AN ANALYSIS OF THE PHYSICAL AND LEGAL ASPECTS OF EROSION ON LAKE MICHIGAN, A CASE STUDY AT ST. JOSEPH, MICHIGAN

By

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ABSTRACT

AN ANALYSIS OF THE PHYSICAL AND LEGAL ASPECTS OF EROSION ON LAKE MICHIGAN, A CASE STUDY AT ST. JOSEPH, MICHIGAN

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This study was designed to analyze the scientific reasons why erosion is occurring along the developed shores of Lake Michigan and to review the possible legal avenues open to riparian owners seeking relief from other than naturally induced erosion damages. The specific geological parameters that interact to cause erosion are described using a process-response model. Erosion rates along the shore at St. Joseph, Michigan have been rapidly accelerating on the south side of the twin harbor piers maintained by the Army Corps of Engineers at the mouth of the St. Joseph River. Littoral sediment is being trapped on the north side of piers to the detriment of the offshore bar system on the south side. The process-response model predicts

that under conditions of rising lake stage offshore bars will not build upward with the stage change. This stage-bar relationship is critical in regulating wave energy at the beach. Lacking adequate bar height waves of higher energy strike the beach thus causing erosion. Under equilibrium conditions sediment which has been eroded by increased wave energy will build offshore bars to a stable stage-bar condition. Equilibrium conditions are then regained. Shore structures built as protection stop the natural rebuilding process and cause accelerated erosion to occur farther down drift. Erosion rate measurements made from aerial photographs taken in 1938 and 1969 through 1973 were used to document the rates of erosion at St. Joseph. These rates were compared with data collected by other researchers working on other areas on Lake Michigan and Huron.

Using the set of facts determined for the conditions at St. Joseph as a basis, four possible legal avenues were analyzed to determine how they could be used to stop man-induced erosion damage to riparian property. The four hypothetical claims are presented using the most applicable legal avenues available to riparian owners. Remedies under

the common law, a federal tort claim, Michigan's Environmental Protection Act (EPA) and the National Environmental Policy Act (NEPA) are reviewed.

The long-term solution to the shore erosion problem at St. Joseph and other areas on the Great Lakes similarly affected is to minimize the disruption of the natural beach and littoral system. The efforts of the riparians at St. Joseph will be most effective if construction of new shore structures is minimized and the Corps of Engineers is encouraged to begin sand transfer and nourishment of the shore south of the harbor piers. Legal actions can be used to aid specific problem areas along the shore when needed. It is anticipated that a Corps public works project will be proposed to rebuild the erosion damaged shore areas. The NEPA can be used as a legal tool to modify Corps plans if they are not consistent with the environmental systems present at St. Joseph. The EPA with its provision for citizen standing can be applied similarly to control public and private erosion control measures if they are not consistent with the shore environment.

It is recommended that sediment nourishment be begun as a first step in rebuilding the natural littoral

environment at St. Joseph. Special legislation to provide for funding of erosion control studies and implementation of the plans should be enacted to aid Great Lakes riparians.

Dedication

To the memory of Charles Frederick Herbert, father and Charles Arthur Herbert, grandfather, both mining engineers and prime motivators of my professional career.

ACKNOWLEDGMENTS

I wish to express heartfelt thanks to my guidance and thesis committee chairman, Leighton L. Leighty, associate professor of resource law in the Resource Development Department for his help in guiding the legal research. Professor Maynard M. Miller of Geology was most helpful with his critical review of the geologic and geomorphic aspects and to him I give special thanks. Thanks are in order to Professor Clifford R. Humphrys of Resource Development and Associate Professor Tony Bloomquist of Civil Engineering for their suggestions and help.

Sincere appreciation goes to my family, Edith and Toby, for their concern and support which will not be forgotten.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

CHAPTER I

INTRODUCTION AND BACKGROUND

Within the political boundaries of the United States there exist approximately 82,000 miles of shoreline which for a continental nation means we are uniquely endowed with both seacoasts and great lake shores. The populace of the United States is curiously oriented toward the beaches and shores. During the past decade 90 percent of our population growth has occurred within the 30 states that border our seacoasts and Great Lakes. These 30 coastal states contain 75 percent of our total population and 12 of the 13 largest cities. Furthermore nearly one-half of this population lives within the coastal counties.[1]

The needs of this large proportion of our population for living space and recreation puts extreme pressure on the coastal zones. Development of shore areas in most regions has taken place at a rate too rapid to regulate

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[1] U.S. Army Corps of Engineers, National Shoreline Study, Washington, D. C., 1971.

effectively. Unplanned development along the coastal zone, especially when man's works extend to the waters edge, and beyond, leads to serious and often catastrophic results.

Erosion of the shoreline places an extreme burden on individual property owners, local and state governments and the federal government as well. People living in the coastal zone who literally fight to save their homes and other works from erosion and flooding have become extremely vocal on this topic in recent years, enough so to motivate Congress to authorize the National Shoreline Study in 1968. The Corps of Engineers of the United States Army carried out this study and reported in 1971 that 20,500 miles of national and territorial shores are experiencing significant erosion. This figure represents one-fourth of all the shoreline in the United States, excluding Alaska.[2] Of this 20,500 mile figure approximately 500 linear miles of the State of Michigan's lake shore are now undergoing significant erosion.

The lure of open water brings many millsions of recreational enthusiasts to the beaches of the coastal zone

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[2]The State of Alaska alone has approximately 34,000 miles of tidal coastline most of which lies in a virgin condition, Alaska Encyclopedia Britannica, 1973 edition.

to partake in various sporting activities. Likewise, the lure of the beach brings many people seeking to buy raw land for homesites or to acquire already developed property. To the occasional or weekend water sports enthusiast the loss of beach areas through erosion has only a temporal affect for he is mobile and can usually seek out new shore areas uncluttered by man's works. For the property owner along the shore the problem of erosion, however, cannot be dismissed because his location with respect to the waters edge is fixed. Each storm brings a new threat to his property, while each unplanned wharf, jetty and bulkhead constructed in his vicinity threatens damage to his investment.

Shore property is extremely valuable, often selling for hundreds or even thousands of dollars for each frontage foot of ordinary residential property and upwards of $10,000 a foot for prime commercial land as found on the "gold coast" of Florida, for example. Man in his traditional well structured thinking often regards shore property as being equal to any other landlocked property, on which monuments are emplaced to delimit the extent of ownership. Once a line has been established, whether it be

shoreline or an ordinary property line, man unreasonably expects it to stay put. The landward extensions of shore ownership are reasonably fixed in their geographical position; however, the seaward or lakeward boundary is subject to fluctuations governed by the geological systems at work along the coastal zone. Man's actions to control the forces of nature (geological forces) in efforts to maintain fixed and permanent seaward boundaries have in nearly all cases to a measurable degree met with failure.

On the beach, nature is constantly striving to achieve a dynamic equilibrium that is alien too often to man's interests and his static sense of equilibrium. In this state of dynamic equilibrium erosion is only one part of the steady-state system of erosion--sediment transport-deposition that moves beach material in response to the other controlling geologic factors. In fact the particular beach conditions, i.e., the seaward or lakeward limit that exists when a shore property owner purchases a segment of shore in a geologic sense, cannot be assumed actually to be stable for more than the time between major storms. The beach, as American naturalist William Beebe wrote is, "the

battleground of the shore."[3] During quiescent periods between storms, the beach maintains a remarkable appearance of seeming stability, with no great movements of sediment occurring. But during one major storm whether it be a hurricane on the Atlantic coast or a sustained three-day "nor'wester" on the Great Lakes the erosion and deposition which takes place can exceed that which had occurred during the most recent geologic time. In turn, within a short period of time, the shore property owners can suffer substantial and even total loss to buildings and structures in an event that many people would call a "natural disaster," Figure 1. From the point of view of the geologist the changes in the beach were only minor adjustments in the natural equilibrium conditions.

Now enter: the engineer, anthropocentric in his view of what he would call the "struggle between man and nature." The coastal engineer can devise structures to change and divert the impact of natural processes on the beach and adjoining uplands, and many times in the short view they are a seeming defensive victory over the natural

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[3]William Beebe, Adventuring with Beebe: Selections from the Writings of William Beebe (New York: Duell, Sloan, and Pearce, 1955).

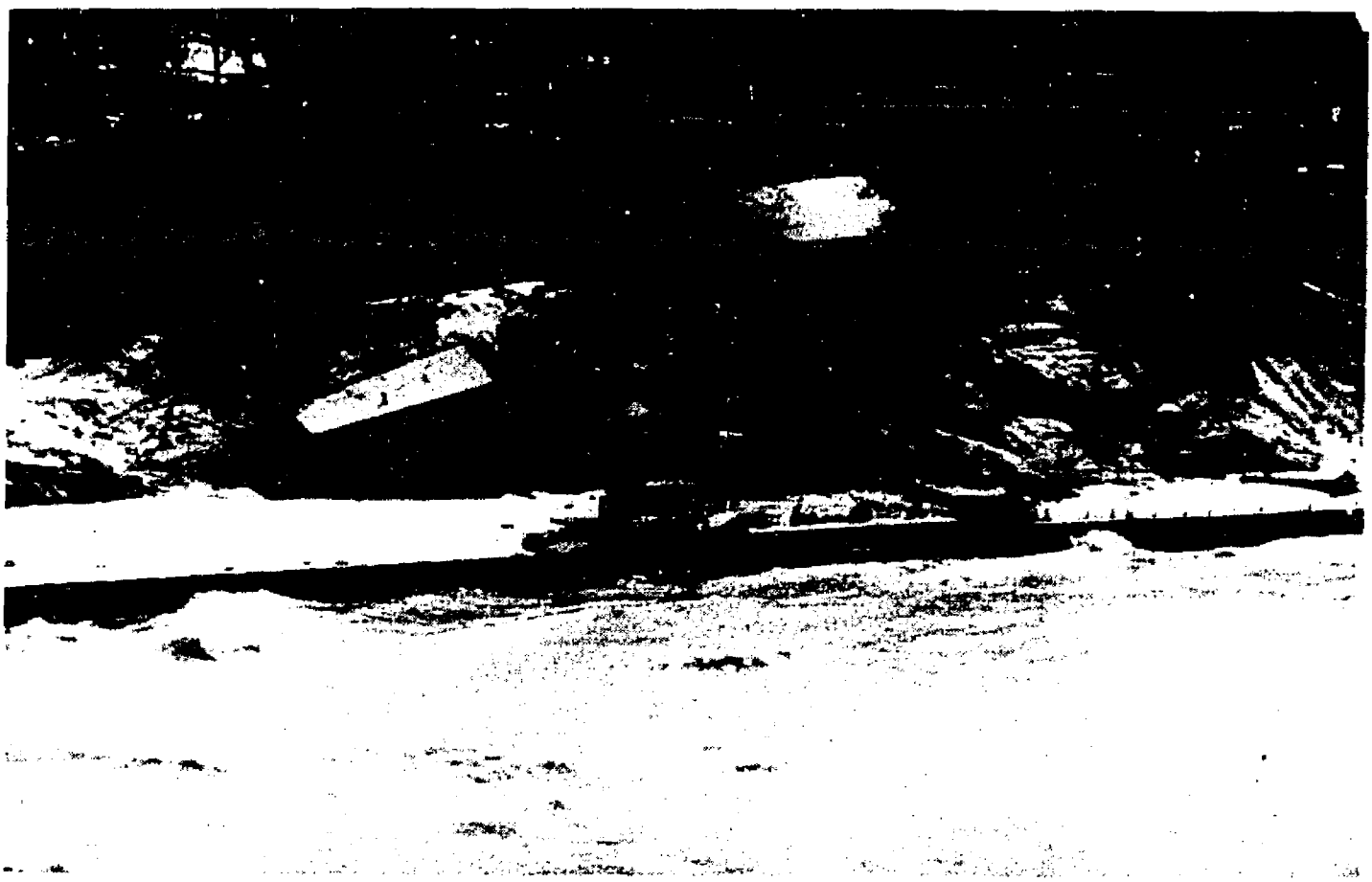

Fig. 1.--Property damage along bulkheaded segment of shore near St. Joseph, Michigan. Photograph was taken in March 1973 following a severe two-day storm on Lake Michigan. (Photo courtesy of the Michigan Water Resources Commission.)

forces involved. What has not been taken into account in most instances is that the beach is the adjacent upland areas own best protector. If in the natural state a beach is continually eroding, then it can be assumed that there is an inherent instability in the geologic system that is causing this change in the beach profile and relative position of the shoreline. The converse involving accretion is also true. In either situation the effect that man can have on large magnitude geologic processes such as those involving glacial rebound or tectonic upwarping or downwarping for example, is totally insignificant. In all such instances man must plan to live with nature. In the long run the minor instabilities and the inherent flexibility in the beach environment are what protects the upland from erosion. On undeveloped shores there is no such thing as erosion damage only a temporary resculpturing of the shoreline.

On developed shores the traditional engineering approach has been to build structural defenses against the forces of wind and waves rather than allowing the shore processes to seek their own end. The Corps of Engineers, the self-proclaimed experts in the field of coastal marine

engineering, have stated their philosophy quite uniquely:

> Unfortunately this natural mode of defense does not retain the former boundaries of the dry land mass in a stable position relative to the sea, nor does it occur when needed, but rather at irregular and unpredictable intervals. Therefore it has been necessary for man to enter the battle with his structural defenses for stabilization.[4]

In the ten years since the above statement was published by the Corps, the position of staff engineers in that agency has not changed at least as far as is represented by their most recent decisions and engineering recommendations.

On the other hand, during this same time period the so called environmental awareness has caught hold across the country and this new public awareness has brought to task many of the previously "sacred" projects of the Corps.

Enter now the private citizen, who is a riparian property owner suffering from accelerated erosion damages to his land as the result of poorly conceived and designed engineering works in the vicinity of his property. What are his alternatives? Much of the same 20,500 miles of national shoreline that are now undergoing significant

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[4]Gary Soucie, "Where Beaches Have Been Going: Into the Ocean," Smithsonian Magazine, June 1973, p. 56.

erosion are in an already developed condition making this a problem of considerable magnitude and one with a large number of citizens being affected. The private owner may have had sufficient foresight to build his dwellings well back from the active erosion zone along the beach. To those owners the loss of a few feet through accelerated erosion during each storm is a minor irritation compared to the disaster reaped by the owner who has positioned his dwelling too near the active beach zone.

The reasons why a riparian would seek to crowd too close to the active zone of the beach can be many. The owner may have wanted the scenic seascapes brought directly into his living room--a personal choice of location. In other instances the riparian owner might have been forced into close association with the active zone by less than scrupulous land development practices. Unenlightened zoning or building regulations of previous years have allowed developers to reap the very maximum dollar return out of shore property, in which cases lots were too often platted with insufficient set-back from the waters edge. This situation in turn has forced the purchasers of these developed shore lots to build too close to the shore. Whatever

is the reason, much of our coastline has achieved a developed state that under newer, enlightened regulations would be considered non-conforming.[5] What then is the solution for the property owners in such developed reaches who are suffering severe erosion damage?

To many owners their first thought is to wage their own personal battle against the forces of nature. The private owner may hire a marine engineer and proceed with protective measures. Often these personally arranged protective measures are even less than sophisticated. Many defensive measures fall in the same category with those in Figure 2. Countless examples can be found on both seacoasts of the United States, the Gulf and along the Great Lakes where the complete spectrum of self-help measures has been tried.

Other owners may seek legal remedy to recoup losses from neighboring riparians for erosion damages, the cause of which can be related to these other riparians' attempts to protect their property. When private owners are involved in litigation and the claims for damages are one private

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[5] In the terminology of zoning a presently non-conforming use may have been in existence at the time the zoning ordinance was enacted.

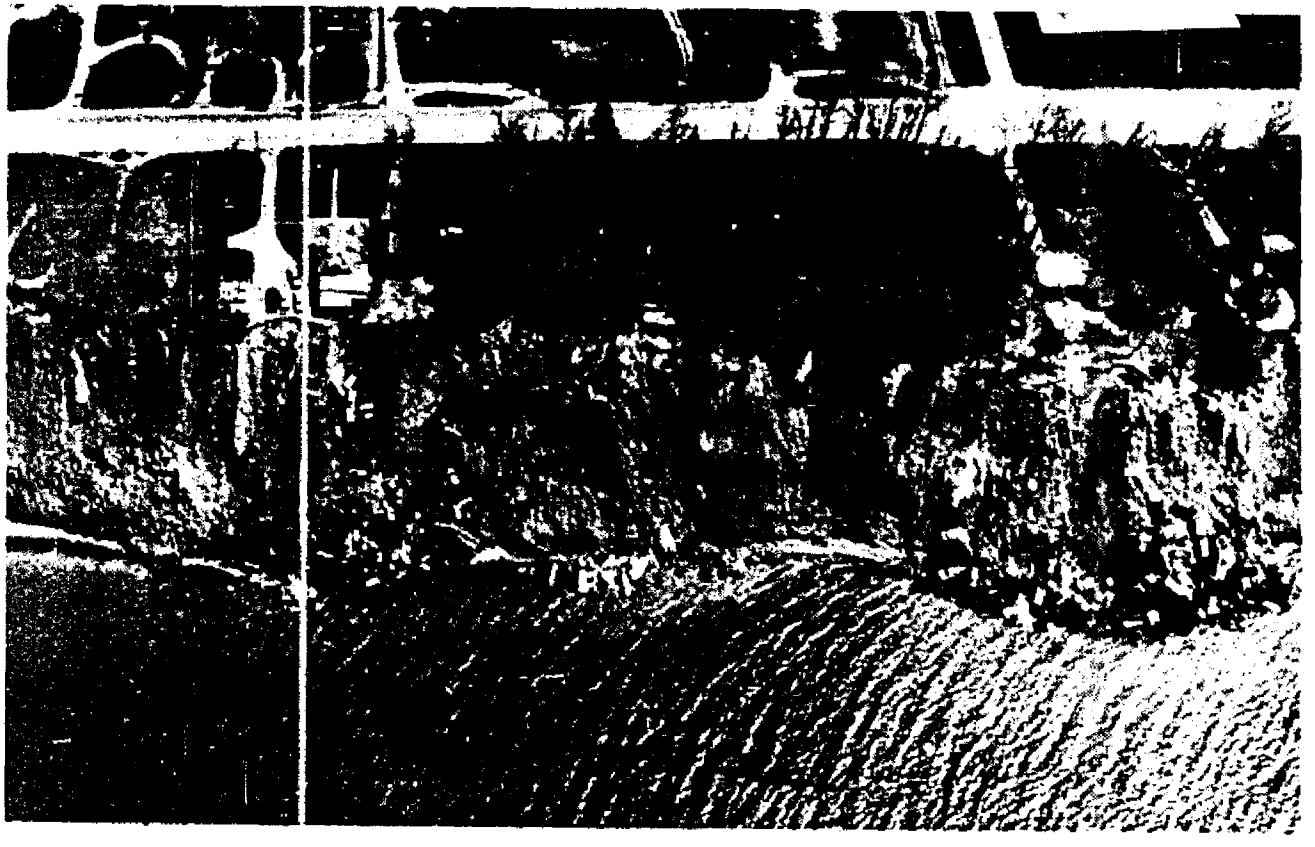

Fig. 2.--Self-help erosion protection along the shore at St. Joseph, Michigan which consists of junk car bodies, old refrigerators, and assorted concrete rubble. (Photo 1970, courtesy of the Michigan Department of State Highways.)

owner against another, there is a common law basis for a ruling for a plaintiff incurring these unusual damages from actions of his neighbor. On the other hand as was described earlier, many of the developed shore areas fall under the physical influence of federal navigational structures built by the Corps of Engineers under the authorization of Congress in order to promote waterborne commerce. Many riparians have sought to collect damages for accelerated erosion caused by federal projects but no amount of legal maneuvering can eliminate the great body of legal precedent supporting the federal government's right to maintain navigational structures without regard for harm to private property.[6]

Recent legislation[7] at both the federal and state level has stripped away some of the unbridled authority of agencies involved in managing our natural resources and has allowed direct citizen intervention on environmental

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[6]See generally pp. 375-396 in Joseph L. Sax, Water Law Cases and Commentary (Boulder, Colorado: Pruett Press, 1965).

