water datum.
- 1986 The east and west piers underwent additional maintenance and were considered to be in fair condition. The pile dike was noted to be badly deteriorated and in ruins.

TABLE 1 – Expenditures for Maintenance and Rehabilitation					
Year	Spent	Repair	Maint	Rehab	S&A
* 1969	\$1,631,095.00		\$941,095.00	\$690,000.00	
1970	\$297,696.00			\$262,820.00	\$ 34,876.00
1971	\$192,388.00			\$175,364.00	\$ 17,024.00
1972	\$194,530.00			\$114,215.00	\$ 80,315.00
1973	\$6,722.00			\$4,523.00	\$ 2,199.00
1974	\$2,497.00		\$2,497.00		
1975	\$57,914.00	\$57,914.00			
1976	\$5,595.00		\$5,595.00		
1977	\$23,452.00	\$7,727.00	\$15,725.00		
1978	\$7,365.00		\$7,365.00		
1979	\$214,130.00	\$209,245.00	\$4,885.00		
1980	\$7,564.00		\$7,564.00		
1989	\$5,643.00		\$5,643.00		
1990	\$175,017.00	\$167,362.00	\$1,886.00		\$ 5,769.00
1991	\$663,290.00	\$643,338.00	\$8,747.00		\$ 11,205.00
1992	\$6,430.00	\$1,137.00	\$5,293.00		
1994	\$11,838.00		\$11,838.00		
1996	\$10,240.00	\$1,484.00	\$8,756.00		
1997	\$21,463.00		\$21,463.00		
1998	\$9,412.00		\$9,412.00		
* Total expended during the life of the project up to 1969					

6. PLAN FORMULATION

a) National Objectives

1) The national objective of water and related land resources planning is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to national economic development (NED) are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

2) The following site evaluation and selection criteria were developed for evaluating navigation project alternatives:

- There is a strong likelihood of developing a technologically feasible and cost effective project, using proven technology;
- Economic resources within the study area are of demonstrated national, regional, or local significance;
- The Federal government may participate in improvements for navigation purposes if the accrued benefits are in excess of the estimated costs;
- There is a reasonable assurance that a public entity (i.e. state or local unit of government) is capable and willing to participate as a non-Federal sponsor(s) in a cost shared project.

b) Study Objectives

- Establish the overall engineering condition and reliability of the existing structure;
- Identify the operational and/or potential reliability problems and/or opportunities for efficiency improvement;
- Identify alternative methods to resolve or manage the problem;
- Develop cost estimates for the proposed solutions;
- Determine if a proposed project is eligible for funding under the major rehabilitation program;
- Estimate the total economic costs and benefits of the base condition and alternative solutions;
- Identify cost sharing requirements;
- Identify environmental concerns and complete environmental consideration reporting;
- Identify the recommended plan.

c) Public Concerns

Public concerns have been identified during the course of this evaluation. Additional input was received through coordination with the potential sponsor and some initial coordination with other regulatory agencies. The public concerns that are related to the establishment of the planning objectives and planning constraints are:

- Failure of Section D has had significant impact on the harbor due to shoaling caused by significant storms emanating from the northeast. This has led to a decrease in depths of the deep draft harbor inside the east end of West Bay;
- Loss of valuable aquatic habitat and significant shoreline changes;
- Decreased property values in erosion areas.

d) Sediment Budget

The Detroit District's *Grand Marias, Michigan, Shoreline Monitoring Report, January 1993*, provided the following sediment budget information in four time periods.

(1) **Sediment Budget prior to Jetty Construction** - 50,000 cubic yards per year of material entered the system from the west. About 25,000 cubic yards would by-pass the natural entrance to the bay and nourish down drift beaches. The remaining 25,000 cubic yards would fill within the bay, rather than form the fillet had the jetties not been constructed. The deficit created by the loss of the 25,000 cubic yards of sediment per year into the bay is made up by the erosion of 25,000 cubic yards per year of material to the east of the bay. In addition, 25,000 cubic yards of material is carried into the bay from the east, creating an additional deficit of 25,000 cubic yards per year on the east side of the bay. The total amount of the deficit is 50,000 cubic yards. This amount is eroded from the region east of the bay.

(2) **Sediment Budget after Jetty Construction (1883-1963)** - The same 50,000 cubic yards of material per year enters the system from the west. However, the material can no longer pass the point where the jetties were constructed. A portion of the material is impounded in the accretion fillet and a portion is trapped in the entrance channel. The rate of impoundment in the accretion fillet was calculated to be roughly 45,000 cubic yards with an additional 5,000 cubic yards deposited in the entrance channel. No material enters the bay from the west. The deficit east of the harbor is now 50,000 cubic yards per year. An additional 25,000 cubic yards per year is still transported towards the west; however, this material now accretes along the pile dike. The total deficit east of the harbor is now 75,000 cubic yards per year. This volume of material is eroded from the coastline east of the harbor, 50,000 cubic yards per year of which are transported out of the system towards the east.

(3) **Sediment Budget after failure of the Pile Dike (1963-1992)** - As before, 50,000 cubic yards per year enters the system from the west, with the same impoundment at the jetties occurring. The loss of the dike allowed West Bay to function as a sand trap. Material eroded from Lonesome Point and carried westward into the bay during reversals in littoral transport could not reenter the littoral stream. On the east side of the harbor, the same 75,000 cubic yards per year deficit exists. Since the general littoral climate on Lake Superior is assumed to be the same as before, 25,000 cubic yards per year would be transported to the west, with the remaining 50,000 cubic yards per year being transported out of the system to the east. Following the deterioration of the pile dike, the material that had accreted around the pile dike is redistributed. Over the preceding 80 years the pile dike had accreted roughly 2,000,000 cubic yards of material. Gull Island accounted for an additional 150,000 cubic yards. After the deterioration of the dike, Gull Island and all of the material accreted around the dike is carried into the bay. Lonesome Point recedes eastward several thousand feet. An additional 1,410,000 cubic yards of material is carried into the bay by the collapse of Lonesome Point. The 25,000 cubic yards of material per year previously carried westward and accreted around the dike now enters the bay again. The total volume material entering the bay during this period is roughly 4,310,000 cubic yards, or 143,700 cubic yards per year.