[7]"The National Environmental Policy Act" 42 U.S.C. 4321-47 (1970) and "The Michigan Environmental Protection Act of 1970, "Michigan Comp. Laws Ann. § 691.12D1-07 (Supp. 1972) are the forerunner in Federal and State environmental legislation.

grounds in situations where mismanagement is implied or apparent. However, specific environmental questions, have yet to be brought to bear on the shore erosion problem.

Admittedly slow to respond in many instances all levels of government have nevertheless begun to respond to shore-zone problems. In recent years the Coastal Zone Management Act[8] has been enacted at the federal level but has yet to be adequately funded. Coastal states like Michigan,[9] Washington,[10] and Florida[11] have recently enacted their own state coastal zone management acts of one form or another. Local levels of government through their police powers have begun to restrict the use of shore areas through zoning and building regulations. The overall governmental response to coastal zone problems is continually growing but the fact remains that many citizens will face

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[8]"The Coastal Zone Management Act of 1972" Public Law 92-583, October 27, 1972.

[9]Michigan Shorelands Protection and Management Act of 1970, Act 245, Public Acts of 1970.

[10]Washington Shoreline Management Act of 1971, Wash. Rev. Stat., Ch. 90.58.

[11]Florida Coastal Construction Law, Florida Stat. 161.053, Chap. 280, Laws of 1971.

considerable losses in land, buildings, structures and personal property in shore areas which are already developed and where less than adequate attention has been paid to long-term environmental compatability with natural shore processes.

This present study emphasizes the many problems associated with erosion along the coastal zone. The perspective is that of the private citizen who is faced with losses in property caused by natural geologic forces that he may not fully understand, forces whose intensity is greatly altered by his own, his neighbor's or the federal government's protective works. This study is aimed at providing basic physical and legal information needed by riparian owners seeking to promote better erosion management on the Great Lakes. This treatment will develop the key physical and legal aspects of the shore erosion problem by using the case study method. The site of the case study is St. Joseph, Michigan, a highly developed shore area which has undergone unusually severe erosion damage periodically over the past 60 years. The geographic location of this site is shown in Figure 3.

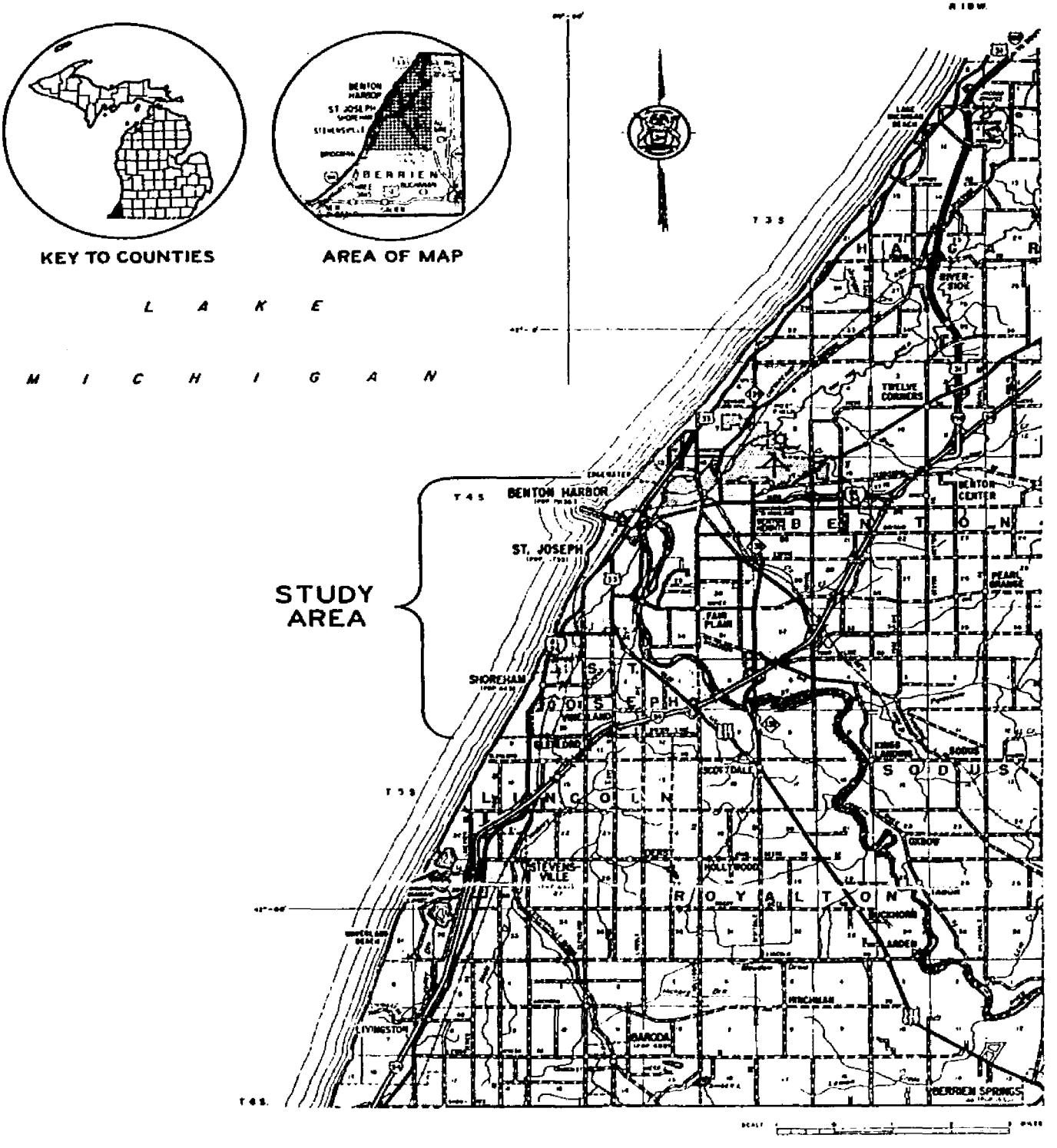

Fig. 3.--Location map of the case study area at St. Joseph, Michigan.

The Problem

The private riparian owner on the Great Lakes suffers erosion damage equal in magnitude to any occurring elsewhere in the world. The Great Lakes riparian is not unique in his erosion problem. Many developed areas on the seacoasts and the Great Lakes are suffering accelerated damages resulting from the emplacement of federal navigational structures or structures sanctioned by federal permit. The Great Lakes riparian, however, is unique in the respect that stages on the Great Lakes fluctuate over a relatively wide range over periods of from 15-30 years. The Great Lakes riparian in Michigan is fortunate in having two recently enacted laws that may in the long run provide some help in dealing with his erosion problems, the Shorelands Protection and Management Act of 1970[12] and the 1970 Michigan Environmental Protection Act.[13] In addition, environmental legislation may aid the riparian's legal arguments. However, none of these legal tools have

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[12]Act 245, Public Acts of 1970.

[13]Act 127, Public Acts of 1970.

yet been brought to bear on the problems of shore erosion resulting from either private or public protective structures.

The private riparian for all intents and purposes stands alone when it comes to protecting himself from damages--either physically or legally. There are loose knit associations of shore owners banded together for self defense. These groups are often, however, taken down the garden path so to speak, by well meaning consultants and lawyers providing solutions to their problems by structural or legal means. All too often these solutions lack the basic geologic information to be effective. Many engineering type solutions are often textbook remedies that never have or never will do the job for which they were designed.[14] In the same respect, legal alternatives often rely on ancient precedent that have no geologic basis in the context of the validity of cause-and-effect relationships.

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[14]While this broad statement is made on the basis of personal observations by this writer, the project maintenance records of the Michigan Department of State Highways and the C&O Railroad Company support this statement for the St. Joseph area.

In the end, only the property owner suffers. The erosion continues, his structural defenses are washed away, his dwellings are destroyed or they have to be moved at great expense and his legal fees are paid in a losing cause. There is a light at the end of the proverbial tunnel, however, which utilizes the same tools only with a sharper cutting edge. The structural defense is not totally futile if it is put into proper perspective and designed to augment and work harmoniously with nature. But such protective measures must be undertaken on an effective scale of operation whereby the entire shore area is afforded the benefits.

Legal remedies probably can be used most effectively if taken on legal points where precedent is favorable. The new environmental statutes at both the state and federal levels give new hope for acting against detrimental agency actions that degrade the shore environment. The private riparian holds the key to his own salvation, and this is where he can be aided by the resource management team made up of the scientist, engineer and lawyer.

This research through a model analysis of the case study area at St. Joseph probes the interrelations of these

three, often diverse disciplines with the aim of providing the much-suffering riparian owner with a workable, long-term approach to solve the erosion problem along developed shores.

Objectives

The specific research objectives sought in this study are as follows:

1. To analyze through use of a prototypical developed area along the Great Lakes coast of Michigan the key natural geologic factors and environmental conditions that produce unusual erosion.

2. To review the effectiveness of currently used engineering structures and other protective measures through examples available in the study area and referenced in the literature concerning other areas of the world undergoing similar erosion. This review analyzes the particular problems inherent in the geological and lacustrine environments of the Great Lakes.

3. To develop a chronology of events both natural and man-induced which have led to serious beach

disruption and on-going erosion problems at St. Joseph, Michigan.

4. To develop a relevant conceptual model of the littoral system in the study area to document the significant process-response interactions and effects in the near-shore environment.

5. To delineate the systemic characteristics of a naturally self-regulating beach environment and related coastal features in the study area as a basis for projecting legal accountability in situations where the self-regulating capacity of the system is disrupted or even destroyed by man.

6. To gather factual information concerning the area's erosion rates to ally to the foregoing objective and to substantiate the legal basis for damage claims resulting from man-induced changes in process-response model.

7. To analyze the possible short-term legal alternatives available to mitigate erosion damages in the light of previous legal precedent and established doctrines. This objective will be accomplished through the use of hypothetical legal actions based on the facts and conditions observed at the study area.

8. To propose an alternative legal approach stemming from recent environmentally based laws in order to bring about changes in administrative agency actions that have caused continuance of the erosion problem.

9. To recommend potential legal procedures and engineering options which are consonant with the realities of the dynamic self-regulating system which controls the evolution of beach profiles in coastal regions subject to the geomorphic stresses of wave energy and long-shore currents.

Writer's Interest in the Problem

This writer has for some time felt strongly about the ignorance of the general public to the importance of fundamental natural phenomena, i.e., geologic forces. This interest stems originally from his undergraduate and graduate training in the field of geology. These perceptions have been strongly tempered by his close professional association with an engineering organization, the Michigan Department of State Highways where he has been employed for the past six years as a field and research geologist.

The writer's doctoral program furthered this interest through enlarged exposure to the multiple disciplines involved in the study of Resource Development. It has become increasingly clear that effective solutions to problems stemming from the man-nature interaction should come through a thorough understanding of the physical problems involved, plus appropriate education of the segment of the populace involved. Such a process would be ideal but it is too simplistic, for in this far-from-perfect society we are too often faced with finding solutions to problems which are so deeply rooted and complex that they are difficult to recognize, let alone assess as to their proper magnitude. The field of law fortunately provides a way of finding equitable solutions to complex problems in our imperfect real world. It is hoped that solutions will also be found in law for these problems arising out of the man-nature interaction along developed shores.

Review of Relevant Literature

This study involves an integration of the three broad-based disciplines, geology, engineering and law, and its unabashed purpose is to attempt to "solve" the problem man is now facing from catastrophic shore erosion in developed reaches. If this is too presumptuous at least this integration can begin to seek a realistic solution to the problem. A review of relevant literature involves drawing from specific sectors in each of these three disciplines.

The literature in geology, specifically in the fields of marine, lacustrine and Pleistocene geology, is fortunately specific in subject matter and regional in its application. The encyclopedic survey of Rhodes W. Fairbridge[15] provides an excellent starting point in the selective search of geomorphological literature. This work provides both specific references to topics such as "littoral drift" and "erosion" and to the regional aspects of the problem. The works of D. W. Johnson,[16] Andre

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[15]Rhodes W. Fairbridge, ed., The Encyclopedia of Geomorphology (New York: Reinhold Book Company, 1968).

[16]Shore Processes and Shoreline Development (New York: John Wiley, 1919).

Guilcher[17] and C.A.M. King[18] gave significant information on coastal processes. Narrowing the subjects of literature search brought to bear significant information written by Jack L. Hough,[19] John A. Dorr, Jr., Donald F. Eschman,[20] Erwin Seibel,[21] and Curtis Larson[22] on specific Great Lakes areas. The general systems theories developed by Luna B. Leopold and Walter B. Langbein,[23]

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[17] Coastal and Submarine Morphology (London: John Wiley & Sons, 1958).

[18] Beaches and Coasts (London: Edward Arnold, Ltd., 1959).

[19] The Geology of the Great Lakes (Urbana: University of Illinois Press, 1956).

[20] The Geology of Michigan (Ann Arbor: University of Michigan Press, 1971).

[21] "Shore Erosion at Selected Sites on Lake Michigan and Lake Huron" (unpublished Ph.D. dissertation, University of Michigan, Ann Arbor, 1972).

[22] "The Cultural Variable in Shore Erosion Along the Illinois Shore of Lake Michigan," (Chicago: Lake Michigan Federation, 1972).

[23] The Concept of Entropy in Landscape Evolution, U.S. Geological Survey Professional Paper 500A (Washington, D. C.: U. S. Government Printing Office, 1962).

Richard J. Chorley[24] and M. M. Miller[25] provided a theoretical basis for this work. Several publications[26] of the Corps of Engineers provided specific information on the Great Lakes.

The most significant work in the field of environment and geology was written by Ian McHarg,[27] a landscape architect by profession. His mandate to the field of geology had a pronounced effect on the distillation of information derived from all the other cited authors.

The engineering literature that focused most significantly on this problem is that published by the United States Army Coastal Engineering Research Center.[28] Other

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[24] Geomorphology and General Systems Theory, U. S. Geological Survey Professional Paper 500B (Washington, D. C.: U. S. Government Printing Office, 1967).

[25] "Entropy and the Self-Regulation of Glaciers in Arctic and Alpine Regions," Symposium on Arctic and Alpine Processes, Guelph University, May 4-5, 1973 and published in Geoscience Abstracts, East Anglia, England, Dec. 1972.

[26] Shore Protection, Planning and Design, Technical Report No. 4, U.S. Army Coastal Engineering Research Center, U.S. Government Printing Office, Washington, D.C., 1966 and Shoreline Protection Guidelines, Washington, D.C., 1971.

[27] Design with Nature (Garden City, New York: Doubleday and Company, Inc., 1969).

[28] Note 26 supra.

publications of the Corps also provided a great deal of helpful information. The Michigan Water Resources Commission has published a number of useful semi-technical reports on the engineering methods for shore protection.[29] A rather complete study of the erosion problem on the Great Lakes was conducted by E. F. Brater and Erwin Seibel[30] of the University of Michigan. Additional relevant information on engineering design for the shore environment is found in the McHarg[31] reference.

The field of law, not being this writer's major discipline, involved a much broader approach in the literature search and review. The review of case law or "court made" law followed a path through many volumes of federal and state reporters after this writer discovered a recent

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[29] Low Cost Shore Protection, Engineering Research Institute, University of Michigan, Reprinted 1959 by the Water Resource Commission, and Great Lakes Shore Erosion in Michigan, Lansing, Michigan, 1969.

[30] An Engineering Study of Great Lakes Shore Erosion in the Lower Peninsula of Michigan, Michigan Water Resources Commission, Department of Natural Resources, Lansing, 1973.

[31] Note 27 supra.

case reported in the Environment Reporter[32] having nearly the same facts as those at St. Joseph, Michigan. A great deal of interpretation on recent trends in the legal field is available through the study of law journal articles. Valuable information was obtained in journal articles by Terry A. Trumbull,[33] Joseph L. Sax,[34] Roger C. Crompton and Barry B. Boyer,[35] Richard W. Bartke,[36] Eva H. Morreale,[37] Donald L. Humphreys,[38] and Leighton L. Leighty.[39]

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[32] A relatively new reporting series published by the Bureau of National Affairs, Inc. (BNA) in Washington, D. C., which specializes in environmental law.

[33] "Private Environmental Legal Action," University of San Francisco Law Review, Vol. 7, Oct. 1972, pp. 27-56.

[34] "The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention," Michigan Law Review, Vol. 68, January 1970, pp. 473-506.

[35] "Citizens' Suits in the Environmental Field: Peril or Promise," Ecology Law Quarterly, Vol. 2, No. 3, Summer 1972, pp. 407-436.

[36] "The Navigation Servitude and Just Compensation: Struggle for a Doctrine," Oregon Law Review, Vol. 48, 1968, p. 1.

[37] "Federal Power in Western Waters: The Navigation Power and the Rule of No Compensation," Natural Resources Journal, Vol. 3, May 1963, p. 1.

[38] "NEPA and Multi-Agency Actions--Is the Lead Agency Concept Valid?" Natural Resources Lawyer, Vol. 5, No. 4, 1973, p. 257.

[39] "The Source and Scope of Public and Private Rights in Navigable Waters--Part I," Land and Water Law

Additional information was gained through a review of relevant texts including those by Joseph L. Sax,[40] Norman J. Landau and Paul D. Rheingold,[41] and the anthology, Law and the Behavioral Sciences.[42]

The field of environmental law is growing at a rapid pace with new literature coming out almost daily, and for this reason only the more significant works that were actually used here have been mentioned. The review of significant case law can be extremely "time sensitive" in that decisions are being handed down almost daily. The case law used represents those relevant cases reported prior to mid-1973.

The official records of public hearings involving Corps of Engineers permits were found helpful in preparation

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Review, Vol. 5, No. 2, 1970; "Public Rights in Navigable State Waters--Some Statutory Approaches," Land and Water Review, Vol. 6, No. 2, 1971, p. 1.

[40] Defending the Environment: A Strategy for Citizen Action (New York: Alfred A. Knopf Co., 1971), and Water Law Cases and Commentary.

[41] The Environmental Law Handbook (New York: Ballatine, 1971).

[42] Lawrence Friedman and Steward Macauly, editors (Indianapolis: The Bobbes Merrill Company, 1969.

for this study.[43] Additional insight was gained through the examination of lawyer's briefs from several actual cases pending in the St. Joseph area. No further reference has been made to these cases for the sake of propriety in that they have yet to be heard in court at the time of this writing.

Definitions

This thesis, by its cross-disciplinary scope, uses many terms that will be unfamiliar to the reader not versed in the fields of geology, engineering and law. As much as was possible these terms have been used with enough subsequent discussion to make their meaning discernible from the text. When an unusual term is used, however, the word has been underlined and reference is given to a more complete definition in the glossary at the end of this work. It is evident that some terms will be foreign even with the textual background. For these cases the reader may wish to

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[43] All public meetings on Corps permits are recorded by a court reporter. This public record is available through the various District Offices of the Corps of Engineers.

refer to the Glossary of Geology,[44] the Engineering Manual[45] and the Ballentine's Law Dictionary.[46] The reader who is unfamiliar with legal citations is referred to A Uniform System of Citations,[47] distributed by the Harvard Law Review Association. For all other matters of style and technique, the recommendations of Kate L. Turabian[48] have been followed.

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[44] American Geological Institute, Washington, D. C., 1972, p. 585.

[45] Engineering Manual (McGraw-Hill, 1967).

[46] Third ed., William S. Anderson, ed. (New York; Rochester: The Lawyers Co-Operative Publishing Co., 1969.

[47] Cambridge, Massachusetts: Garnett House, 02138.

[48] A Manual for Writers of Term Papers, Theses, and Dissertations (Chicago: The University of Chicago Press, 1967).

CHAPTER II

PROJECT DESIGN

The Case Study Approach

In this dissertation the case study method of research is used. Analysis of a problem through the use of specific sets of facts and conditions has several advantages over a broadly based and widely ranging research approach. These advantages may be summarized as follows:

1. The case study focuses on an actual problem area where solutions are both beneficial and applicable to the problem area at hand while at the same time having broad application to the overall problems involved.

2. The case approach allows factual illustrations to be developed without relying on hypothetical situations which may or may not be fitted to real world conditions.

3. The development of research around a case study allows a certain degree of flexibility in scope, but at the

same time restricts it to a manageable size through having to restrict discussion to a limited set of facts.

4. The case study approach can be "solution oriented," whereby the problem analysis leads to resolving the problems of the case study area itself.

Selection of the Study Area

This case study will develop the facts and historical aspects relevant to an area at St. Joseph, Michigan, in order that this information may be used to examine the physical problems that are unique to the Great Lakes and applicable to the seacoast as well and to analyze the legal alternatives of private riparian owners along the shore. The study area at St. Joseph was selected because of the varied physical and legal aspects, including a history of repeated erosion damage and pending litigation.

The ultimate selection of the area at St. Joseph, Michigan was preceded by extensive field reconnaissance work by this writer. There are many areas along Michigan's Great Lakes shores that are undergoing extensive erosion damage that could have been used for study and many of

these areas were field checked while traveling the State during the summers of 1971 and 1972.

The selection of St. Joseph as the study area was fostered through inquiries with personnel from the Michigan Department of Natural Resources, Submerged Lands Section[1] and the Corps of Engineers, Detroit District.[2] Their help provided the background for further detailed on-site field investigation on the St. Joseph area. Personal interviews with public officials and riparian property owners provided additional substantiation for selecting the St. Joseph area. Once the selection of the study area was made, in-depth field and library research began.

Research Methods

It is understandable in today's extremely complex society that any one discipline such as law, engineering, geology or sociology cannot on its own be used to solve

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[1]Messrs. George Taak and Mogens Neilson of this section of the DNR provided essential background information for this study.

[2]Messrs. Allan Aaron and Urban Boresh of the Corps directed this writer to key aspects of the study.

resource management problems which comprise an inhomogeneous blend of subject matter to begin with. This study tries to "bridge the gap" between those disciplines to point the way toward solutions that in the long run will be acceptable in each separate field.

The scientists and engineer often forget that most of the world runs on emotion. With what A. Gordon Everett has called "tunnel-visioned rigor"[3] scientists and engineers have made decisions that exclude the qualitative approximation and emotional considerations. In recent years this has led to a "backlash" against technology. These other considerations are equally valid so the problem really becomes one of finding a way to factor science and engineering into a relevant relationship in public decision-making that includes all aspects and viewpoints of objectivity and subjectivity.[4]

In the same respect, the field of law as discussed in C. P. Snow's The Two Cultures[5] is heavily dependent

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[3] "Geology in Public Decision Making," The Professional Geologist, Vol. 9, No. 5, December 1972, pp. 7-10.

[4] Ibid.

[5] C. P. Snow, The Two Cultures and a Second Look (Cambridge: University Press, 1964).

upon human drama and emotion. Both science and law seek to use the intellectual capacities to find facts and to solve problems. According to Everett "Between the polar ends of science and of this specialized version of art, lie all human experience."

The case study of the erosion problems at St. Joseph, Michigan provides the bridge for a physical scientist to begin seeking answers to difficult resource management problems at some common latitude between these "polar ends."

Scientific Research Method

Basic research was carried out to determine the geologic and engineering aspects of the erosion problem at St. Joseph. All relevant scientific and engineering information related to the St. Joseph area was brought together and reviewed. This was followed by detailed on-site field surveys to confirm the conclusions from the literature. Additional field work was carried out that included a photo-reconnaissance flight over the study area in a charter aircraft and detailed examination of shore structures and bluff conditions at all possible points of entry

along the shore. At these points a photographic record was also made.

The laboratory phase of the study involved examination of aerial photography taken during the period 1969-1973 as well as earlier photographs taken from 1938-1969 to determine rates of erosion at various points during previous and current high-water erosion periods. The aerial photographs were assembled into controlled strip mosaics from which all measurements were made. This photographic record also provided an excellent record of the performance of the engineering structures over this same time period. The information on erosion rates was then used to form the factual basis for the hypothetical legal cases presented in a subsequent chapter.

Legal Research Methods

The methods employed in this phase of the study follow an investigative procedure similar to that used by attorneys in preparing a case. With the scientific information as background for analysis of legal alternatives this research concerned, first, the determination of the historical events which can lead to the formation of legal

arguments. Second, a search of legal doctrines, statutes, case law, and administrative procedures was conducted to determine the relevant material and precedent that could be used in interpretation of the facts. Thirdly, some in-depth fact-finding through personal interviews was conducted much in the same way as an attorney seeks information through depositions. This fact-finding process led to interviews with public officials (local, state and federal) involved in the development and management of the shore in this area, with riparian owners, and with leaders in citizen groups working toward an improved management of the coastal zone. In addition, much valuable information was gathered through the study of transcripts of Corps of Engineers public hearings involving permit applications for structures in the Great Lakes and from briefs prepared for other similar cases. This writer also attended two rather lengthy and vocal public hearings concerning permits for the Cook Nuclear Plant in the coastal zone near Bridgeman, Michigan.

The fact-finding also included interviews and correspondence with attorneys now engaged in suits of similar nature to the hypothetical situations presented here.

Specifically, the respective attorneys in the Cook Nuclear Plant case were interviewed as were the attorneys for the plaintiffs and defendant in the St. Joseph case involving claims against the federal government for erosion damages. The pertinent information obtained through interviews with these attorneys who are directly involved with on-going cases of a similar nature was extremely helpful.

Conceptual Foundation

Methods by which the previously listed objectives of this study are attained are based on the dual techniques of scientific inquiry and of in-depth legal analysis.

The scientific method[6] utilizes standardized procedure of inquiry (combined deductive and inductive) by which:

1. A question is formulated,
2. A set of experiments is designed to answer it,
3. The experimental observations are made,

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[6]There are many conceptualizations of the scientific method, but this work utilizes the geologic methods presented by John C. Griffiths in the text Scientific Method in the Analysis of Sediments (New York: McGraw-Hill Book Company, 1967), p. 2.

4. The observational data are analyzed,

5. Conclusions (inferences) are drawn from the data,

6. A hypothesis is erected,

7. A set of predictions is made,

8. Further tests are made,

9. The hypothesis is accepted or rejected on the basis of the agreement or disagreement with the predictions.

Prior to undertaking scientific analysis the researcher must have a proper concept of the systems model he is studying. Essentially the study of the physical aspects of shore erosion can be best described by a process-response model of the littoral environment formulated by W. C. Krumbein[7] and modified by the writer, the following relationships among elements can be expressed as shown on page 40 of this study.

The process-response model predicts that changes in one or more of the initial process elements will result in a corresponding response with feedback effects further modifying the model. The case study area exhibits conditions

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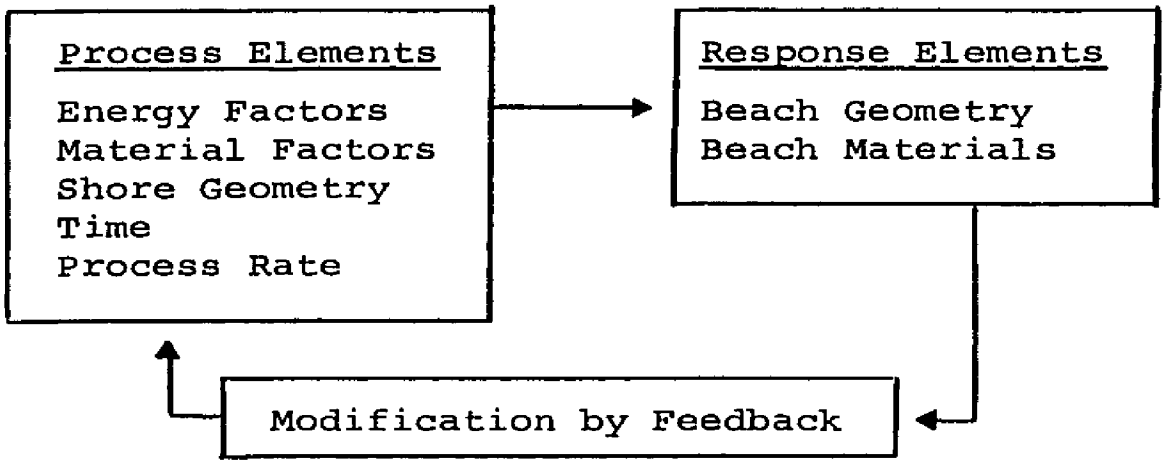
[7] "A Geological Process-Response Model for Analysis of Beach Phenomena," Bull. Beach Erosion Board, Vol. 17, pp. 1-15.



where all seven process-response elements are involved. The wave energy system has been changed, the rate of energy application has consequently varied, material has been removed from the system and the shore geometry has been altered by structural works. The resulting response has been that destructive erosion has taken place during high energy periods (storms) that have occurred during high stages on the Great Lakes. The important question to be answered is: What is the rate of progression, i.e., the acceleration of process of this manifestation of the process-response model?

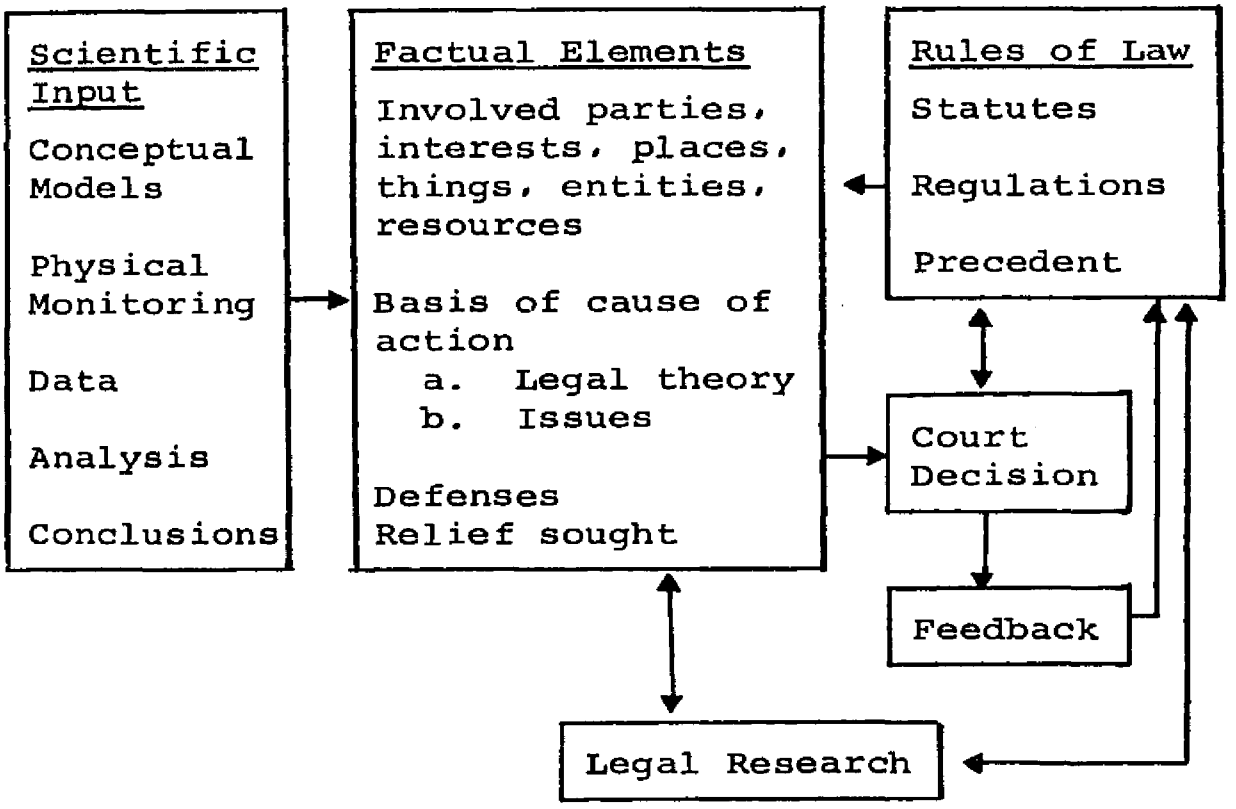
The experiments needed to answer this question can be performed by measuring particular bluff positions at various time intervals, a task readily accomplished on aerial photographs taken at intervals over a period of

years. The experimental design must include a basis for comparison, background or control. The basis for comparison for data collected at the St. Joseph study area is developed by determining rates of erosion for other similar areas on the Great Lakes. Extensive work reported by other researchers provides this background information.

The process-response model of the near shore system found along the coast at St. Joseph has applications in the legal system as well. The legal solutions to erosion problems stemming from man's interaction with process-response elements will rely heavily on an understanding of the geological system by all respective parties involved in legal actions. In this study the rate of erosion is only a rather broad based quantification of the degree disruption within the system. Further study would be needed to more fully describe and measure other model elements.

The quantification of accelerated erosion rates is a reasonable scientific basis for legal action aimed at remedying this aberration in the geomorphic system. The scientific information is factored into the legal analysis in the following model of legal analysis which has been

suggested by Leighton L. Leighty, Professor of Resource Law, Department of Resource Development, Michigan State University.



This diagram of the legal model depicts the various factors that must be integrated to determine the basis for a claim or defense. The scientific input is directed into the factual elements. The factual presentation of places, things, entities and resources is aided directly by scientific analysis. In the case of the St. Joseph erosion problem, these factors are often difficult to comprehend

and probably are best described by a conceptualized model of the system. The basis of cause of legal action is aided by scientific input by insuring the validity of the specific issues (i.e., data supplied by analysis of process-response interactions). The type of defense utilized is greatly enhanced by consultation with the scientific sector. Finally, the relief sought, whether money damages or injunctive relief, is often based on inputs derived from outside sources such as expert witnesses. In the case of St. Joseph, the type of relief sought could be a function of what the physical, social and legal systems will tolerate.

CHAPTER III

THE ST. JOSEPH STUDY AREA

Introduction

The study of the various legal solutions for physical and engineering problems related to the shore erosion question is best discussed in the context of a case analysis. It is for this reason that a segment of shoreline at St. Joseph, Michigan was selected. This area has had substantial notoriety in the press through dramatic photographs depicting homes on the brink of an eroded shore bluff or the splintered remains of once beautiful summer homes that have already fallen victim to shore erosion and land slides, Figure 1.

In recent years the State of California has received a good share of notoriety on coastal problems and natural disasters with earthquakes, mud slides, oil spills, brush fires and coastal erosion. The study of shore problems in California and other states has proven useful in

bringing together a great body of information on coastal management problems. The fact that the State of Michigan has more shoreline than any other state except Alaska in itself is justification for selecting a study area in this state. Michigan's Great Lakes shores are also of interest in that in many ways they are analogous to the world's great inland seas and that knowledge gained from ocean and sea coast areas can apply in this respect. However, for the most part, the Great Lakes remain a singularly unique fresh water environment found in the heart of one of the more heavily populated regions of the North America continent.

While it was the publicity attending environmental damage that first drew attention to this study area, it is the historical aspects of erosion problem that makes the study area of special interest. The coast at St. Joseph provides a nearly continuous historical record of man's interaction with the littoral environment over the past 140 years. Out of these interactions have grown the erosion and shore management problems the residents face today. Historical documentation of these events provide the essential time frame to which the geological studies of process

and response are keyed and from which the basic factual relationships (cause and effect) for the legal analysis are drawn.

Geographical Location

The study area includes an approximately five mile strip of shoreline located in the City of St. Joseph and the Village of Shoreham in Berrien County, Michigan, Figure 3. This five-mile-long study area extends southward from the federal harbor piers at the mouth of the St. Joseph River to the St. Joseph township boundary which also forms the southward limit of the Village of Shoreham.