(4) **Sediment Budget for the Future (After 1992)**- The budget for the future is nearly the same as that following jetty construction except that the 25,000 cubic yards of material per year being transported to the west will enter the bay instead of being accreted along the pile dike.

e) Problems and Opportunities

The bay and coastline in the vicinity of Grand Marais Harbor continues to adjust to a change in conditions caused by natural erosion and accretion processes, the Federal harbor structures, and the failure of Section D.

Problems:

1) **Accretion of sediment at Grand Marais Harbor** (The following information was extracted from the Detroit District's *Grand Marais, Michigan, Shoreline Monitoring Report, January 1993*).

- **Jetties and Navigation Channel.** Accretion takes place along the Lake Superior coastline west of the jetties resulting in a fillet extending lakeward and some of this sediment passes around the jetties to the east side and into the Federal navigation channel. Material passes around the south end of the east jetty causing shoaling at the southeast end of the entrance channel. These shoaling conditions may result in additional maintenance dredging requirements in the navigation channel and the possibility of increased water depths alongside the east jetty caused by scour along the south end of the east jetty.

- **West Shoreline of West Bay.** Without intervention, sand carried alongshore will continue to accumulate at the west end of West Bay. Over the past 10 years, the shoreline has moved lakeward an average of 6.7 feet per year. This rate should continue, or even increase, over the next ten years as more material is pushed onshore at the east end of the bay. At some point, years in the future, the rate of material entering the bay should stabilize at about 25,000 cubic yards per year and the rate of growth of the beach should decrease and stabilize.
- **West Side of West Bay.** The western side of West Bay continues to slowly shoal. Material enters the west basin primarily from the east. From 1988 to 1993 the shoaling was accumulating at a rate of 0.2 feet/year. This represents roughly 5,000 cubic yards total over the five years. Between 1971 and 1987, there was no measurable shoaling. The bay is becoming smaller due to the widening of its beaches. Material enters the bay primarily from the east. Without intervention, West Bay will continue to slowly shoal. The rapid rate at which the eastern half of West Bay has shoaled is not an indicator of the expected shoaling rate of the west basin. As a minimum, it is expected that the shoaling rate of the west basin would continue at its present rate of 0.2 feet per year. At this rate, the west basin would approach the project depth of 18 feet in roughly 150 years. However, it is more likely that the shoaling rate will increase. It has been calculated that 25,000 cubic yards of material per year will enter the bay from the east. If all of this material is carried into the west basin, it would take a little over six years for the west basin to shoal to project depth. The 1993 report indicated that the available sounding data does not cover a sufficient length of time and does not cover enough of the west basin to permit an accurate prediction of the shoaling rate. This report also indicated that as the area offshore of the east side of West Bay continues to erode, water depths will increase and allow higher energy waves to enter the bay from the northeast. The 1993 report predicted that shoaling of the west basin will continue at an unknown rate between a minimum 1,000 cubic yards per year to a maximum of 25,000 cubic yards per year. The length of time for the west basin to shoal to the project depth of 18 feet below Low Water Datum is estimated to be from 6 to 150 years.
- **East Side of West Bay.** The average depth of the east side of West Bay is roughly 10 feet where it was once 50 feet. Conversely, areas near the pile dike are about 15 feet deep where it was once 15 feet above water (Gull Island). The 1993 report predicts that the area offshore of the east side of West Bay will continue to erode and water depths offshore will increase. Some of the material eroded from the offshore will be transported east, but most of the material will be pushed onshore or transported towards the west. At the time of the 1993 report, the offshore contours are nearly parallel to the shoreline and their distance offshore is roughly the same as on the open coast of Lake Superior. The deeper water offshore allows higher energy waves to reach the shoreline.

- **South Shoreline of West Bay.** The south shoreline of West Bay is accreting, however, as a balance between the erosive forces and the influx of material shifts, portions of the south shoreline should begin to erode. The Detroit District's *Grand Marias, Michigan, Shoreline Monitoring Report, January 1993*, also compared shoreline positions over the prior 10 years, which suggested that erosion occurring in the Kahle Park area would extend westward. The predicted erosion of this area will probably be due to northwest waves being diffracted around the jetties as well as northeast waves reaching the now unprotected shoreline. In addition, this area will begin to feel the adverse erosional effects of the blockage of littoral material from the west by the jetties. Further west, the shoreline in the vicinity of Carpenter Creek should continue to accrete or at least stabilize as material continues to be transported into this partially protected area from the east.

2) Erosion of sediment at Grand Marais Harbor (The following information was extracted from the Detroit District's *Grand Marias, Michigan, Shoreline Monitoring Report, January 1993*).

- **Kahle Park.** Kahle Park has been eroding steadily for the period 1982-1992 as the coastline realigned. The 1993 report indicates that severe erosion will continue in this area even after the shoreline has realigned due to the diffraction of waves around the jetties, the blockage of alongshore material by the jetties and its exposed location. The report indicated that the recession rate of Kahle Park has been about 345 feet over the past 10 years and would continue for the next 10 years, then begin to diminish.
- **Lonesome Point.** The 1993 report predicted that Lonesome Point will continue its severe erosion for the near future as it continues to realign. Recession rates averaging 20 feet per year in this area should continue for another 10 years or so, at which time the recession should begin to approach the long-term average rate of roughly 9 feet per year.

3) Unsafe wave conditions in West Bay Harbor (The following information was extracted from the Detroit District's *Grand Marias, Michigan, Shoreline Monitoring Report, January 1993*).

The deterioration of the Section D has resulted in deeper water in the vicinity the pile dike, which allows larger waves to access the shoreline. The 1993 report predicts that the offshore area east of the jetties will continue to deepen and the offshore contours would move landward until an equilibrium profile is reached, which will result in a high wave energy environment within the bay.

Opportunities

- **Reduce critical erosion and accretion impacts**

Specific areas within Grand Marais Harbor have been identified that are impacted by either erosion forces or accretion of littoral material. Structural alternatives are available which can reduce and/or eliminate the erosion and accretion impacts within the harbor.

There is an opportunity to restore fishery habitat. The MDNR has indicated that Grand Marais had a good fishery, but sand that is filling the deepwater basin (West Bay) and Sucker River has eliminated much of the spawning habitat, including rock and gravel substrate, and submerged vegetation. The sand has filled in deep parts of the Sucker River resulting in shallower depths and warmer temperatures in those impacted sections. The remnant deep-water area of the harbor still provides spawning in limited stone rocky areas (whitefish) and a few areas of submerged vegetation (Northern Pike and Perch and minnows).

Any implemented restoration alternative that, over time, reduced the accretion process in West Bay would allow the harbor to continue its use as a Harbor of Refuge. Without Grand Marais, light-draft vessels would be to navigate an approximately 89-mile stretch of Lake Superior's most dangerous waters without a place for refuge.

f) Planning Objectives

The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent changes in the without project conditions. The planning objectives are specified as follows:

- To reduce erosion and accretion impacts as related to the demise of the Section D.
- To establish a clear link between implementation of restoration activities and subsequent measurable improvements

g) Planning Constraints

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints are:

- The Grand Marais area has historically been a nesting place for the Great Lakes piping plover, a federally listed endangered species. Grand Marais is also included in the recent designation of critical habitat for the piping plover throughout the Great Lakes Basin. The U.S. Fish and Wildlife Service has indicated that any project that would further diminish the extent of piping plover habitat in Grand Marais, and particularly near the mouth of the Sucker River would be of concern.

h) Measures to Address Identified Planning Objectives

A management measure is a feature or activity at a site, which address one or more of the planning objectives. During the past 20 years a variety of measures have been evaluated both by the Detroit District, Corps of Engineer's and the University of Michigan. The Detroit District prepared the *Section 111 Final Environmental Impact Statement on Shore Damage at Grand Marais, Michigan, dated July 1980*. The University of Michigan prepared the *Final Report for Grand Marais Harbor Rehabilitation Design Alternatives, dated 1 December 2000*. Each proposed restoration measure was assessed and a determination made regarding whether it should be retained in the formulation of alternative plans. Most of the formulated alternatives in the Detroit District, Corps of Engineer report were found to be infeasible due to technical, economic, or environmental constraints. The Detroit District's Section 111 report, dated July 1980, recommended a non-structural plan involving shoreland restoration.

The *Final Report for Grand Marais Harbor Rehabilitation Design Alternatives, dated 1 December 2000, prepared by the University of Michigan (Dr. Guy Meadows)* recommended a structural alternative involving the replacement of Section D by a rubble mound structure constructed at 15-degree or 55-degree angles to the shoreline. These options would decrease shoaling of material within West Bay and decrease the loss of sediment along the shoreline in the vicinity of Lonesome Point. This University of Michigan based their recommendations on the reduction of shoaling and erosion within the harbor. The University of Michigan's report did not include an economic benefit-to-cost analysis. However, the University of Michigan plan meets the local communities desire to maintain and/or preserve the harbor.

By letter dated 12 January 2001, the Burt Township Board expressed support for the recommendation made in the University of Michigan study. The Burt Township Board has requested that reconstruction of the Section D be located along its original location as a first preference. However, the Burt Township Board indicated that in the event funding is limited the selection of a second option to reconstruct the breakwater along a line 15-degrees toward the shoreline from its original location would be acceptable to the community.

Alternatives for Reconstruction of Section D

Based on the results presented in the University of Michigan study and the recommendations made in the Burt Township letter, dated 12 January 2001, the alternatives that were evaluated in this study included various plans for the reconstruction of Section D.

All of the design alternatives involve the construction of a rubble mound structure offering varying amounts of usable harbor area. These rubble mound structures would consist of three layers of stone, each having different gradation, arranged in such a way that wave energy is absorbed and smaller stone is not lost.

Three different alignments for the rubble mound breakwater design have been considered (See Appendix A, Plate 4). Each orientation originates from the breakwater near the south end of the east jetty and ends approximately 100 feet from the ordinary high water mark. The reason for ending the breakwater short of the low water mark rather than tying into the shoreline is to prevent stagnation within the harbor and to reduce pedestrian traffic onto the breakwater from the shoreline. It is believed that pedestrian traffic onto the breakwater would negatively impact the piping plover along the shoreline.

Alternative 1 - Reconstruct a rubble mound breakwater next to the original alignment of Section D.

A new breakwater structure would be constructed on a line parallel to the original pile dike. The structure would extend 7,000 feet east shadowing the original breakwater and possibly using stone from the old structure. This alternative offers the most usable harbor area of the three structural alternatives considered. See Appendix A, Plate 5 for a cross-section of this alternative.

Based on a 20-year design wave height of 13.8 feet and a top of structure elevation of +7.0 feet above LWD, the armor stone for the rubble mound would range in size from 6 to 12 tons, with a majority of the stone being larger than 8 tons. The minimum layer thickness calculated for the armor stone is 9 feet and the crest would be 14 feet wide. The underlayer stone at this site would range between 1,100 and 2,100 pounds and would need to be a minimum of 4 feet thick. The core stone, or bedding stone would consist of a 2-foot layer of stone ranging in size from 4 pounds to 100 pounds.

Alternative 2 – Abandonment of the existing remnants of Section D and reconstruction of a rubble mound breakwater on an angle 15-degrees toward the shoreline from the original pile dike alignment. See Appendix A, Plate 6, for a cross-section of this alternative.