Physical Setting

The study zone is located in an area of generally high, 20-100 foot bluffs composed of clay, unconsolidated glacial till, and stratified sand and gravel, Figures 1 and 2. At both the north and south ends of this reach of shoreline the bluffs are less steep. The bluff line at the north end from the city waterwards to the breakwater

lies several hundred feet landward from the present water line. The Silver Beach Amusement Park and the Lions public beach are located on the remnants of the old delta of the St. Joseph River. Except for this northern portion of the study area, the water's edge is in close proximity to the toe of the bluff and during high lake stages with storm conditions, wave run-up reaches the bluff causing serious undercutting and slumping, Figures 1 and 2. The generally variable composition and stratification of material in the bluff aids the rate of undercutting at which erosion takes place. Water seeps or springs occur throughout the entire length of the study area at various elevations depending upon the stratigraphic sequence and the position of an impervious clay layer known locally as "hardpan." This surface seepage adds to the wastage problems by providing lubrication for slip surfaces, although this is a minor effect compared to that produced by wave energy dissipated on the beach.

The bluff face has approached the normal angle of respose for unconsolidated sandy sediment (ranging from approximately 30 to 33 degrees) during periods of low water when wave attack did not reach the bluffs. For example,

during low water stages between the years 1955-1957 the bluffs stabilized at this angle so as to allow the establishment of extensive vegetation, Figure 4. A temporary sense of stability was afforded by this vegetation during this interim low water period when many new homes and a large apartment complex were built close to the bluff line.

The study area is dominated by the presence of the twin breakwater piers maintained by the Corps of Engineers as an aid to navigation for the port cities of Benton Harbor and St. Joseph, Figure 5. While the purpose of the breakwater is primarily for harbor protection, the structure has been since its beginning an effective barrier to southward moving littoral sediments, as will be demonstrated below. Approximately 600 lineal feet of accreted land have been added lakeward from the shore on the north side of the breakwater in the 120 years since its construction in the 1860's, Figure 6.

South of the federal harbor works privately constructed shore erosion structures have been installed intermittently for the entire length of the study area. The most notable are those that have been constructed by the City of St. Joseph for the immediate purpose of protecting

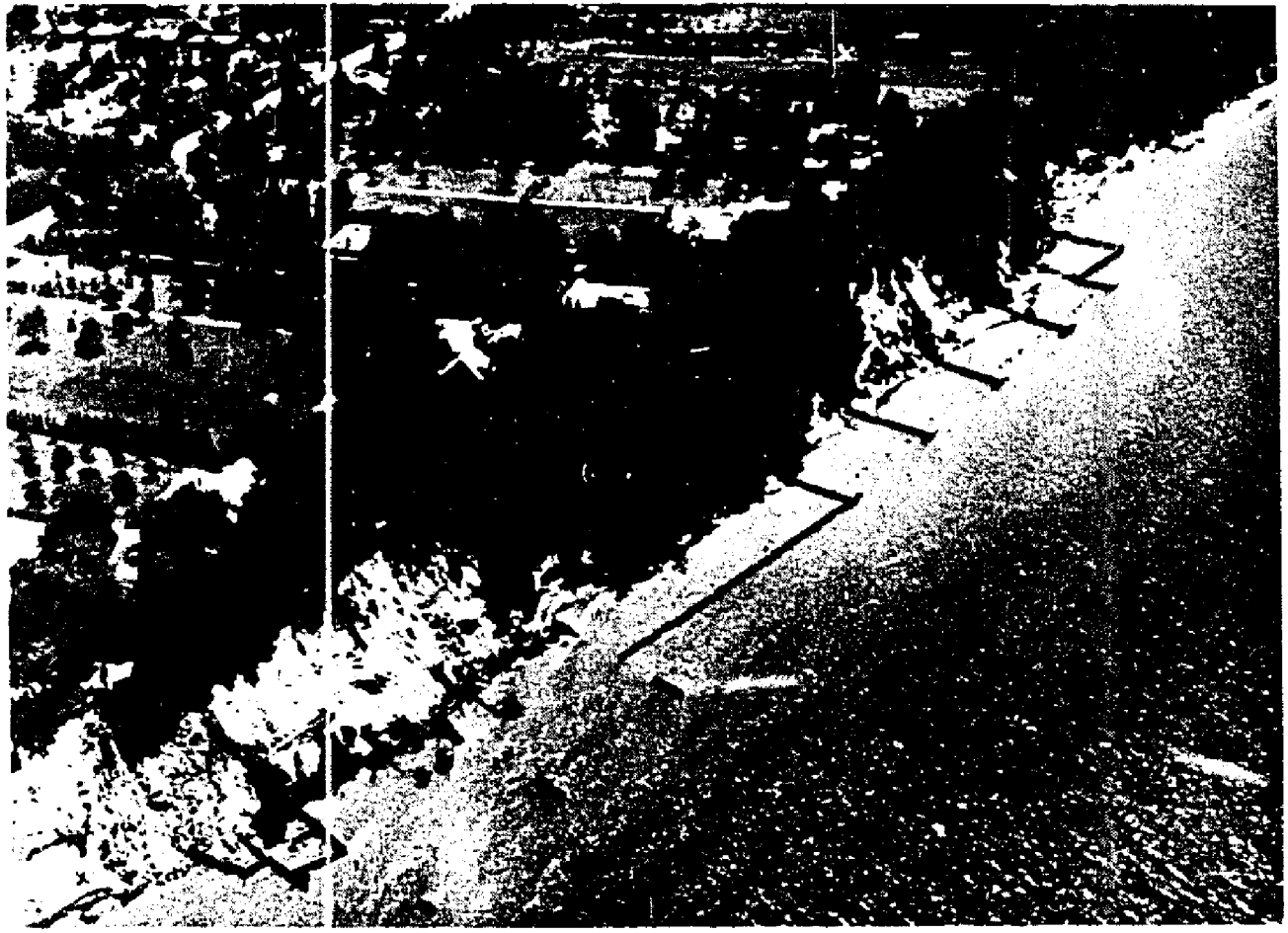


Fig. 4.--Vegetation stabilized bluffs at St. Joseph, Michigan in June 1969. (Photo courtesy of the Michigan Department of State Highways.)

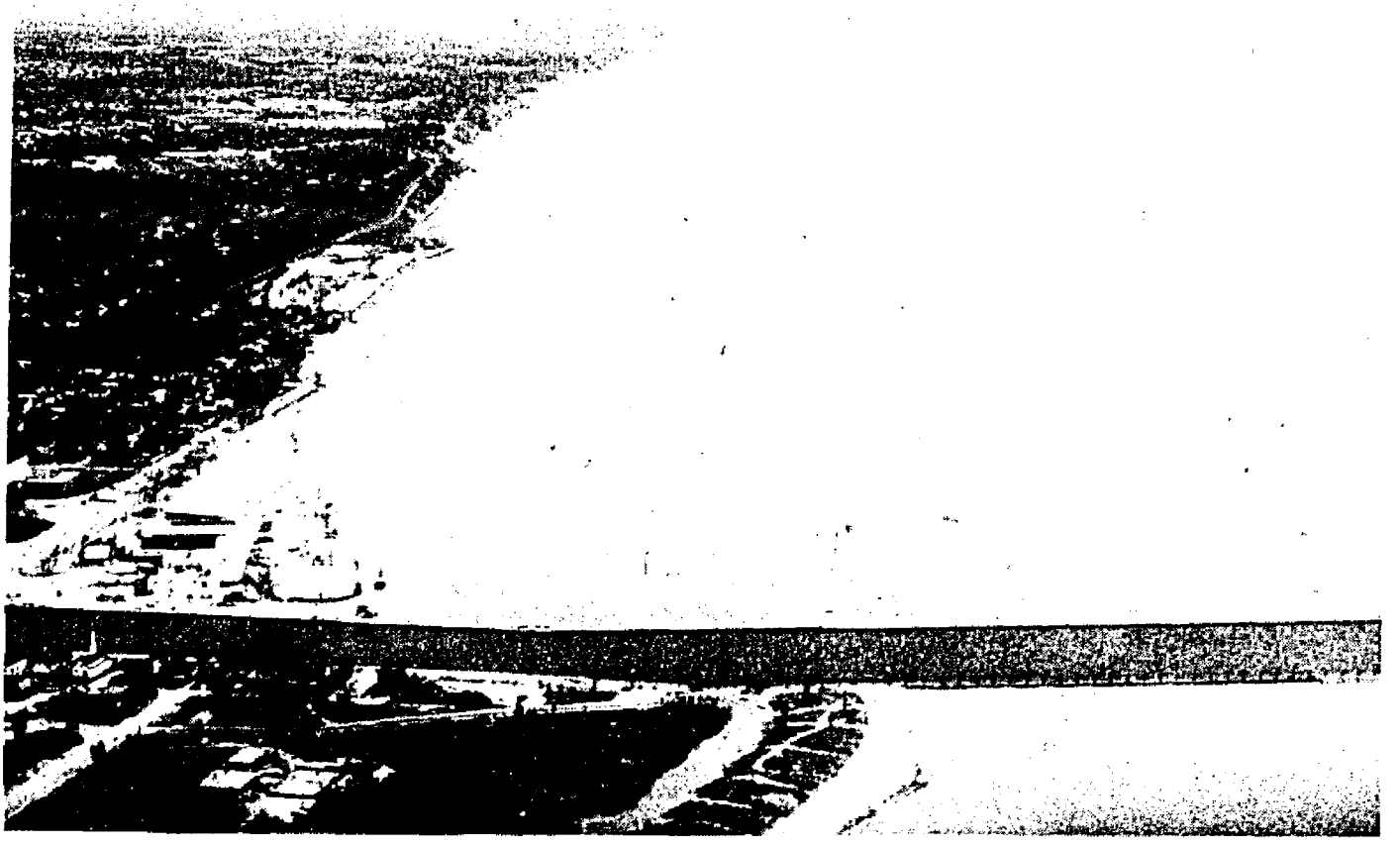


Fig. 5.--High oblique photographic view to the south with the twin federal piers at the mouth of the St. Joseph River in the foreground. (Photo May 1973, by T. A. Herbert.)

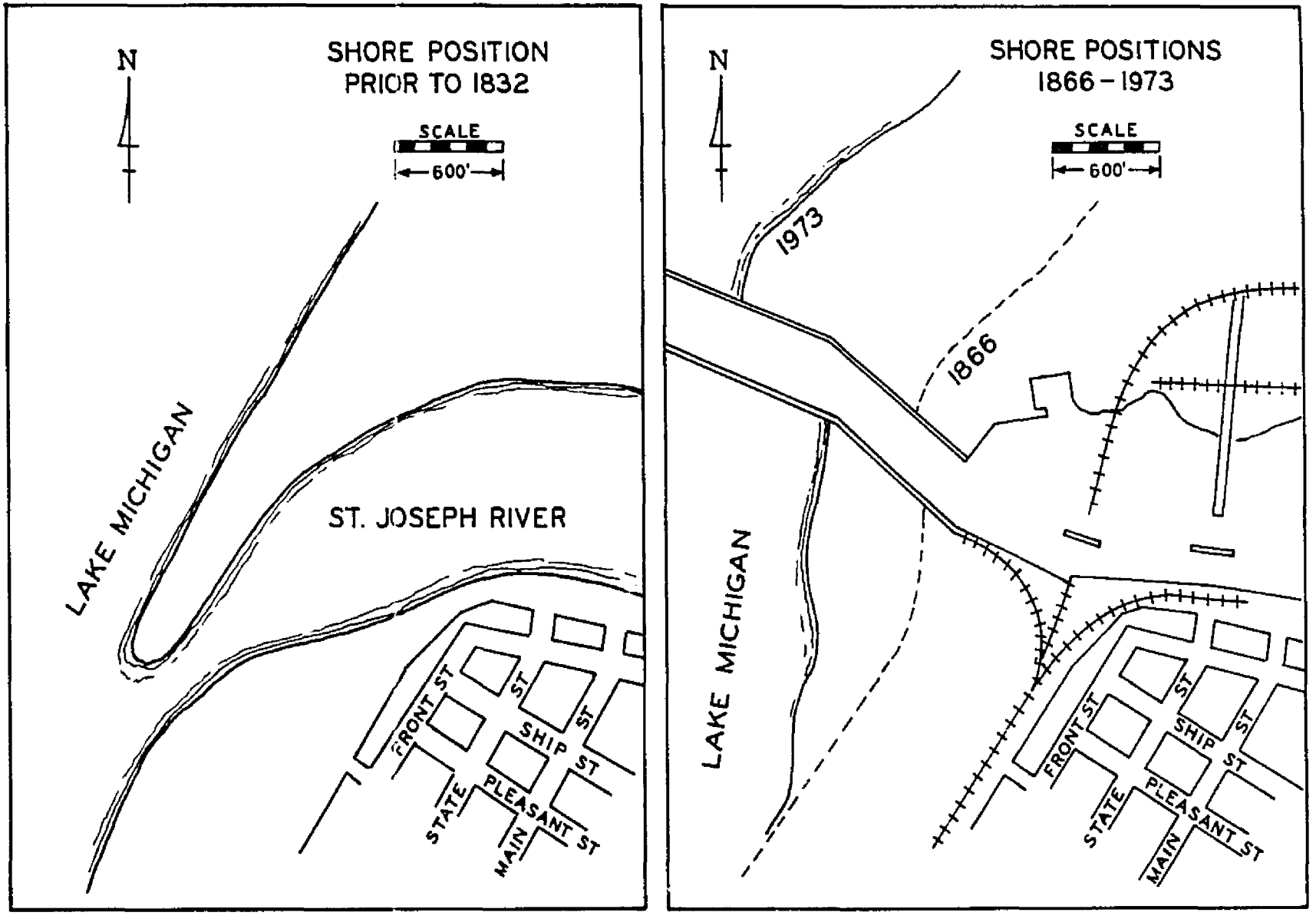


Fig. 6.--Approximate shore positions at the mouth of the St. Joseph River during the past 140 years based on information from the archives of the St. Joseph Public Library.

the City water works, and those constructed by the C&O Railroad Company to protect nearly a mile of track south of the water works, as well as those constructed by the State Highway Department immediately south of the railroad structures to protect approximately 0.9 mile of business loop I-94 (Red Arrow Highway) that enters St. Joseph from the south, Photo Map 1 (foldout of vertical photography follows final page of this work). From the south terminus of the highway structures there are also numerous private structures that have been built to protect dwellings.

The structural design (or lack of it) for the protective works south of the federal structures is found to be of quite differing quality.[1] The City of St. Joseph, the C&O Railroad, the Highway Department and many of the private owners have resorted to steel sheet piling or wooden piling groins and bulkheads.[2] For the most part where

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[1]The lack of qualified professional engineering design is readily apparent along the shore as is shown in Figure 2 where junk car bodies have been dumped over the top of the bluff.

[2]Professional engineers were used to design many of these structural works.

these structures have been able to withstand wave action they present a striking geometric pattern along the shore as is depicted in Photo Map 1 and Figure 5. At the same time interspersed among the regular geometric patterned structures are rather unesthetic[3] remedies conceived by other riparian owners, Figure 2.

Offshore from this entire reach of shoreline the water is turbid as the result of active erosion of the clay and sand bluffs. Brown plumes of turbid water are visible from the air and are recorded on the aerial views in Photo Map 1.

Cultural - Political Setting

The study area is located in the City of St. Joseph, the Village of Shoreham, in St. Joseph Township in Berrien County, Michigan. The area along the shore itself has approximately 150 separate riparian parcels of land. The entire area is controlled by overlapping political entities

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[3]The esthetics qualities of the structural works is, of course, a matter of opinion. This writer feels strongly that in most instances structural works cause more damage to the shore than would occur if the natural shore systems were allowed to work unimpeded.

including county, township and village boards, and the City Council. Commercial interests in the shore area are represented by the Lakeshore Chamber of Commerce.

The riparian property owners are organized into an increasingly vocal group called the Lakeshore Property Owners Association.

Chronology of Significant Events

The following synopsizes the historical record of the events which have occurred during the development of the erosion problems at St. Joseph. This information is based on various written sources, personal inquiry, and inference by the writer.

Prior to 1831--The condition of the shore was essentially unaffected by man's activity. The St. Joseph River flowed southwestwardly out through a break in the line of bluffs along the coast and was deflected even more to the south by a spit of land extending south from the north bank, Figure 6.

1836 to 1866--The Corps of Engineers constructed 1,100 feet of pier extending from the north bank of the river and 212 feet from the south shore, Figure 6.

1866 to 1868--The Corps added another 200 feet to the south pier.

1872--The Corps added another 416 feet to the south pier.

1876--The Corps added another 300 feet to the south pier.

1877 to 1881--The Corps added another 350 feet to the north pier.

1886--Record high water levels occurred on the Great Lakes.

1892--The Corps added another 350 feet to the north pier.

1902--The Corps added another 1,000 feet to the south pier and 350 feet to the north pier.

1904--The Corps added 1,002 feet to the north pier, and 1,803 feet to the south pier. The physical construction of the piers was completed at this time.

1917--The City of St. Joseph built 700 feet of protective works along the shore to protect the water

intake and pumping station. High water stages occurred on the Great Lakes.

1929--The Chesapeake and Ohio (C&O) Railroad Company began general protective work which over the years has included seawalls, groins, jetties, bank excavation, drainage facilities and plantings with a total expenditure of $1,610,000 since that time.

1940--The C&O Railroad Company installed 500 lineal feet of steel sheet pile bulkhead.

1943-44-46--The C&O Railroad performed general repair.

1949--The Michigan Department of State Highways (MDSH) constructed groins and nourished the beach with material trucked from land sources.

1951-1955--MDSH constructed groins, timber bulkheads and further nourished the beach.

1952-1953--The peak of the high water period on the Great Lakes, the City of St. Joseph spent $250,000 on protection for the water works, three private homes

were lost and two more moved. Private owners began installing extensive protective works.[4]

1954-1961--Extensive litigation by one property owner against his insurance company for land slide damage to his house. Ultimately the case was decided in favor of the landowner but no insurance was written for any shore damage after 1954.[5]

1956--A Corps of Engineers report stated that 100,000 cubic yards of sand must be placed into the beach zone south of the harbor jetties to replenish that which was being blocked by the harbor jetties. The City took no action because of the high cost involved.[6]

1960-1961--Low water period on the Great Lakes, up to 100 feet of dry sand was exposed between the water's edge and the foot of the bluff, mature vegetation stabilized (Figure 4) the bluff slopes creating an attractive

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[4]Personal communication with Mr. Leland Hill, City Manager of St. Joseph and former City Engineer.

[5]Westchester Fire Insurance Co. v. Hanley, 284 F2d 409, 365 US 869.

[6]Personal communication with Mr. Leland Hill, St. Joseph City Manager.

setting, many of the older homes were sold and some new homes were constructed on vacant land near the bluff line.

1964--An all time low water stage measured on Lake Michigan-Huron.

1968--The Rivers and Harbors Act Section 111[7] authorized the Corps of Engineers to study problem of erosion caused by Federal navigation structures. Preliminary study on the St. Joseph harbor jetties was begun. The high water cycle was on the upswing.