At an angle 15-degrees clockwise from the original pile dike the second design alternative would extend the new breakwater structure approximately 4,800 feet to the south shore just west of the entrance to the east bay.

Based on a 20-year design wave height of 10.7 feet and a top of structure elevation of +7.0 feet LWD, the armor stone for the rubble mound would range in size from 3 to 6 tons with a majority of the stone being larger than 7,500 pounds. The minimum layer thickness calculated for the armor stone is 7 feet and the crest would be 11 feet wide. The underlayer stone at this site would range between 500 and 1,000 pounds and would need to be a minimum of 3 feet thick. The core (bedding) stone would consist of a 2-ft layer of stone ranging in size from 2-50 pounds.

Alternative 3 – Abandonment of the existing remnants of Section D and reconstruction of a rubble mound breakwater at an angle 55-degrees toward the shoreline from the original pile dike alignment. See Appendix A, Plate 7, for a cross-section of this alternative.

The third orientation for the breakwater is at an angle of 55-degrees clockwise from the original pile dike alignment. This alignment would result in a 2,500-foot breakwater, which extends to the south shore just east of a large drop in elevation in the bay from approximately 7 to 53 feet.

Based on a 20-year design wave height of 8.7 feet and a top of structure elevation of +7.0 feet LWD, the armor stone for the rubblemound placed along the 55-degree breakwater alignment would range in size from 3,000 to 6,000 pounds with a majority of the stone being larger than 4,000 pounds. The minimum layer thickness calculated for the armor stone is 6 feet and the crest would be 9 feet wide. The underlayer stone at this site would range between 250 and 600 pounds and would need to be a minimum of 2.5 feet thick. The core stone, or bedding stone, would consist of a 2-foot layer of stone ranging in size from 1 pound to 20 pounds.

Alternative 4 – No Action.

The Corps of Engineers is required to consider the option of “No Action” as one of the alternatives in order to comply with the requirements of the National Environmental Policy Act (NEPA). No Action assumes that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. No Action, which is synonymous with the Without Project Condition, forms the basis from which all other alternative plans are measured.

The No Action alternative would minimize Federal project expenses while maintaining the harbor of refuge. If the No Action alternative is selected, then the erosion and shoaling processes would continue to impact the shoreline in the vicinity of Grand Marais Harbor. However, prior hydraulic analysis reporting indicates that the majority of these processes are ambient, and not induced by the Federal structures. This alternative would require no Federal expenditure, but would provide no benefits.

If No Action is taken, then the fishery at the harbor could continue to degrade. The MDNR has indicated that Grand Marais had a good fishery, but sand filling the deepwater basin has eliminated much of the spawning habitat, including rock and gravel substrate and submerged vegetation. The sand fill has changed the Sucker River from cold water to warmer.

i) Preliminary Plans

The harbor currently operates with the two original parallel jetties. The original timber pile dike identified as Section D has completely deteriorated. The timber pile dike is non-functional and fully submerged leaving the harbor vulnerable to storms and increased accretion and erosion processes.

A May 2002 site visit found no land access for construction of any of the alternatives. Therefore, it was assumed that construction would be marine based. This type of construction would require some dredging of the harbor to accommodate the draft required by the construction vessels. It was assumed that a channel of dimensions 50-foot wide and 10-foot below LWD would be needed.

All of the design alternatives involve the construction of a rubble mound structure offering varying amounts of usable harbor area. These rubble mound structures would consist of three layers of stone, each having different gradation, arranged in such a way that wave energy is absorbed and smaller stone is not lost. Rubble mound structures typically have relatively lower construction costs as compared to other design alternatives, however, maintenance costs tend to be higher. Another disadvantage to rubble mound structures is they allow for less usable area in the harbor than other types of structures.

j) Hydraulic Engineering Evaluation

The information obtained since 1993, including the University of Michigan report (2000), generally support the conclusions contained in the Corps of Engineers Detailed Project Report for Grand Marais Harbor (1980) and the Grand Marais Monitoring Report (1993). The projected shoaling rate for West Bay of between 1,000 and 25,000 cubic yards per year from the 1993 monitoring report still appears to be a reasonable estimate. The more recent bathymetric surveys, presented as Figure 2.2 in the University of Michigan report (2000) suggests that the shoaling rate within West Bay over the past decade has been at the lower end of the 1,000 to 25,000 cubic yard per year range.

Higher shoaling rates (on the order of 100,000 cubic yards per year) as well as the shoaling that has taken place at the eastern side of West Bay have been cited in each of the above referenced reports. This shoaling and the high shoaling rate occurred over a period of years following the demise of Section D. During this period, a redistribution of a large volume of accreted material occurred. The period of time under which this shoaling rate occurred was relatively short-term and the conditions that existed during that time do not represent the normal littoral transport climate.

k) Conclusions from the Preliminary Screening

Due to the lack of maintenance, the pile dike at Section D no longer functions as intended. The original pile dike now lies in ruins below water level. Consequently, efficiency improvements would not enhance the operation of major project components. Also, the pile dike breakwater is in such a degraded condition that no significant major project features remain to rehabilitate in order to improve reliability and defer capital expenditures to replace the structure.

If Section D were to be reconstructed under a Major Rehabilitation effort, then any of alternatives 1 thru 3 would decrease the sedimentation and erosion processes occurring along the shoreline of East and West Bay and restore the effectiveness of the structure. Alternative 3, Abandonment of the original pile dike and reconstruction of a rubble mound breakwater along a 55-degree angle to the shoreline would provide the highest benefit-to-cost ratio. However, the benefit-cost ratio is 0.62 and could not be approved for implementation. A benefit-to-cost ratio less than one normally indicates insufficient Federal interest and restricts a recommendation to proceed to the next phase of work.

7. FEDERAL INTEREST

a) Economic Evaluation

The harbor of Grand Marais has historically been used as a port of refuge from storms and high seas on Lake Superior. The harbor was originally authorized as a harbor of refuge by Congressional action on 17 May 1950. The following quote is from house document 751:

"The primary justification for improvement of this harbor is to prevent loss of life and property and to insure safe conditions for an established commerce. Reduction in loss of life and property, which is difficult to evaluate, is considered ample justification for an estimated annual carrying charge that would be incurred by the proposed modification."

"The harbor at Grand Marais was improved originally by the Federal Government to provide a harbor of refuge in the 89-mile dangerous reach between Whitefish Point, Michigan and Munising Harbor, Michigan. The harbor has been used as a refuge for all types of boats up to 350 feet in length."

In 1946 Congress authorized a plan providing for a continuous chain of harbors of refuge for light draft vessels along the entire Great Lakes. These harbors are located so that the maximum distance between them was no more than 30 to 40 miles. Facilities to be provided include only those required for reasonable accommodations. General navigation features include a safe entrance, protected anchorage and mooring areas. Justification for the improvement of the harbors rests upon the general benefits arising from utilizing the harbors as links in the general plan.

The Federal objective of water and related land resources planning is to contribute to national economic development (NED) consistent with protecting the Nation's environment, in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to national economic development (NED outputs) are increases in the net value of the national output of goods and services expressed in monetary units, and are the direct net benefits that accrue in the planning area and the rest of the nation. Project outputs of Federal navigation features for small boat harbors are enhanced access to recreational boating, sport fishing opportunities, and commercial fishing activities. Estimating benefits for recreational activities involve the selecting of a method based on criteria outlined in guidance published within ER 1105-2-100. Additionally, charter fishing craft are considered commercial vessels and will be considered as commercial navigation benefits when project output is measured as changes in net income.

The above guidance states, "... change in net income measure of benefits is appropriate only for existing vessels currently using harbor facilities." The Burt Township Supervisor stated there are five chartered boat operations providing fishing and sightseeing cruises. It is presumed that the No Action alternative of minimally maintaining the harbor of refuge would be sufficient for the continued operation of chartered boats. If, however, this were not the case the opportunity cost of the No Action alternative would be the lost income from chartered operations. No specific charter boat financial statements were available so it was necessary to rely on 1994 Sea Grant New York research study. The study's title is: "New York's 1994 Great Lakes Charter Fishing Industry" and is the result of research funded by the National Oceanic and Atmospheric Administration Award #NA90AA-D-SG078. The responses of the study were used to compile average financial characteristics of the charter boat business and are the basis of estimating their contribution to Grand Marais Harbor. Grand Marais benefit from chartered boats is estimated to be \$16,100 per annum. The average sales and cost amounts reported in the report are shown below and adjusted to current year dollars.

Criteria	Judgement Factors					Point Value
Recreation Experience TOTAL POINTS: 30	Two general activities 0-4	Several general activities 5-10	Several general activities: one high quality value activity 11-16	Several general activities; more than one high quality high activity 17-23	Numerous high quality value activities; some general activities 24-30	10
Availability of opportunity TOTAL POINTS: 18	Several within 1 hr. travel time; a few within 30 min. travel time 0-3	Several within 1 hr. travel time; none within 30 min. travel time 4-6	One or two within 1 hr. travel time; none within 45 min. travel time 7-10	None within 1 hr. travel time 11-14	None within 2 hr. travel time 15-18	2
Carrying Capacity TOTAL POINTS: 14	Minimum facility for development for public health and safety 0-2	Basic facility to conduct activity(ies) 3-5	Adequate facilities to conduct without deterioration of the resource or activity experience 6-8	Optimum facilities to conduct activity at site potential 9-11	Ultimate facilities to achieve intent of selected alternative 12-14	5
Accessibility TOTAL POINTS:18	Limited access by any means to site or within site 0-3	Fair access, poor quality roads to site; limited access within site 4-6	Fair access, fair road to site; fair access, good roads within site 7-10	Good access, good roads to site; fair access, good roads within site 11-14	Good access, high standard road to site; good access within site 15-18	8
Environmental TOTAL POINTS: 20	Low esthetic factors that significantly lower quality 0-2	Average esthetic quality; factors exist that lower quality to minor degree 3-6	Above average esthetic quality; any limiting factors can be reasonable rectified 7-10	High esthetic quality; no factors exist that lower quality 11-15	Outstanding esthetic quality; no factors exist that lower quality 16-20	20

45

Point Values	General Fishing and Hunting Values
40	\$6.16
45	\$6.16
50	\$6.70
	\$6.43

Recreation days	
Aggregate boat use 2002	2109
Kayak Symposium	2800
Splash-in	1500
Skiing etc.	1825
Sum Recreation days	8234
Recreation Benefit	\$52,944.62
Rounded	\$52,900.00

	1994	CPI	2003
Average Gross Fees	13,775	1.21	16,668
Average Operating cost	<u>11,110</u>	<u>1.21</u>	<u>13,443</u>
Net Cash flow	2,665	1.21	3,225
Number of Charters			<u>5</u>
Income to G.M. Harbor			16,123

The beneficial effects of project recreation were evaluated using the unit day value method based on the criteria specified in paragraph E-50b (4) of ER 1105-2-100. Under this method the estimated annual use over the project life relative to the without project condition provides the estimate of recreation benefits. These benefits are measured in terms of willingness to pay. A value for benefits is obtained by applying a unit day value to estimated use. No statistical study exists providing average annual use of Grand Marais Harbor. Burt Township provided boat use, event use, and daily activity use for 2002 that was used to estimate recreation days. Point values were applied to defined criteria and used to calculate the equivalent dollar value for unit day value. Economic Guidance Memorandum 02-04 specifies the range available for unit day values and Grand Marais recreation benefit is estimated to be: Recreation days include the three-day Splash-in event that consist of seaplanes and float plans visiting Grand Marais Harbor. It should be noted that though the event is included as a benefit, constructing a breakwater might be an obstacle to aircraft and render the harbor useless for this activity.