1968-1969--Winter storms began active erosion of shore areas south of the harbor jetties.

Property owners began building structures and dumping rubble on lower slopes for protection. Court order issued for removal of junk cars from slopes. State Highway Department began survey and design for highway structure. Lakeshore Chamber of Commerce retained a private consulting firm[8] to conduct a study on beach and bluff erosion.

1970--A study by the Corps of Engineers of the erosion caused by the federal harbor piers was required by

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[7]Public Law 90-485, 82 Stat. 731 111.

[8]Gove Engineers, Kalamazoo, Michigan.

Governor Milliken. To the date of this writing, this Corps of Engineers report has not been released despite inquiries by local citizens, legislators and congressmen. Rebuilding of protective structures was continued all along those shores, especially at the water works and along the railroad right-of-way. Also the contract for the most recent Highway Department structures was let and construction was begun.

Lake levels remained high with periods of several fall and winter storms causing increasingly greater damage.

1971--High water levels continued, winter and fall storms caused continued and increasing damage. The Highway Department project was completed.

Waterworks protection was continued, sheet pile groins and bulkheads were constructed, and rubble was placed on a continuing basis during this period.

The C&O Railroad continued to fill and place rubble revetment material during this period. Extensive private works started to protect a large apartment complex immediately south of the Highway Department project. Individual property owners were forced to build structures or move homes in danger of destruction. Private, protective

structures were remodeled and strengthened throughout the entire study area. Many property owners not faced with loss of houses and other buildings did not participate in the building of protective structures.

1972--High water levels continued and began a steady rise toward the end of the year. On November 14, 1972 an intense storm throughout Michigan caused the most rapid erosion of shore and bluff ever recorded. Berrien County was declared a disaster area thus became eligible for low interest loans from the federal Small Business Administration.

Property owners filed application for low interest loans to finance further protective measures. The property owners also became eligible to make claims for casuality losses on their 1972 Federal Income Tax Returns.

1973-Present--The water level of Lake Michigan continued a steady rise aided by an extremely warm, wet winter in 1972-73. Little or no shore ice formed during the colder months, thus erosion was allowed to continue through the winter without this natural barrier.

On March 17, 1973 a late winter storm caused record erosion rates to continue. Berrien County again was

declared a disaster area. Property owners claimed casualty losses for erosion damages on their 1972 Federal Income Tax returns. Applications for low-interest Small Business Administration disaster loans denied for 177 of the 179 applicants.[9]

The Present--Near record high water stages occurred on Lake Michigan in the summer and fall of 1973. For the shore-term future high lake levels may be expected to continue for a few more years. Recent world-wide climatic predictions by several scientists[10] reveal a reversion to cooler and drier conditions toward the end of the century.

Analysis of Events

While this list by no means provides an exhaustive chronology of the historical events that have taken place in the study area, enough has been cited to give the reader

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[9]Personal communication with Mrs. Donna Asselin, Lake Shore Property Owners Association, South Lakeshore Drive, St. Joseph, Michigan.

[10]M. M. Miller, et al., "A Principles Study of Factors Affecting the Hydrological Balance of the Lemon-Ptarmigan Glacier System, S. E. Alaska, 1965-1969," Institute of Water Research, Tech. Report 33, Michigan State University, 1972.

reasonable background information on the events that have taken place in the last 150 years.

The flow of events that have occurred over the most recent period of erosion, 1968 to the present, points to one major flaw in our system of shore development and management. Each entity, whether private property owner or government agency, has operated in a vacuum without regard to integrating shore protection activities. Some cooperation was undertaken on the Highway Department's protective works project, but this was more a matter of agreement by the private owners to let the State of Michigan and the Federal Highway Administration pay for protecting private property under the guise of protecting the endangered roadway. Likewise some cooperation and pooling of efforts were undertaken by private owners in a few cases when contiguous structures happened to be built simultaneously.

The larger-magnitude and longer-term erosion management effort which should integrate the entire shore protection effort in some logical manner has been <u>totally lacking</u>. Without an integrated or coordinated approach each property owner, whether the city or private individual,

is faced with stop-gap solutions, a "bandaid" approach as one private owner has called them.

From the flow of physical events in this chronology several interesting conclusions can be drawn. The overall influence of the two piers built in the 1860's was not felt until 1917 when the City of St. Joseph took their first remedial, protective action. Part of the reason for this can be attributed to the length of the piers in relation to the zone of active littoral drift. The zone of drift was probably not completely blocked by the piers until their final completion in 1904. It is interesting to note that the highest water recorded on the lakes occurred in 1886 at a stage only a fraction of a foot higher than the stage of 1972. Given adequate littoral drift and sediment for off-shore bars there were no reported damages during the 1886 high stage.

By 1929 the Chesapeake and Ohio Railroad Company had to in turn take remedial action to protect their tracks. This was in a span of only little more than a decade. By 1949 the Michigan Department of State Highways had to take measures to protect the Red Arrow Highway. And by 1952 many of the private citizens along the shore

began to be affected by the entrapment of littoral drift material by the federal structures and by updrift neighboring structures. In this latest high water episode nearly every owner within the "shadow" of the federal structures suffered extensive damages.

From interpretation of this chronology it is equally evident that the federal government is reluctant to take any responsibility for their actions. Both the Corps of Engineers and the Small Business Administration (SBA), the latter having no real "reputation" at stake as does the Corps, have merely given the private riparian owner the "short end of the stick." This is the consequence of the Corps' failure to implement the Rivers and Harbors Act of 1968, Section 111, to its fullest extent, i.e., to begin to repair the damages resulting from the federal works; and it is also a consequence of the SBA not supporting the urgent requests for low-interest loans to repair damage to homes. For whatever reason lack of federal action[11] has allowed erosion to continue without even token efforts at remedy.

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[11]At the time of this writing legislation is pending both in the Michigan Legislature and the Federal Congress to implement procedures for funding erosion damage repair at St. Joseph, Michigan.

CHAPTER IV

PHYSICAL ANALYSIS OF THE EROSION PROBLEM AT ST. JOSEPH

Background

The five mile reach of shoreline comprising the study area at St. Joseph, Michigan represents only a small segment of the total beach around the lower peninsula of the State that has been influenced by eustatic fluctuations in Lake Michigan-Huron. This segment, however, is one of the most critical locations on the entire coastline as far as erosion damages are concerned.

From the geologic viewpoint the physical causes for the erosion problem have a range in magnitude from large regional isostatic crustal movements called rebound, to small magnitude adjustments in the beach profile. While the geomorphic processes in evidence on the beach are the active causal agents for erosion, the meteorological and hydrologic factors affecting water stages and providing

the principal energy sources for erosion are equally involved. The hydrology of the Great Lakes system is regulated by gated works and has been altered by diversions of water both to and from the Great Lakes watershed. Divisions and regulation of levels and flows have been cited as causal factors contributing to erosion damages.

Engineering works have been erected for harbor protection and to protect shore areas often with total disregard for the other physical parameters involved or the long-term effects of these structures. As a result, structures along the shore have been blamed for a large share of the erosion damages.

This chapter describes the various underlying physical factors influencing the erosion problem at St. Joseph. The discussion by virtue of the magnitude of the Great Lakes system necessitates a review of factors outside the immediate geographical vicinity of St. Joseph.

It is most important for the engineer, lawyer, and riparian owner alike to be apprised of what are the underlying geologic causal factors, what has been tried before in terms of engineering works, and from the legal standpoint what the basic facts are concerning cause and effect

relationships. From the point of view of the property owner it is critical that he understand what can realistically be accomplished in a low cost erosion management program. Larger, more comprehensive erosion management programs must be undertaken and often must be precipitated by concerted citizen legal action. There are several legal avenues open to the riparian owner seeking to initiate suits for erosion damages or to force governmental action to provide more comprehensive erosion management. Legal counsel for these citizens, therefore, must be familiar with the physical (geological) systems in order to develop a factual basis for possible court action. The engineer too has been intimately involved in providing designs and supervision of construction of both public and private protective works often without an adequate working knowledge of the full scope of the geologic problem. This chapter is aimed at providing the background information on the geologic and engineering aspects of the erosion problem for all involved parties.

One of the most beneficial outcomes of the analysis of physical factors controlling erosion should be the

understanding gained by all parties as to the true scope of the problem. In turn, this should allow the concerned citizen, riparian owner, lawyer and professional alike to view the long-term erosion management goals in their proper perspective.

Geologic History

The recent geologic history (i.e., the past 10,000 years, Figure 7) of the Great Lakes, especially in the upper lakes, has followed a sequence of general lowering of lake levels in relation to the land surface. The lowering of the levels is the result of two factors: first, the upwarping or rebounding of the land surface subsequent to the removal of the weight of glacial ice; and second, the subsequent gradual downcutting and lowering of the outlets of the upper lakes through the various post-glacial outlets. The St. Clair River at Port Huron is the natural outlet presently controlling lake stages for the Lake Michigan-Huron system.

The geomorphology along the shores of the lakes provides a record of this gradual lowering effect.

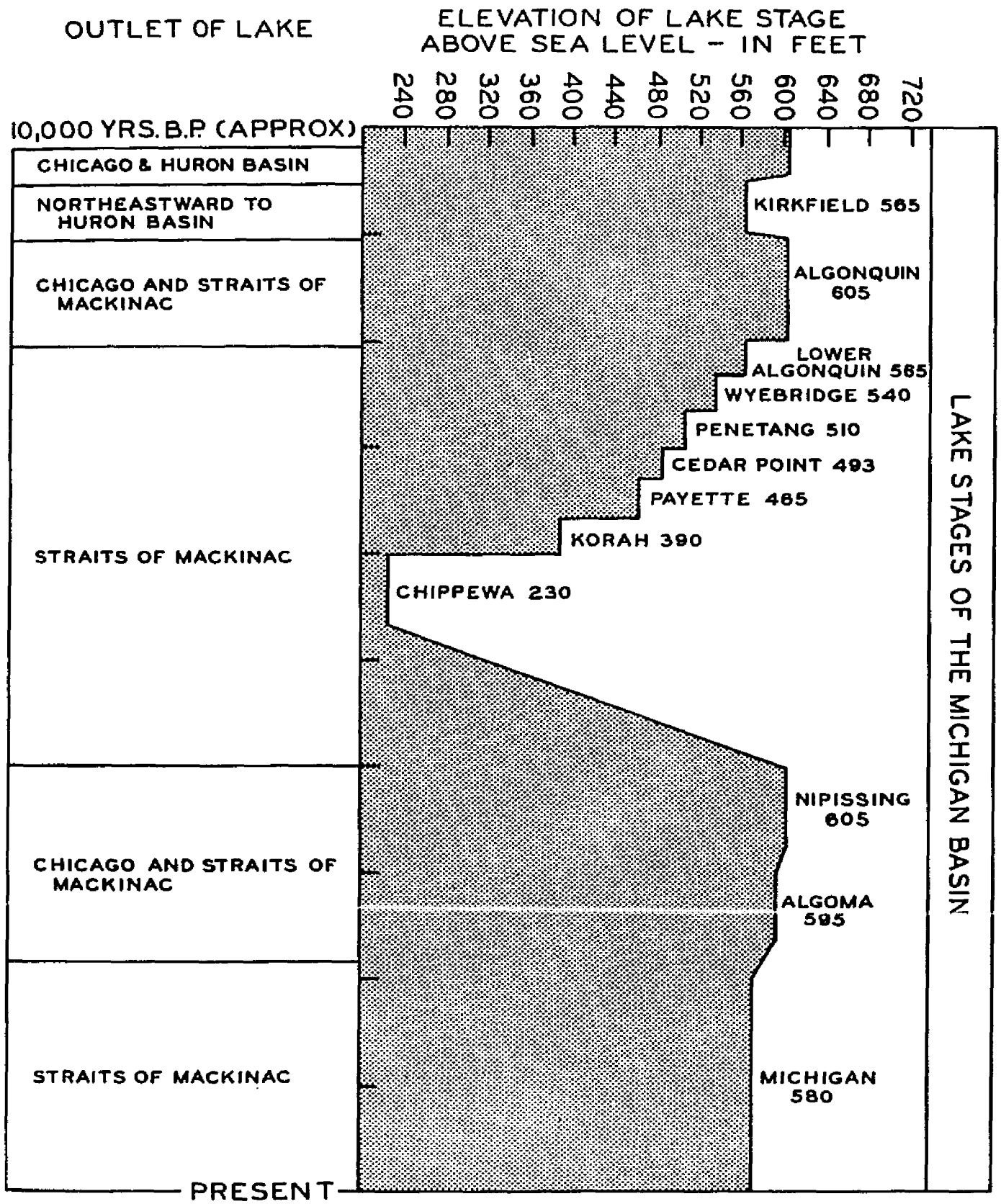

Fig. 7.--Lake stages in the Great Lakes basin during the past 10,000 years, modified from Hough (1958).

Abandoned beach terraces which delimit ancient shorelines are found on upland areas from elevations only a few feet to more than 200 feet above modern lake stages. The presence of abandoned beach ridges at various elevations on these terraces gives evidence that period fluctuations in the levels of the lake have occurred at intervals since the formation of the incipient glacial Great Lakes 10,000 years ago during deglaciation, Figure 7. These beach ridges were formed at high water periods when storm waves and winter ice push piled beach sediment into mounds several feet above the lake stage at that time. In the succeeding years uplift of the land and lowering of the outlets caused a general lowering of lake levels to a new stage. Whereupon storms and winter ice formed other ridges at these somewhat lower stages.

Downcutting of one of the major Canadian postglacial outlets caused a rapid lowering to an extreme low water stage during what is called the Chippewa low water stage,[1] Figure 7. Crustal rebound, or tectonic uplift of

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[1] J. L. Hough, Geology of the Great Lakes (Urbana: University of Illinois Press, 1958), pp. 263-68.

the land as the result of deglaciation, closed this outlet and new lower level outlets were found. The lakes then filled to levels higher than those of the modern lakes and resumed a slower lowering rate. The rate of lowering of the most recent Great Lakes has slowed to a rate that has been calculated to be .03 feet per year since 1860.[2]

These inferences from the geologic record of higher level beaches put the overall geologic system of the Great Lakes into a time perspective. Over the span of the last 10,000 years the levels of the lakes have fluctuated through a range of several hundred feet, Figure 7. From the best geological evidence it can be determined that most of the more rapid lowering of lake stages has ceased. The crustal rebound has generally stabilized and down-cutting of outlet channels has either grounded on bed-rock or has been greatly reduced. Man's activity has aided this stabilization through the installation of regulatory works on the outlets. The most recent geologic history is

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[2]Gilbert C. Ropes, "Vertical Control of the Great Lakes," Proceedings of the American Society of Civil Engineers, Surveying and Mapping Division, April 1965, pp. 39-49.

a record of man's interaction with the natural systems. The present shore conditions are to a large degree the result of man's activities.

Shore Processes

The discussion of shore processes in this work is by necessity somewhat condensed. A number of excellent textbooks[3] and articles[4] on geomorphic processes in the shore environment are available should the reader wish more detail.

The littoral belt along seacoasts and large lakes encompasses geomorphic processes that are varied and among the most vigorous on the face of the earth, Figure 8. In the broadest sense these processes can be described as

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[3] C.A.M. King, Beaches and Coasts (London: Edward Arnold, Ltd., 1959); A. Guilcher, Coastal and Submarine Morphology (London: John Wiley & Sons, Inc., 1958); and A. Holmes, Principles of Physical Geology (2d ed.; New York: Ronald Press, 1965).

[4] P. Brunn, "Sea Level Rise As a Cause of Shore Erosion," J. Waterways Harbors Div., Am. Soc. Civil Engrs., Vol. 88, 1962, pp. 117-130; M. Schwartz, "Laboratory Study of Sea-Level Rise as a Cause of Shore Erosion," J. Geol., Vol. 73, No. 3, 1965, pp. 528-534.

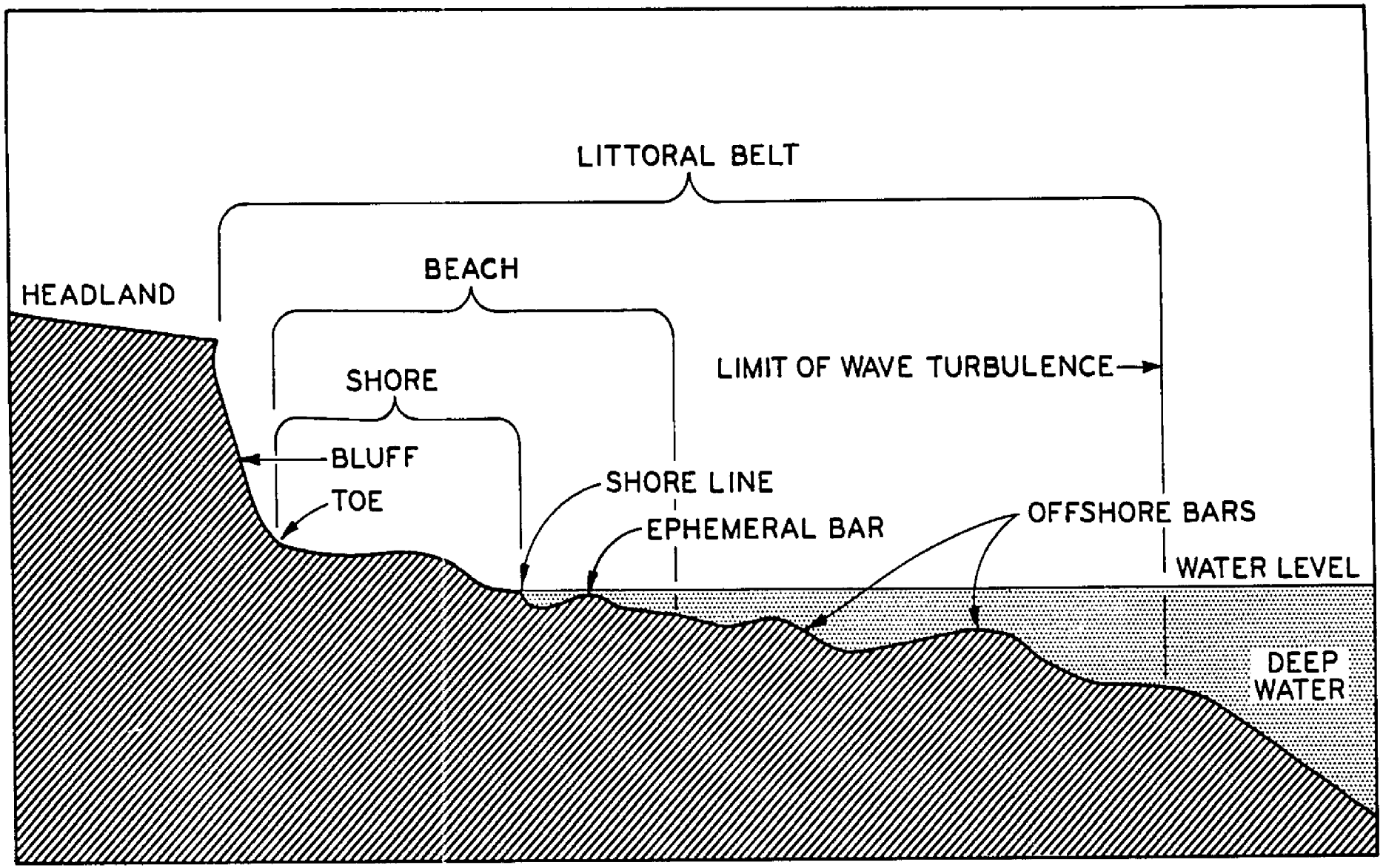

Fig. 8.--Terminology associated with geomorphic features in the littoral environment along a typical Great Lakes shore in the vicinity of the study area.

ones involving erosion transportation, and deposition, each aided by the motive forces of wind, waves and current. The littoral belt is the environment in which man's activities and efforts to live and to control the forces of nature are most dramatic. His confrontation is with the erosion-deposition and sediment transport system. A conceptualization of this system is again the process-response model for the littoral environment presented in Chapter II.