Commercial fishing benefits can be measured as the incremental change to net income due to the change in catch plus cost saving to current harvest. The State of Michigan's economic profile of Alger County report there was no employment or personal income in the fishing industry for 1999 and 2000. However, correspondence from Burt Township states that there is a tribal fishing enterprise. No information was available about the tribal commercial fishing enterprise based in Grand Marais. The Great Lakes Indian Fish and Wildlife Commission under the Lake Superior Fishery banner reports that most of the fishery is comprised of small boats but that a majority of the harvest is taken by large boats. The Department of the Interior Great Lakes Science Center has published commercial fishing reports for the years 1971 to 2000. These reports contain the total pounds and dollar value of commercial catch for the Great Lakes by year, lake, state and species. In addition the data is broken out by tribe and state license catch. The average annual tribal harvest for Lake Superior from 1991 to 2000 is 864,650 pounds at an average dollar value of \$.865 (adjusted to the current price level). Given all the above information Grand Marais was assigned a value of ten percent of the total Lake Superior tribal catch. This was also used as the incremental change to measure benefits and was estimated at \$73,200 per annum.

Three alternatives presented for the breakwater design are the original alignment, 15-degree, and 55-degree. Although no project is recommended in this report, project costs have been developed for use in the benefit-cost analysis and are described on page 33. Average annualized cost was calculated using a 50 year life and a 5 7/8% Federal Discount Rate. There were no positive net benefits for the three alternatives and the benefit/cost ratio for each came to 0.14, 0.26, and 0.62, respectfully. The below table excludes annual maintenance cost therefore the B/C ratio would be less than shown.

	Original Alignment	15-degree Alignment	55-degree Alignment
Working Cost	15,840,000	8,883,000	3,670,000
Annualized	\$987,466	\$553,766	\$228,788
Rounded	\$987,500	\$553,800	\$228,800
Benefits:			
Commercial fishing	73,200	73,200	73,200
Chartered Boats	16,123	16,123	16,123
Recreational: UDV	52,900	52,900	52,900
Benefits	142,223	142,223	142,223
Benefits less cost	(845,277)	(411,577)	(86,577)
B/C Ratio	0.14	0.26	0.62

The no action alternative from the Major Rehabilitation Evaluation Report is: “. . . minimize Federal project expenses while maintaining the harbor of refuge.” The average annual expenditure for maintenance and rehabilitation at Grand Marais since 1980 has been \$54,000. This amount is expressed in current year dollars by using the construction cost index. Basing future activity on historical expenditures the recommended NED plan is to continue the no action alternative.

b) Environmental Considerations

Grand Marais Harbor is a designated harbor of refuge on the south shore of Lake Superior in the eastern upper peninsula of Michigan. The harbor is protected from wind and wave impacts emanating from the west by Coast Guard Point. The River and Harbor Act of 1880 authorized construction of parallel timber crib piers extending through Coast Guard Point out to the 22-foot depth contour in the lake, and a closure of the eastern bay harbor entrance by a 5,770-foot-long pile dike breakwater extending from the piers eastward to Lonesome Point. As early as 1982 the pile dike breakwater was in a state of complete ruin. Loss of the breakwater resulted a mass sand movement into the harbor basin, which significantly reduced depths and restricts boating activity to remaining deepwater areas in the west half of the harbor. Additionally, since the breakwater fell apart, much of Lonesome Point has been lost to erosion. The nearest harbors to Grand Marais are Little Lake Harbor, 30 miles to the east, and Munising Harbor, about 35 miles west.

Alternatives - Breakwater rehabilitation alternatives being considered include 1) Original Alignment, 2) 15-Degree Alignment, and 3) 55-Degree Alignment, and 4) No Federal Action. All three of the action alternatives would be of rubble mound construction and would attach near the inner end of the east entry pier. Alternatives 2 and 3 would angle landward from the original alignment, thereby resulting in shorter lengths. The breakwater would be 7,000 feet long under Alternative 1; 4,800 feet long under Alternative 2; and 2,500 feet long under Alternative 3. While Alternative 1 follows the original breakwater alignment, it is 1,230 feet longer because the erosion of Lonesome Point has changed the shoreline. The no Federal action alternative serves as a baseline from which to compare the impacts of the action alternatives.

Alternatives 1, 2, and 3, would eliminate most sand deposition into West Bay by blocking shoreline sand movement from the east. Alternative 1 would include the Sucker River and both creeks behind the harbor structures; Alternatives 2 and 3 would only include the creeks. Under the No Action alternative sand would continue to deposit in the harbor area with the possibility that eventually the remaining deep-water area of the western harbor basin would be filled.

Fish and Wildlife Habitat - The Lake Superior shoreline at Grand Marais is a low sandy plain. To the west the shoreline rises rapidly, forming a substantial bluff leading into the Grand Sable Banks and Dunes a couple miles west of the harbor. On the east side of the harbor is another bluff in the vicinity of Lonesome Point. Behind Lonesome Point is East Bay, a small bay at the mouth of the Sucker River. Carpenter and Chipmunk Creeks drain into the main bay.

The beach in the project area is one of many areas recently designated as critical habitat for the piping plover (*Charadrius melodus*), which is Federally listed as endangered in the Great Lakes area. The U.S. Fish and Wildlife Service noted that Grand Marais is generally considered an important piping plover breeding area in Michigan (correspondence, March 20, 2002). They expressed concerns with the potential for project effects on plover habitat due to possible changes in erosion and accretion, and that a shore connection to the breakwater could affect piping plover through increased human traffic through the nesting areas. They also noted that the project could benefit piping plover if it stabilizes habitat or results in creation of new habitat.

Appropriately designed, none of the breakwater alternatives would be expected to have adverse impacts on plover habitat. Nor would the breakwaters be expected to exacerbate the current erosion at Lonesome Point. Breakwater construction on the original alignment (Alternative 1) potentially could result in some sand accretion at Lonesome Point. An offshore breakwater design would be considered to prevent increased human traffic through plover habitat. If an offshore breakwater were used, the design would have to consider the possibility of a sandbar land connection forming. Any of the breakwater rehabilitation alternatives would provide habitat for shorebirds on the breakwater and would create a calmer water area that could be used by waterfowl.