The terminology used to describe the various subunits within the littoral belt vary slightly among disciplines. Geologists frequently employ the term littoral belt to include the zone from the lower limit of wave-generated turbulence to the beach and continuing to the backshore sand dunes, beach ridges, cliff line, or bluff line, Figure 8.

The shore in the lacustrine environment is defined as the zone extending from the low water to the maximum swash line (the highest limit of wave run-up). The term coast is a loosely defined expression that includes the shore and the adjacent belt of land directly influenced by

it. The coastline is the boundary between water and dry land.[5]

The beach is defined as a shore consisting at least partly of unconsolidated material. The material is most often sand sized, but may be cobbles or shingles, which leads to the term cobble beach or shingle beach. Finer material in the clay size fraction when found on a beach leads to what is called a mud beach.

Along beaches composed of sand sized and larger material up to the maximum size capable of being moved by wave action, this sediment is carried shoreward to the limit of swash or wave run-up and seaward with the backwash as depicted in Figure 9a. Incoming waves are rarely parallel to the shore causing the motion of this sediment to

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[5]The term coastline in the geologic sense is the land-water boundary. The legal definition of Ordinary High Water Mark (OHWM) on the Great Lakes and Mean High Tide (MHT) on the seacoasts of the U.S. establishes the demarcation between private riparian ownership and public trust ownership by the State. The OHWM was set at the datum of 579.8 feet above mean sea level in Michigan on Lakes Michigan-Huron by the Submerged Lands Act (Act 247 of the Michigan Public Acts of 1955). The 579.8 feet elevation is the demarcation line for boundary purposes in the St. Joseph area. Mean high tide along tidal coasts of the U.S. is determined by accurate tidal gauging by the National Ocean Survey (NOS). In Florida, for example, the NOS surveys are being undertaken to firmly establish the limits of private and public ownership defined by the MHT line.

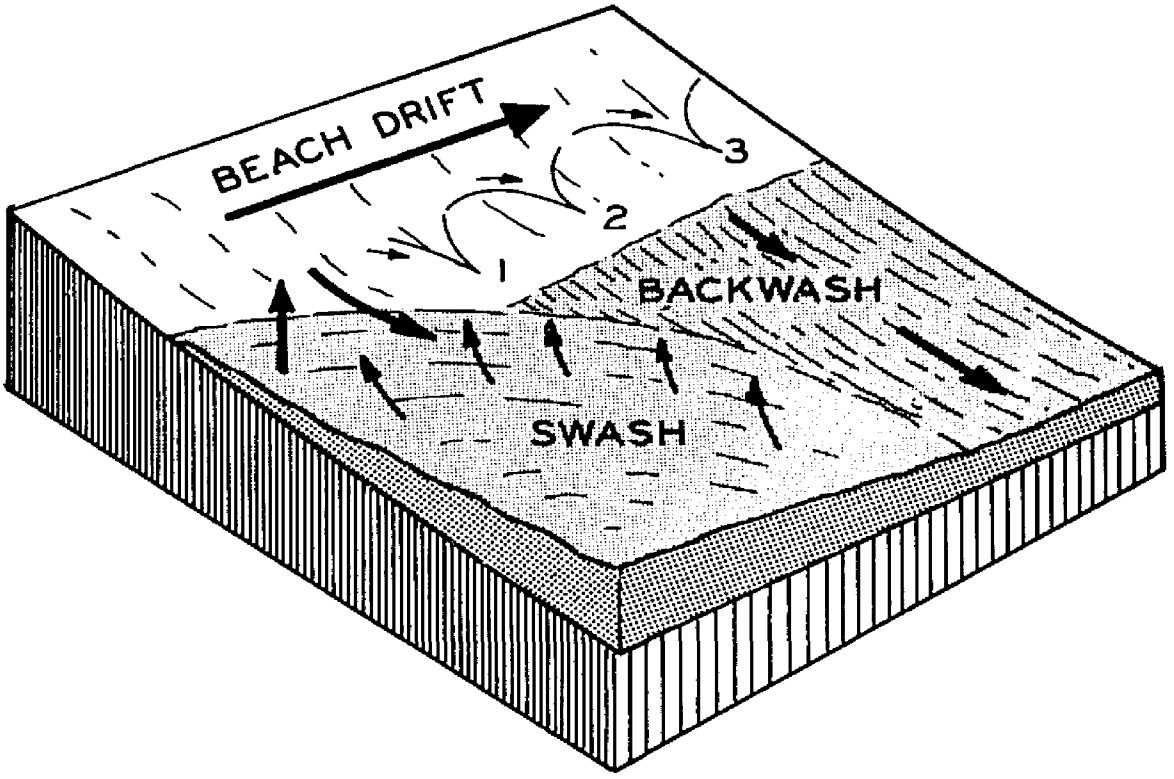

Fig. 9a.--Movement of sediment by beach drift, diagram modified from Strahler (1960).

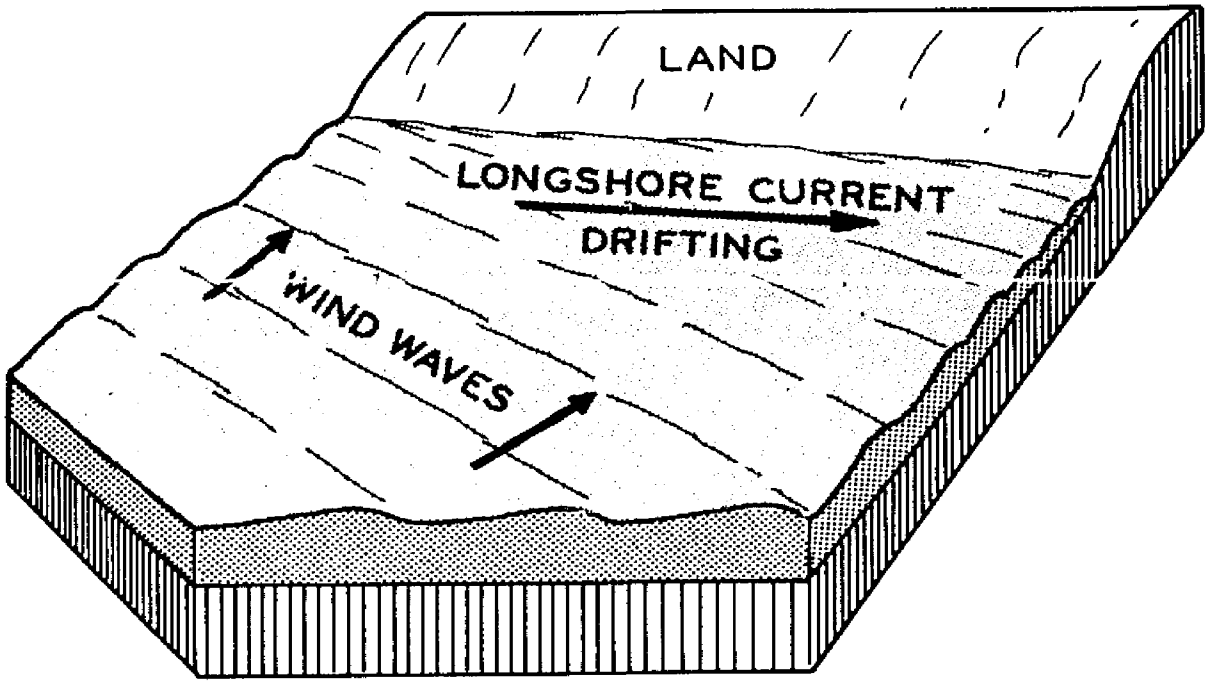

Fig. 9b.--Littoral drift or longshore drift of sediment in the littoral belt, diagram modified from Strahler (1960).

follow a zig-zag path up and down the beach, Figure 9a. The result is what is known as beach drift, which is defined more specifically as the slow net movement of material in the swash zone away from in-coming waves. Wave direction is a function of wind directions. Beach drift occurs during all wave energy conditions from mild ripples to storm waves.

This same general process occurs offshore in the zone of wave turbulence beginning at the point where waves begin shoaling and is referred to as longshore or littoral drift, Figure 9b. Strictly defined longshore drift refers to the wind generated longshore current. Littoral drift is the process of sediment movement. In general usage no distinction is made between longshore drift or littoral drift and they are often used interchangeably. The best estimates indicate that littoral drift is confined almost exclusively to periods of high wave energy and turbulence. Brater and Seibel[6] state that 90 percent of all movement or displacement of littoral material occurs during the two

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[6] An Engineering Study of Great Lakes Shore Erosion in the Lower Peninsula of Michigan, Water Resources Commission, Department of Natural Resources, 1973, p. 4.

or three largest storms on the Great Lakes over a three year period. Because the storms that are most responsible for littoral transport occur during the fall, winter and spring months when weather patterns move in from the northwest, the predominant direction of the longshore drift on Michigan's west coast (e.g., in the St. Joseph area) is to the south.

On the Great Lakes[7] longitudinal offshore bars occur on the bottom profile from the edge of the swash zone to a distance of up to 1,000 feet off shore, depending upon the bottom slope angle and water depth. The ephemeral bar is found near the edge of the swash zone while up to three other bars are found regularly spaced into deeper water at a depth of 15-18 feet. The maximum depth at which bars form is a function of the maximum wave height. Wave turbulence molds the littoral sediment into the ridge-like shapes of the offshore bars, Figure 8.

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[7]According to C.A.M. King in Beaches and Coasts at p. 333: "Submarine bars are best developed where tidal range is small such as in the Mediterranean Sea and the Great Lakes of North America."

The process of erosion can be defined as a net loss in sediment, as in this case from a particular segment of beach. In the natural condition assuming relative "stability" in the long-duration geologic processes, erosion is often only temporal. The material removed is usually replaced later by deposition of material that has been transported along the beach in response to a wave and current action from updrift areas. This condition of dynamic stabilization where erosion is followed by deposition is called beach equilibrium.[8] Barring unusual offshore conditions such as natural or artificial barriers near shore, while the system is in equilibrium at a given water stage most littoral sediment remains in the littoral zone.

Under the equilibrium conditions of continuing static water levels, the profile of the beach will assume a stable configuration. For a shore composed of finer sediment and having steep backshore bluffs of unconsolidated

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[8] According to C. A. M. King in Beaches and Coasts at p. 328:

> The equilibrium gradient of any beach in nature is not a static slope but one which will be continually tending to adjust itself to the changing variables on which it depends . . . . (T)he equilibrium is a dynamic one, not a static one.

sediment such as those found at St. Joseph, the configuration of the littoral belt can be depicted as shown in Figure 8.

An equilibrium which is dynamic connotes the ability of the littoral environment as a total physical system to adjust to changes in the mass/energy input over time. Changes in the configuration of the waterland interface over long periods of time, such as have taken place during the gradual lowering of Great Lakes stages in the Holocene (i.e., the last 10,000 years or so of geologic history) give evidence of dynamic equilibrium conditions. In the short-term view of a few years, however, stable on-shore and off-shore configurations are quickly achieved under the state of dynamic equilibrium, barring significant interference from man's works.

Stage-Bar Relationship

On the beach built on unconsolidated sediment, as shown in Figure 10a, there develops a series of off-shore bars. The presence (or absence) of these bars in any shore

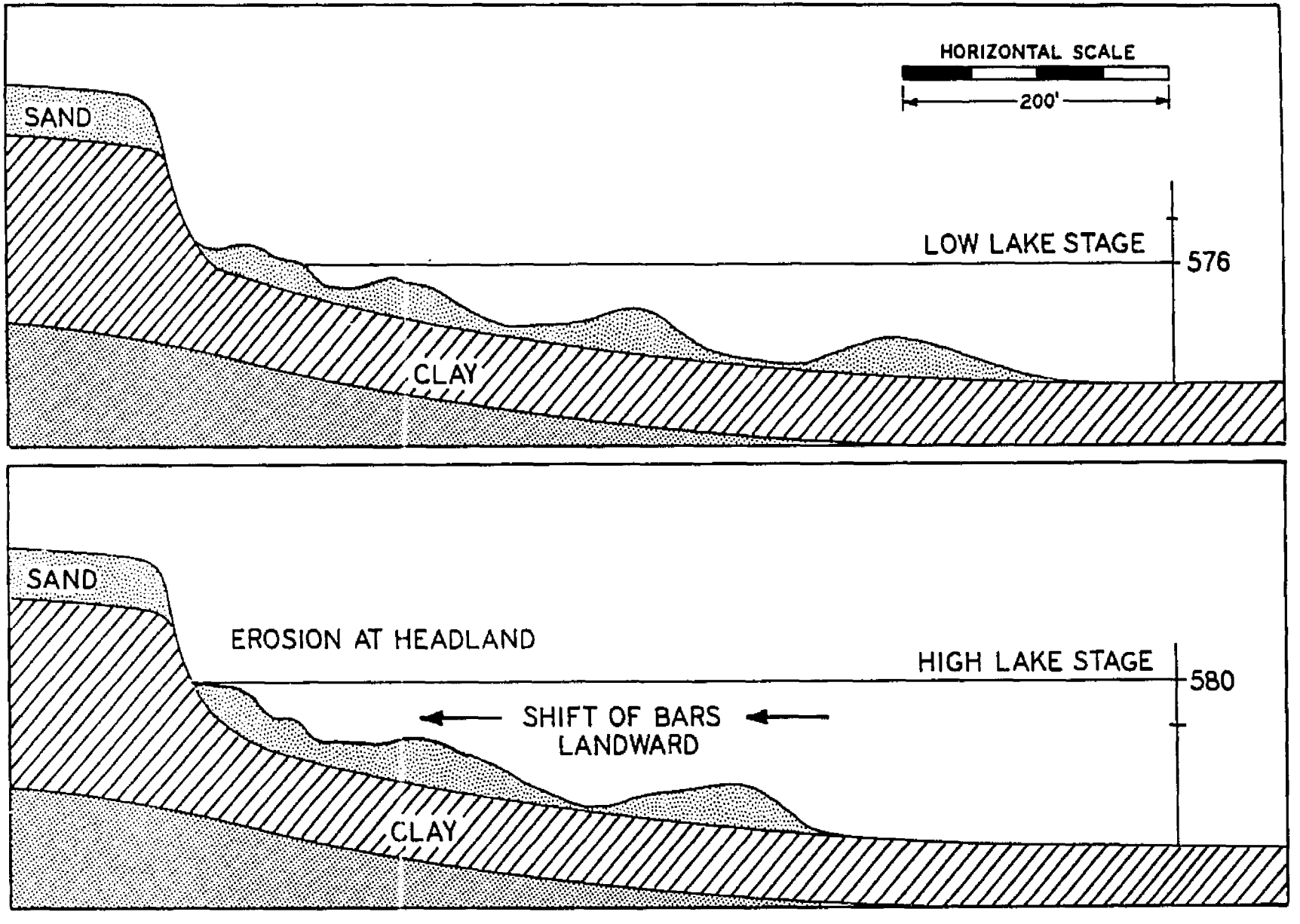

Fig. 10a (above).--Hypothetical stage-bar relationship at near equilibrium conditions at a low-water stage on the Great Lakes.

Fig. 10b (below).--Hypothetical stage-bar conditions depicted during rising stage. Note landward shifting of bars with subsequent erosion until equilibrium is again achieved.

system such as the one at St. Joseph is the factor controlling establishment of equilibrium conditions.

According to King, et al.,[9] when disequilibrium conditions are in evidence, accelerated erosion or deposition occurs on the beach until the off-shore bars shift and reform to new equilibrium positions. This means under lowering lake stages (aggrading conditions) the bars gradually move to positions farther offshore and conversely they move inshore under conditions of rising stages, (degrading conditions) Figure 10b. During the recession of water levels little or no headland erosion is apparent and a widening of the beach is the only visible geomorphic change. Beneath the water, however, the off-shore migration of bars to their new equilibrium positions occurs, Figure 10a.

Under degrading conditions there is a reduction in beach width accompanied by a shoreward migration of the off-shore bars, Figure 10b. When the peak stage is reached headland erosion provides some additional sediment for the beach and offshore bars. It is important to note that

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[9]Notes 3 and 4 supra.

this erosion replaces sediment lost to deep water during the previous low stage.

This basic concept elucidated by Holmes[10] for eustatic changes in sea level has been shown to be equally operative in the Great Lakes system by Davis,[11] Schwartz,[12] Saylor and Hands,[13] and Larson[14] in their considerations of aperiodic fluctuations in lake stage.

Offshore bars play a key role in establishing the equilibrium conditions through the manner in which they dissipate wave energy. Wave energy is actually a function of wave height. In turn wave height is a function of wind

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[10] Principles of Physical Geology (2d ed.; New York: Ronald Press, 1965).

[11] "Sedimentation in the Nearshore Environment, Southeastern Lake Michigan," (unpublished Ph.D. dissertation, University of Illinois), p. 131.

[12] "The Bruun Theory of Sea Level Rise as a Cause of Shore Erosion," Jour. Geol., Vol. 75, No. 1, 1966, pp. 76-92; "The Scale of Shore Erosion," Jour. Geol., Vol. 76, No. 3, 1967, pp. 356-363.

[13] "Properties of Longshore Bars in the Great Lakes," Proceedings of the Twelfth Coastal Engineering Conference, Washington, D. C., September, 1970.