In a personal communication with the Newberry, Michigan, Department of Natural Resources office (July 23, 2002), a fish biologist indicated that the ongoing sand filling of the harbor basin has eliminated spawning runs up the Sucker River and filled in much fish spawning habitat, including rock and gravel substrate and submerged vegetation. The remnant deepwater area in the western end of the harbor still provides some spawning in limited stony/rocky areas (whitefish) and a few areas of submerged vegetation (northern pike and perch). Coho salmon, steelhead, smelt, suckers and minnows also are found in this part of the harbor. Any breakwater alignment would protect this remnant habitat from being filled in with sand and lost.

Project construction would result in some minor, short-term sediment suspension and noise, which would be a temporary disturbance to nearby shorebirds and fish. Fish and birds can avoid the immediate project site during construction. If construction activities are near active plover nesting and potentially could disrupt nesting activities, then construction of that portion of the project would have to be delayed until after the nesting season. Construction could begin at the opposite end of the breakwater so that areas nearer to plover habitat would not be under construction until later in the season. Turbidity from project construction would be from the sandy bottom material and would settle quickly. This would not be expected to affect fish spawning activities. Any of the breakwater rehabilitation alternatives would provide a rubblemound artificial reef, which would serve as habitat for fish and other aquatic organisms.

Water and Sediment Quality - Lake Superior is classified as oligotrophic (low in nutrients and organic material) and has very good water quality. Water quality in the Grand Marais Harbor vicinity is generally excellent, since there are no major industrial influences and the area is not highly developed. Within the harbor there may be minor petrochemical residues from boat traffic and associate activities. Analysis of sediment samples collected for maintenance dredging at Grand Marais Harbor has not shown significant contamination. The breakwater construction area is in a wave-washed sand deposition area. Sand settles quickly and does not carry contaminants. Sand disturbed during breakwater construction would not adversely affect water quality.

Cultural Resources - The National Register of Historic Places and available shipwreck maps have been reviewed. No historic properties, items, sites, or shipwrecks are documented in the area under consideration for breakwater rehabilitation. A number of shipwrecks are noted as having sank outside Grand Marias Harbor, though it appears that none sank along the breakwater. The breakwater could be eligible for inclusion in the National Register of Historic Places solely based on its construction date (1895-1907); however, the massive deterioration that has occurred has left little of the original structure. The breakwater no longer retains integrity because of its dilapidated condition.

The breakwater alternatives were coordinated with the State Historic Preservation Office (SHPO). The SHPO stated in a letter of July 16, 2002, their opinion that “**no historic properties are affected** within the area of potential effects of this undertaking.” They also noted, however, that the project site is an area of high archeological sensitivity and that it is possible that unrecorded shipwreck remains may be present near the former breakwater. If a shipwreck were discovered in one of the proposed breakwater alignments, then a different breakwater alignment could be implemented and/or the impacts on the shipwreck would have to be mitigated.

Recreation and Social Effects - Recreation and tourism are a large part of the local economy in the Grand Marais area. A variety of parks, campgrounds, winter sports areas, and historic and scenic sites are available in the Grand Marais vicinity, which is comprised mostly of forested lands. The most prominent recreational feature in the project vicinity is the Pictured Rocks National Lakeshore, which begins immediately west of Grand Marais and extends about 30 miles along the shore, nearly to Munising.

An important component of the Grand Marais economy is sport fishing, which has been restricted in extent by the continued sand filling of the harbor. The sand destroys fish habitat by covering it and, because it constantly shifts with currents, does not support any significant habitat. Ultimately, this filling would eliminate the remaining deepwater and vegetated fish habitat in the harbor. This likely would have significant adverse impacts on recreation and the local economy.

A breakwater rehabilitation project would benefit recreation by protecting the harbor basin from northeastern storms, providing calmer waters for small craft, would improve the safety of the harbor of refuge, and would sustain the remaining fishery and associated benefits to the local economy. Sport fishing may be improved with the presence of the rubblemound breakwater, which essentially is an artificial reef that would attract a variety of fish to the area.

8. Real Estate Plan

It is anticipated that none of the alternatives being considered, including no action, will require the non-federal sponsor to provide land for the Project. The three breakwater alternatives recommend construction of a breakwater in the navigation servitude. Temporary access and work areas will either be marine based or located on land owned by the federal government and under the administrative jurisdiction of the Corps of Engineers. Preliminary plans show public facilities or utilities will not require relocation. These findings indicate \$0 value for Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas (LREED's).

During the Feasibility phase, the Real Estate Division will develop detailed information on the Project's real estate requirements, participate in developing project alternatives, update the non-federal sponsor's legal and financial capabilities, and prepare a final Real Estate Plan for inclusion in the Feasibility Report.

A Real Estate Drawing is provided as Plate 8 in the Appendix B, Real Estate Plan. Also, provided in Appendix B are Plates 9 and 10, which are Department of Army Lease (Outgrant) information for Federal property at Grand Marais Harbor, Michigan.

No project is recommended in this report, however, if a project were to be implemented a Temporary Work and Storage area would likely be located on available Federal property at the harbor. The location for a Temporary Work and Storage area would be selected so as to not impact the existing outgrant leases at the harbor.

9. PRELIMINARY FINANCIAL ANALYSIS

a) No project is being recommended, however, in the event a navigation project were to be approved for study and implementation under Section 107 of the River and Harbor Act of 1960, the following is provided as a project cost summary.