[14] The Cultural Variable in Shore Erosion Along the Illinois Shore of Lake Michigan (Chicago: Lake Michigan Federation, December, 1972).

velocity and length of fetch, the fetch being the distance of wave build-up over open water. Maximum fetches range from 70 to 100 miles across Lake Michigan and over this distance a wind of 30 knots blowing for seven hours can produce approximately five-foot waves in deep water. A 40 knot wind for the same duration can produce waves 14 feet in height.[15] Shoaling begins when the lower limit of wave turbulence encounters the bottom. The offshore bar, therefore, acts as a wave energy dissipator by causing these incoming waves to begin breaking or shoaling before they impinge against the beach.

In the natural situation of rising water levels, the point at which waves begin breaking will be shifted landward allowing more wave energy to reach the beach with the result being erosion of the beach or headland. Once the sediment resulting from this erosion rebuilds the offshore bars to a sufficient height wave energy is again largely dissipated offshore from the beach. The beach equilibrium condition is reached when the offshore bars are rebuilt, (aggraded) to meet the new stage conditions.

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[15] Note 6 supra.

In this situation, erosion (degrading) of the headland has ceased or occurs only at times of abnormal storms.

Sediment in littoral transit (drift) is the continuing source of the material needed for bar reformation. In order to maintain a natural state of dynamic equilibrium there must be a near constant volume of sediment in active transit along the shore. Natural or man-made barriers to the natural flow of sediment reduce the height of bars downdrift with the result that less energy dissipates there and erosion at the beach or headland must continue to compensate for these losses. This erosion will continue until equilibrium conditions are achieved.

Natural barriers to littoral sediment may include such features as bedrock points, fallen trees or deep water close to shore such as a trench or canyon. Most natural barriers are accommodated rather quickly by the system, as in the case of trees. Major natural impediments to sediment movement have forced reformation of coastlines over time. In general, the littoral system is probably in near equilibrium condition and if left to evolve unincumbered by man's works it will remain so.

Man-made structures are equally if not more effective barriers to sediment flow than any natural impedence. Structures such as harbor mouth jetties, piers or breakwaters and groins are man-made barriers to littoral movement. Bulkheads that retain a section of beach and which prevent sediment nourishment from the upland are also important interruptors of natural sediment replenishment.

The shoreline at St. Joseph has many artificial structures that are effective barriers to natural sediment movement and replenishment as can be observed in Figure 5 and Photo Map 1. The harbor structures at the mouth of the St. Joseph River provide an especially effective barrier to littoral drift. Over the years the resultant downdrift erosion at times of high water had led to further protective works being built in the sediment shadow area, Figures 11 and 12a. These smaller works have in turn produced their own sediment shadows.

Erosion in the sediment shadow area, once initiated, will continue until equilibrium conditions are achieved. Unfortunately, however, this equilibrium condition will never be achieved in the present state of the system. Where all or most of the sediment flow is blocked by the

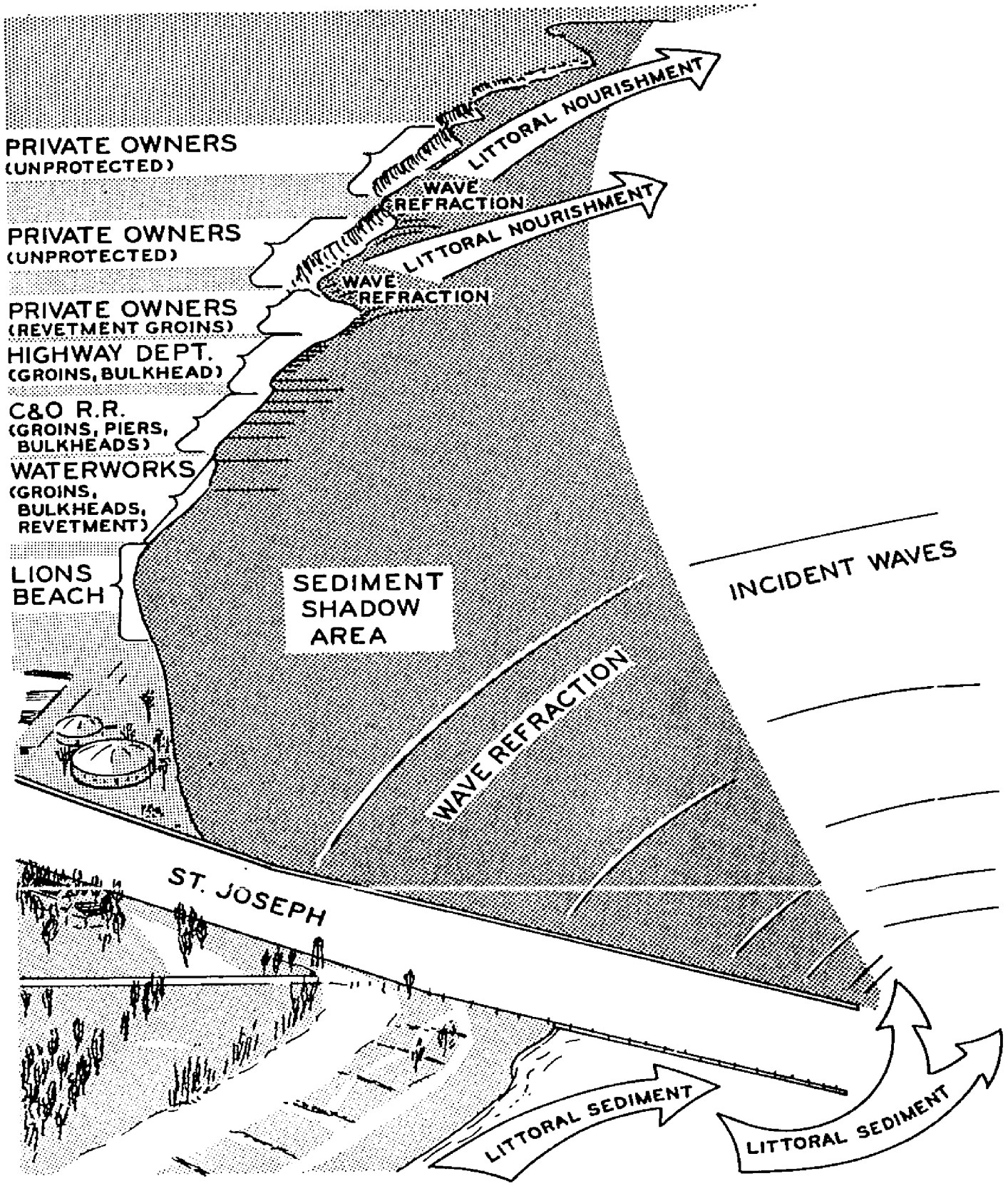
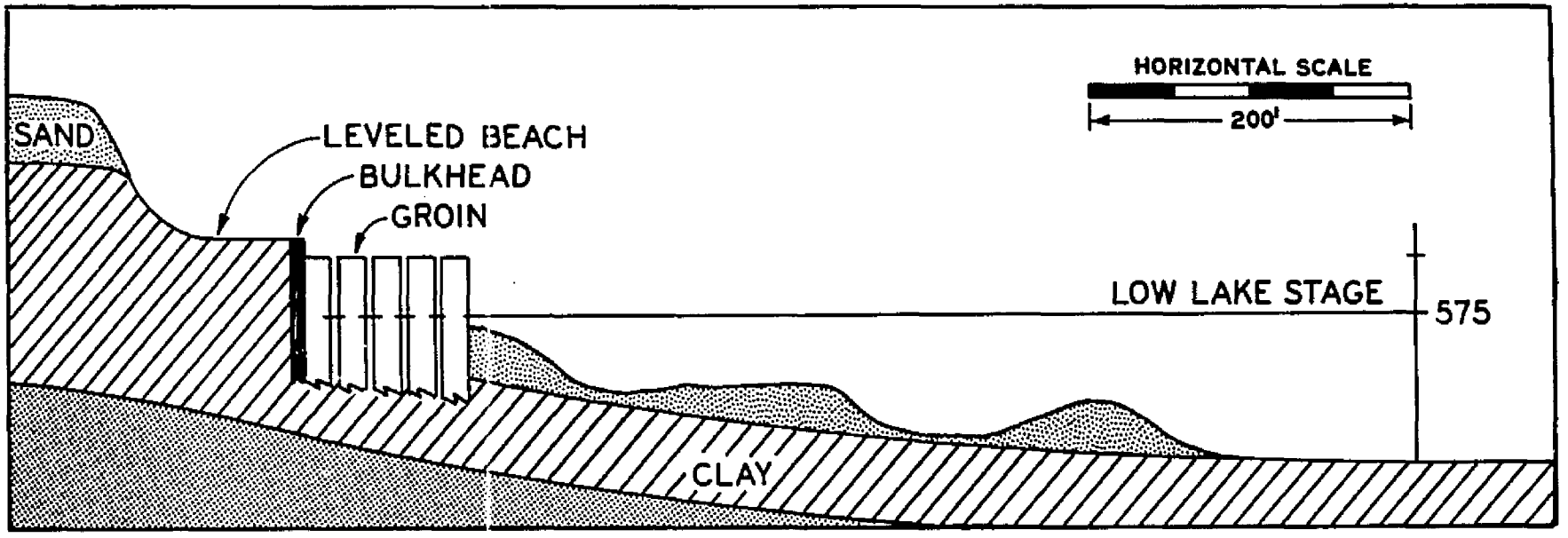


Fig. 11.--A conceptualization of the littoral system at St. Joseph, Michigan as sketched from the photo view in Figure 5. Top of diagram is south.



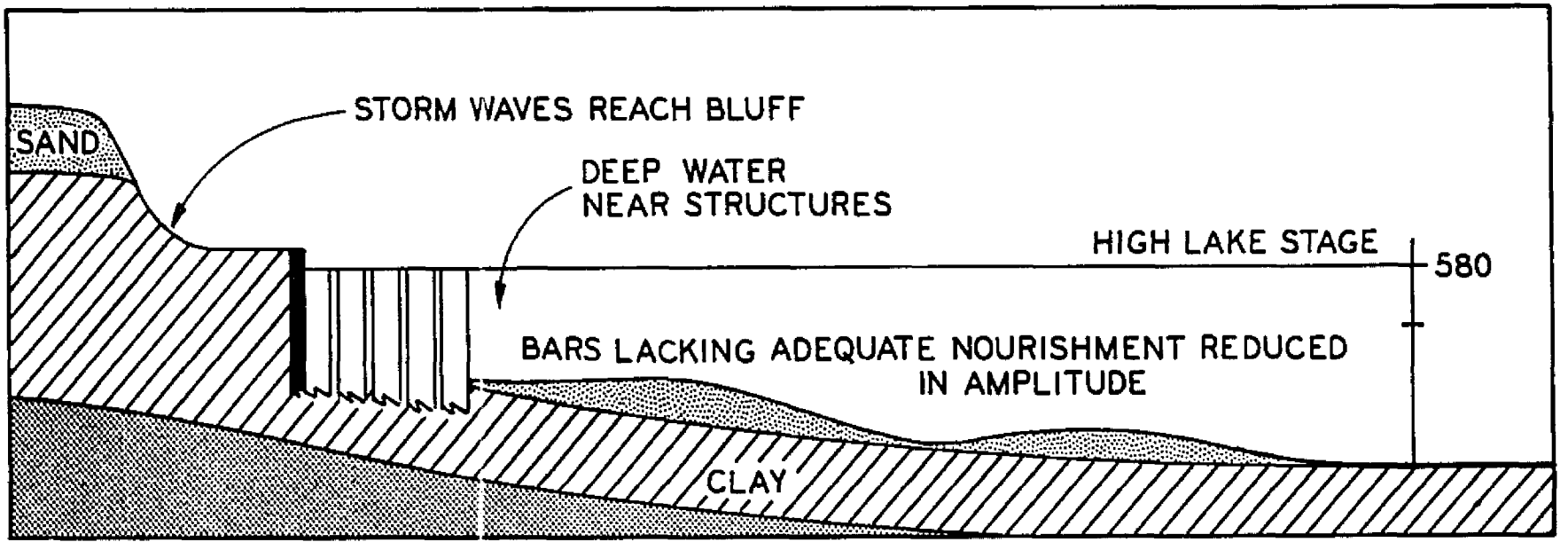


Fig. 12a (above).--Schematic representation of the stage-bar conditions on a structurally altered shore at a low-lake stage.

Fig. 12b (below).--Schematic representation of the stage-bar conditions on a structurally altered shore at a high lake stage.

federal harbor piers, the system will strive toward equilibrium by removing material in the sediment shadow area through erosion. Blocked by bulkheads and other protective works, the system remains highly unstable. Deep water occurs farther inshore in the absence of the natural bars, Figure 12b. Thus, greater wave energy is transmitted to the beach and beyond to the headland. The presence of vertical bulkheads against which water smashes adds to the greater turbulence at the land-water interface. Depths as much as 15 feet have been measured off steel pilings that were originally driven in water 2-3 feet deep, Figure 12b. Sheet piling 20 feet long has been bent and demolished by storm waves shortly after its installation at the City waterworks in St. Joseph in the spring of 1973. Here, extreme turbulence at the bulkhead formed deep water (15 feet) at which time the piling was easily bent and uprooted by the waves. Similar in-shore water depths have been measured off all the other bulkhead structures along the St. Joseph shore.

The stage-bar relationship for bulkhead and groin protected shores is presented in Figures 12a and 12b. In this situation deep water affects inshore areas and the

increased turbulence moves a greater amount of sediment to deeper water. This results in further deeping of the near-shore water which in turn intensifies the erosion during succeeding storms. The natural bar, as the significant self-regulating element in the system, at this point has completely broken down. At the present time this is the condition of the littoral system at St. Joseph. Other shore segments on the Great Lakes are in comparable stages of system degeneration.

The Process-Response Model at St. Joseph

The physical conditions along the shore in the vicinity of St. Joseph can be described by a conceptual process-response model. This conceptual model provides the mechanism for testing long-term erosion control measures and, more importantly, in this study it provides the factual basis for legal arguments. The model itself can be best illustrated by the sketch in Figure 11, which is an artist's rendering of the shoreline at St. Joseph with the significant modular factors depicted.

The federal piers protecting the St. Joseph harbor entrance are the single major hindrance to the natural system about which all other small magnitude process-response interactions have evolved. The piers have completely stopped the flow of natural beach sediment in the littoral zone. South from the piers there exists a sediment shadow zone which extends southward an undetermined distance. The southward extent of the sediment shadow (at St. Joseph) is a function of the amount of sediment returned to the system by erosion of the headland. It is probable that the full response effects from the elimination of littoral sediment extend well past the limits of the study area.

The accretion of sediment on the north side of the piers has diverted sediment father off shore to the point where a portion of this material is being lost to deep water. This is depicted by the arrows in Figure 11. While no field data supports this assumption, probably little if any sand-sized material reaches the south side of the piers. The loss of sediment, in general, has caused the offshore bars to be destroyed or disrupted to the extent that no regular bar patterns are now present close to the pier structures. Bathymetric maps show a chaotic pattern of

bar segments cut by rip-channels.[16] Other researchers, most notably Edith McKee, believe this disruption of deeper water bars immediately south of the piers is caused by wave front refraction around the piers. The resultant wave turbulence in turn produces the chaotic bar patterns, Figure 11.

In response to this reduction in the off-shore bars and the degrading of the bottom profile, accelerated erosion began affecting developed shore segments south of the piers. The immediate action of shore owners was to erect shoreline structures such as groins and bulkheads. This has been documented earlier in the historical sequence of events. Each of these structures placed along the shore eventually produced unnatural effects on neighboring down drift segments. The process by which shoreward erosion introduces replacement sediment to the system was then being regulated by the groins and bulkheads. In consequence deep water formed at the shore and caused groins and piers to be lengthened, trapping more sediment. The lakeward projecting structures at the beach also changed

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[16]Personal communication with Edith McKee, Certified Professional Geologist.

the angle of wave advance immediately south of these structures. Refraction of these waves resulted in "break-back" or "flanking" of the structures. This smaller magnitude process and the response interaction is depicted in Figure 13.

The sequence of erosion, structural protection and flanking proceeded southward, shore segment by shore segment to the present state. The shoreline in the study area at this time is a nearly continuous line of protective structures with the exception of two rather short segments, Figure 11.

The preceding narrative interpretation of Figure 11 points to three actual shore processes that have been modified by structural works, littoral sediment transport, angle of wave approach and natural erosion at the beach and headland. The response of the shore system has been directed toward resumption of a more stable, equilibrium shore configuration. Sediment has accumulated on the updrift side of major structures. But the lack of sediment has changed the offshore profile, the response again being erosion at the headland. The change in angular relationships of advancing wave fronts at the harbor piers, the

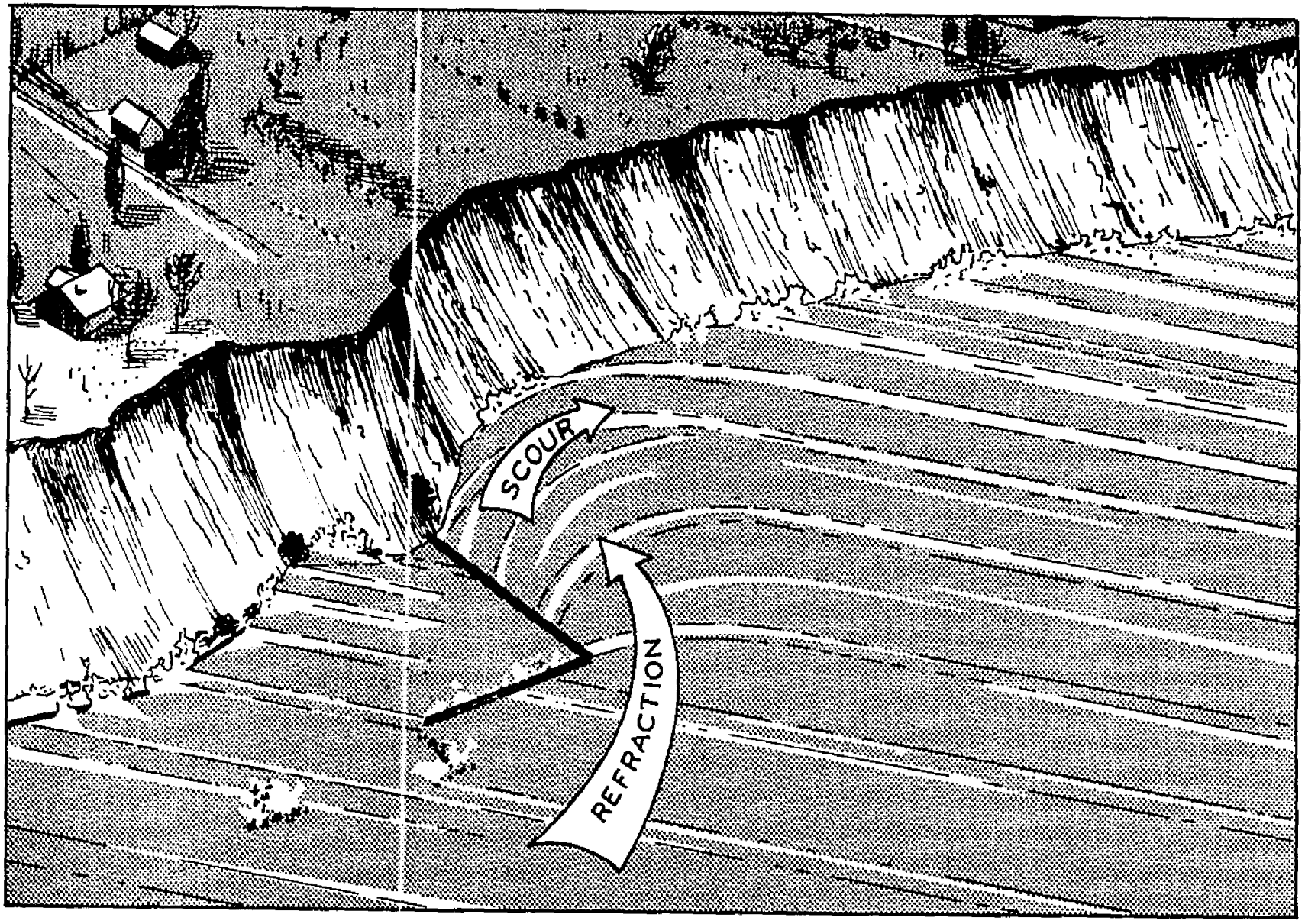

Fig. 13.--Simplified illustration showing process-response model with destruction of the littoral system by structures. Breakback or flanking greatly accelerates the erosion rate on the downdrift side of the installed structure.

many individual jetties and piers, and at protected promentories has caused turbulence and erosion to destroy offshore bars and to rapidly erode the flanks of protective structures.