PHASE	TOTAL COST	NON-FEDERAL	FEDERAL
Feasibility Study	\$ 274,000	\$ 87,000	\$ 187,000
Plans & Specifications	109,000	54,500	54,500
Construction (55-deg Alt)	3,541,000	1,770,500	1,770,500
Total	\$ 3,924,000	\$ 1,912,000	\$ 2,012,000

b) Non-Federal Requirements:	LERRD *	\$ 0
	Cash	\$ 1,912,000
	Work-in-kind	\$ TBD
	Annual O&M	\$ 35,000

* LERRD's value = LERRD's cost (\$ 0). All land required for the Project is either owned by the Federal government or subject to navigation servitude.

SUMMARY OF PROJECT COSTS (Note: No project is recommended in this report, however, these costs have been developed for use in the economic analysis and are provided here for information purposes):

Federal Allocations to Date for the	\$	107,500	(FY 2002)
Major Rehabilitation Report:	\$	15,000	(FY 2003)
Major Rehabilitation Evaluation Report	\$	122,500	
Feasibility Study	\$	274,000	
Plans and Specifications	\$	108,500	
Implementation (Construction)			
• Original Alignment	\$	15,840,000	
• 15-degree Alignment	\$	8,883,000	
• 55-degree Alignment	\$	3,670,000	

10. ASSUMPTIONS AND EXCEPTIONS

It is assumed that if a construction project were to occur, then construction would be accomplished by marine based equipment. This type of construction would require some dredging of the harbor to accommodate the draft required by the construction vessels. It was assumed that a 50-foot width channel would need to be dredged to a depth of 10.0 below low water datum.

Additional assumptions consider that dredging of the harbor, beyond the access needs for construction plant, and removal of the existing pile dike structure will not be necessary.

11. SCHEDULES

No project is being recommended, however, in the event a project were to be approved for study and implementation the following is provided as a schedule summary.

<u>Phase</u>	<u>Duration</u>	<u>Start Date</u>	<u>Finish Date</u>
Feasibility Phase (FCSA&PSP)	18 Months	Apr 2004	Sep 2005
Plans and Specifications	6 Months	Oct 2005	Mar 2006
Project Cooperation Agreement	4 Months	Apr 2006	Jul 2006
Advertisement and Award	3 Months	Aug 2006	Oct 2006
Construction	18 Months	Nov 2006	Apr 2008

12. VIEWS OF OTHER RESOURCE AGENCIES

Because of the funding and time constraints of the reconnaissance phase, only limited and informal coordination has been conducted.

During the early phases of the reconnaissance study contact was made with a number of Federal, state, and local entities, which expressed interest in the study and provided information used in the development and formulation of the Major Rehabilitation Evaluation Report. The following points of contact have been made:

- Michigan State Historic Preservation Officer - By letter dated 16 July 2002 the Michigan SHPO indicated that no historic properties are affected by the proposed project to reconstruct Section D.
- U.S. Fish & Wildlife Service - By letter dated 20 March 2002, the USF&WS indicated that the Grand Marais area has been designated as critical habitat for the piping plover. Plovers nest along the Lake Superior shoreline west of the pier at the Coast Guard light station. The USF&WS has expressed concern about any project that would increase the level of human use of the area occupied by piping plover and diminish the extent of piping plover habitat in Grand Marais, and particularly near the mouth of the Sucker River. USF&WS also indicated that a thorough hydrologic modeling study should be undertaken to understand the long-term effects of proposed project to reconstruct Section D.
- The office of U.S. Senator Carl Levin by letter dated May 20, 2002 expressed interest in the continuation of a study to implement a project at Grand Marais to construct a breakwater to restore the harbors recreational and commercial use.
- Michigan Department of Natural Resources - The MDNR's Lansing, Michigan office (Hal Harrington) reviewed the preliminary proposals for reconstruction of Section D and by telephone conversation, dated 30 May 2002, recommended implementation of a project to reconstruct the dike along a 55-degree angle.
- Also, the MDNR's Newberry, Michigan Field Office (Jim Waybrant) indicated that Grand Marais had a good fishery, but sand that is filling the deepwater basin (West Bay) and Sucker River has eliminated much of the spawning habitat, including rock and gravel substrate, and submerged vegetation. The sand has filled in deep parts of the Sucker River resulting in shallower depths and warmer temperatures in those impacted sections. No significant spawning runs are known to remain in the river. The remnant deep-water area of the harbor still provides spawning in limited stone rocky areas (whitefish) and a few areas of submerged vegetation (Northern Pike and Perch and minnows). Also found in the basin are smelt, suckers, Coho salmon and steelhead. Any breakwater habitat alternative would protect this habitat. The fishery is the main income source at Grand Marais in the Summer.

13. RECOMMENDATIONS

Due to the level of funding provided, this report was scaled to an appropriate level to identify and evaluate the problems, opportunities, alternatives, benefits and costs derived for implementation of a project to reconstruct the pile dike, Section D, at Grand Marais Harbor, Michigan. Standard Major Rehabilitation Study tasks such as a reliability analysis, M-CASES cost estimate, Project Cooperation Agreement and Project Management Plan were not prepared.

This study evaluated the economic justification (Federal interest) for abandonment of the existing pile dike breakwater and reconstruction of a new breakwater structure. Federal interest for navigation projects must show economic feasibility, compliance with current regulations and policies, and that a willing and financially capable local sponsor can be found. The benefits-to-cost analysis has indicated that for all alternatives, except No Action, the benefit-to-cost ratio is less than 1. There is no Federal interest to participate in a project to reconstruct the Section D pile dike.

Although this report recommends No Action, the FY 2003 Federal Budget (O&M, General) included an appropriation of \$ 175,000 for Grand Marais, Michigan with report language requesting initiation of a design to replace the existing breakwater. Design work has been initiated. It is recommended that design work continue until all Congressionally appropriated funds have been expended. In the event that a project is approved for implementation, this report would recommend the selection of the alternative that proposes abandonment of Section D and reconstruction of a rubble mound breakwater along a 55-degree angle from the original location of the pile dike. This alternative had the highest ratio of benefits-to-cost.