Hydrometeorologic Aspects

The fluctuations in the levels and outflows and the incidence of storm conditions on the Great Lakes watershed are a function of the hydrologic and meteorologic factors. As discussed earlier, changes in lake levels lead to periods of intense erosion. Storm conditions generate the high energy waves that are the precipitators of specific erosion damages. Involved here are the disciplines of meteorology, as the science dealing with the atmosphere and the movement of water as vapor and as liquid in the air, and hydrology as a division of earth science concerned with the distribution of water on the earth's surface and beneath. The fluctuations in the levels or stages of the Great Lakes are aspects of the hydrology of the Great Lakes watershed while the causal factors of specific periods of

intense coastal erosion are aspects of fundamental meteorologic concern.

Long-Term and Seasonal Stage Fluctuations

The period of record from 1860, when gauging of the lake stages began, to the present involved continuous measurements of the combined effects of both seasonal and long term variations in lake level. The primary factors which control the longer period fluctuations of the levels of each lake are meteorologic and climatologic in their origin. Periods of below average precipitation coupled with hot dry summers produce high evaporation rates. These periods are followed by corresponding low water stages on the lakes. Higher than average precipitation combined with cool cloudy summers correspondingly produce periods of high water stage. Over periods of years in which several dry years occur in succession, the net effect on the levels in the lakes can be cumulative. The plot of the Lake Michigan-Huron stage for the period of record (1866-1973) in Figure 14 illustrates the nature and character of long-term fluctuations. As can be seen on the plot of the mean,

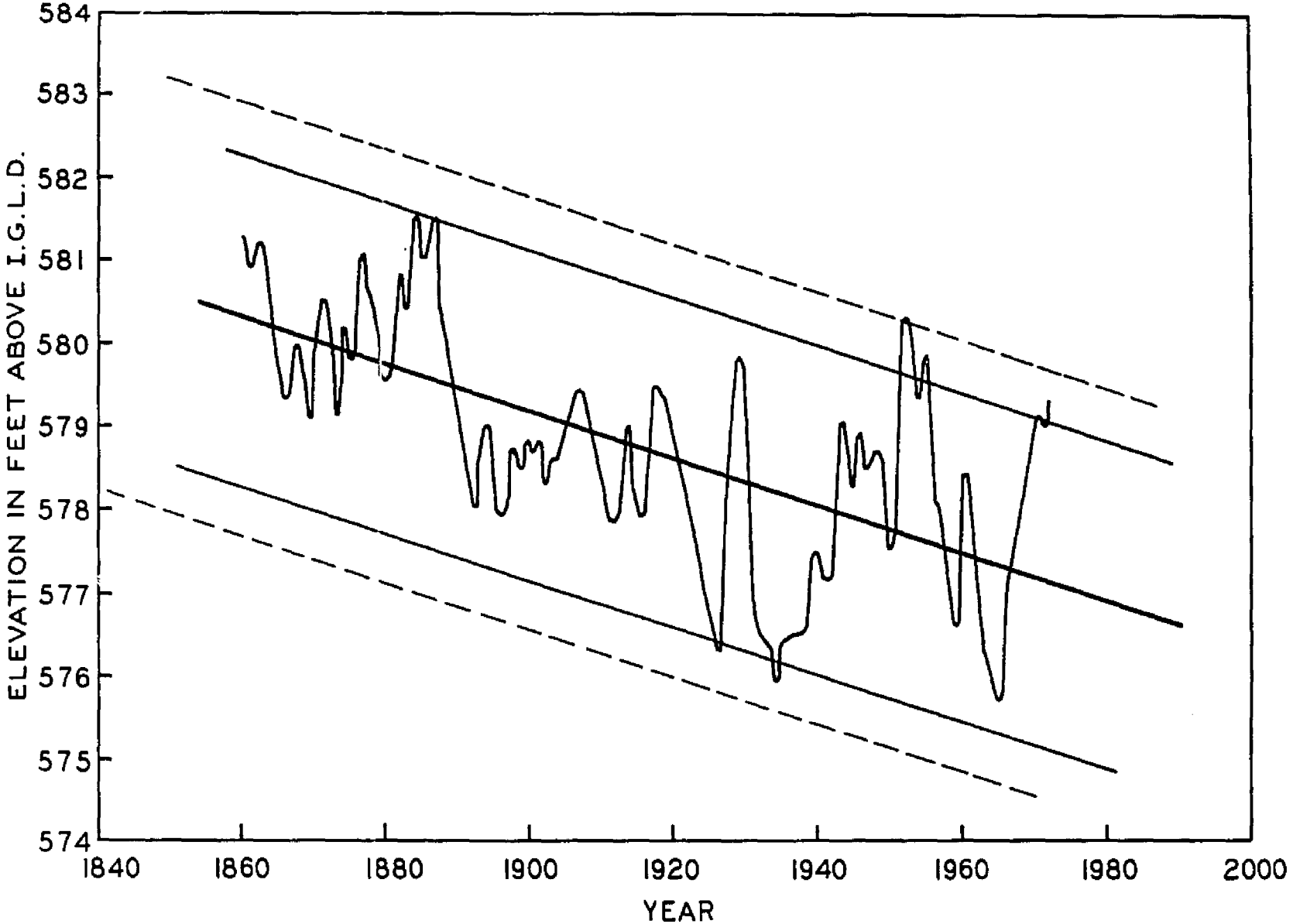

Fig. 14.--Lake Michigan-Huron stages for the period of record 1860-1973 with the 0.03 ft. per year observed lowering trend applied to the data points, diagram modified from Larson (1972).

annual lake levels in this figure over the period of record the most recent high water periods occurred in 1952-53 and in 1969-present, but the record is marked by other high and low stages which have occurred in an aperiodic frequency. Peak highs have occurred roughly every 15-25 years.

On an annual basis seasonal fluctuations in the levels of the lakes follow the general pattern of high stages in the summer resulting from spring rains and snowmelt and low stages in the fall resulting from the generally drier conditions and increased evaporation through the summer months. From year to year the amplitude of the fluctuation is quite variable depending upon short-term meteorologic factors but, in general, the seasonal pattern remains consistent.[17]

Short-Term Variations in Lake Levels

While both long-term and seasonal fluctuations in lake levels are the underlying cause of high water erosion,

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[17] Water Levels on the Great Lakes, Report on Lake Regulation, Appendix A, Hydraulics and Hydrology, Detroit District, 1965.

the meteorologic processes associated with short-term fluctuations lead to greatest changes in the beach environment. According to the studies completed by Seibel[18] and Fox and Davis,[19] as much as 90 percent of all changes in the profile of the foreshore, beach and offshore bottom occurs during storm conditions. A fair estimate would be that 90 percent of the total changes in the upland, beach and offshore profiles occur during one percent of the time.

Short-term variations in the levels of the lakes are independent of both long-term or seasonal variations and the volume of water in the lakes and can be related directly to local or regional meteorological phenomena. During the periods of short-term variation surface water is moved in response to barometric pressures and wind. Wind-driven waves tend to raise levels along windward shores especially in narrow bays where the effects are

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[18] "Shore Erosion at Selected Sites on Lake Michigan and Lake Huron" (unpublished Ph.D. dissertation, University of Michigan, 1972).

[19] Computer Simulation Model of Coastal Processes in Eastern Lake Michigan, Tech. Report No. 5, Williamstown, Mass., Williams College.

focused and magnified. Along leeward shores a corresponding lowering of levels occurs. This mass transfer of surface water is equalized during prolonged storms by subsurface return.[20]

Short period oscillations which are produced by meteorological forces such as wind or barometric pressure and whose periods are longer than those of surface waves are frequently referred to as a "seiche." A seiche condition may result in the temporary raising and lowering of lake levels with an amplitude of up to 8.4 feet.[21] Seiche conditions have been termed wind tides by some researchers.

During a seiche condition wave run-up can often reach extremely high upland areas causing erosion and damage to property that shore owners initially considered safe from such attack. It is during periods of extreme high lake stages and under seiche or wind tide conditions that waves have their greatest effect on upland property. This present period of high lake levels has focused public

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[20] Note 1 supra p. 44.

[21] The maximum temporary rises have been measured at 8.4 feet on Lake Erie and 2.5 feet on Lake Huron according to Hough, p. 44, Note 1 supra.

attention on two areas of the state where damages have been costly. Shore owners along Lake Erie have been faced with flooding when winds drive lake water inland along distance of flat-lying shores. Likewise, along the eastern shore of Lake Michigan, especially where high bluffs which are susceptible to undercutting and erosion are found as in the vicinity of St. Joseph, wind driven waves reach unprotected bluffs in spite of protective works.

Two recent studies on Lake Michigan have pointed at the short-term wind-generated set-up, (i.e., tilting of water in the lake basin) in the lake system as the most significant factor causing short-term changes in beach environment. Fox and Davis[22] examined the influence of atmospheric pressure changes (i.e., frontal systems) on the rate of change of the beach profile while Seibel[23] used the frequency of low pressure cells. Seibel's work encompassed a 32-year span through the use of aerial photographs dating back to 1938 on which were measured the bluff-line migration rate. Bluff recession rates were correlated with

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[22]Note 19 supra.

[23]Note 18 supra.

low pressure conditions. The Fox and Davis study was for a shorter period of time (six years) and utilized on-site measurements of littoral conditions on a continuous basis during periods of both relative quiescence and storm activity. Seibel's work concluded that over the longer time spans erosion rates remain statistically uniform for long periods of time unless influenced by man-made structures. Larson's study[24] in Illinois supports the work of Seibel. The studies of Fox and Davis reported rapid adjustments in the beach and offshore zones during periods of high wave energy.[25]

Artificial Factors Affecting Stage

Man-made regulatory works, dredging for navigation, and water diversions both in to and out of the Great Lakes have modified the natural hydrology of the watershed significantly. The overall net changes in levels, however, are minimal. Gated regulatory works at Sault Ste. Marie

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[24]Note 14 supra.

[25]Note 19 supra.

control the level of Lake Superior by regulating outflow which in turn influences levels in the lower lakes. A diversion into Lake Superior of 5,000 cfs (cubic feet per second) from the Albany River basin through Long Lake and the Ogoki River has since 1938 increased the water supply flowing into the lower lakes at the Soo works.[26] During the extreme high water period over the years 1951, 1952, 1953 and again during the present peaks, an agreement with Canada secured a reduction in this diversion in an effort to ease the erosion problem. The net effect of the Long Lake-Ogoki diversion on the lower lakes is to raise the level +0.37 feet (4.5 inches) on Lake Michigan-Huron and +0.23 feet (2.75 inches) on Lake Erie, Table 1.

Water, however, has been diverted out of the Lake Michigan Basin into the Mississippi drainage system through Chicago since 1848. The City of Chicago by Supreme Court decree has been restricted to the amount of 3,200 cfs on an average basis for both domestic use, and direct diversion to maintain levels in the shipping and sanitary

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[26] Note 17 supra.

TABLE 1

SUMMARY OF ARTIFICIAL DIVERSIONS AND THEIR EFFECT ON LEVELS ON THE GREAT LAKES[a]

Diversion	Long Lake-Ogoki	Chicago	Welland Canal	Net Effects
Annual Rate	5,000cfs	3,100cfs	7,000cfs	
Lake Michigan -Huron	+0.37 foot or +4½ inches	-0.23 foot or -2-3/4 in.	-0.10 foot or -1¼ inches	+0.04 +½ inch
Lake Erie	+0.23 foot or +2-3/4 inches	-0.14 foot or -1-5/8 inches	-0.32 foot or -3-7/8 inches=	-0.23 2-3/4 inches

ULTIMATE EFFECTS OF EXISTING DIVERSION ON WATER LEVELS
(+) DIVERSION RAISES LEVEL OR (-) DIVERSION LOWERS LEVEL

[a]L. D. Kirshner, "Effects of Diversions on the Great Lakes," Miscellaneous Paper 68-7, U.S. Lake Survey, November 1968, p. 296.

canals. The famous court case[27] stemming from this diversion while gaining much notoriety had little basis in fact because it can be shown that the diversion at Chicago has minimal effect on lake levels due to the compensating effect of the Long Lake-Ogoki diversion into Lake Superior, Table 1.

Channel dredging in the St. Clair and Detroit Rivers has had the net effect of lowering the level 0.59 foot in the Michigan-Huron system.[28] However, preliminary Corps of Engineers plans to remedy this lowering by a system of sills placed in the channels are being developed at the present time.

The summary of all natural and artificial contributions to the levels of the Great Lakes is presented in Table 1.

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[27] 87 U. S. 1774-76, July 1, 1967.

[28] I. M. Korkigian, "Channel Changes in the St. Clair River since 1933," Proceedings of the American Society of Civil Engineers, Journal of the Waterways and Harbors Division, May 1963, pp. 3-8.

Engineering Aspects

The engineer has sought to provide harbors of refuge and centers for commerce on the Great Lakes and the seacoasts. The needs of waterborne commerce are met when river and bay mouths are protected from heavy seas and channels leading to safe anchorages are maintained to an adequate depth. While originally conceived as being a boost to the economy of the immediate vicinity, harbor works have in most instances wrought extremely high maintenance and secondary costs. The dredging which is used to maintain channel depths is a constant task involving constant cost. Additional secondary costs are those attributed to damages caused by the interruptions of littoral drift and erosion losses. The balancing of benefits and costs using the proper weighing of secondary benefits would probably show very few if any of the harbor structures on the Great Lakes to be beneficial from a cost-benefit standpoint. The costs of beach protection must be included as part of any harbor project. Most recently developed harbor projects take this aspect into account.

Beach protection can be brought about in several ways and may utilize both structural and nourishment techniques.[29] The structural methods that have been prescribed for many years by engineering texts are in two categories; those extending outward from shore and those constructed parallel with the shore.

Seaward or lakeward projections are commonly called groins or jetties, the latter being somewhat longer in length. Groins and jetties are usually constructed at a slight angle toward the prevailing incident waves. In the case of St. Joseph and other west Michigan locations they are usually oriented slightly to the north of west Photo Map 1. The primary function of the groin is to trap littoral sediment thereby building beach on the updrift side.[30] Rapid erosion on the downdrift side which is often referred to as flanking or break-back, will result if not adequately nourished on a continuing basis, Figure 13. For this reason, groin fields (multiple groins) are often used to

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[29] See generally, Shore Protection Guidelines, Department of the Army, Corps of Engineers, Washington, D. C., 1971.

[30] Ibid., p. 41.

protect a longer section of beach. Groin fields afford marginal protection at best in their own right so artificial fill for nourishment is usually recommended.[31] Filling will retard the formation of a sediment shadow downdrift from the structures. If nourishment is not undertaken or is not done on a regular basis, flanking proceeds rather quickly during high water conditions. The consequent entrapment of a portion of the littoral drift material therefore creates a temporary net loss to the littoral system.

The materials used for constructing groins or jetties may include natural stone, concrete, wood or steel. The permanency of any material type is a function of design and funds available for construction. While no "rule of thumb" exists the lower cost structures seem to be the least permanent.[32] However, many instances can be pointed out where expensive steel piling was destroyed rapidly

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[31] Ibid.

[32] "Low Cost Shore Protection for the Great Lakes," Engineering Research Institute Report, University of Michigan, reprinted October 1959 by the Water Resources Commission, Michigan Department of Natural Resources.

during one winter storm and where old auto bodies afforded better than average protection.

Protection at the shoreline is usually called either a bulkhead or seawall. They may be sloped and armored with interlocking concrete or natural stone in which case they are called revetments. Revetments are normally constructed to be energy-absorbing and as such they often have rip-rap of concrete or natural stone placed at the toe of the structure to reduce wave energy. Bulkheads are a form of seawall that are nearly vertical to the water level. They may be of concrete, wood or steel that is either poured in place, jetted or driven into the bottom. Backfilling often is used to level the beach slope. Under quiet water conditions bulkheads perform their intended function to level the beach area. However, near-shore heavy water turbulence during storms often undermines and destroys bulkhead structures standing alone without rip-rap protection.[33]

Structural designs abound at St. Joseph, Photo Map 1. The federal harbor works are comprised of

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[33]Note 29 supra.

concrete-capped wood piling, but almost every other form of structural design and construction material has been tried along this reach over the years. Wood pilings were used extensively during the 1950's and earlier but steel sheet piling has been more common during the present high water episode. Steel sheeting can be driven in place whereas wood pilings are usually jetted into position. Steel can be fabricated more rapidly, thus giving it a cost advantage over wood.

Concrete rubble revetments placed at the natural bluff angle have been constructed as well as many other "non-engineered" designs. Photo Map 1 shows examples of the lakeward and shore-based protective structures found in the study area at St. Joseph.

The success or failure of the protective measure at St. Joseph can be measured by the cost and frequency of repair and through a study of the rate of bluff recession. With the possible exception of the rubble revetments which were somewhat haphazardly constructed at best, none of the other small-sized private structures have protected the bluffs to the degree intended by their designers.

In general, the most successful protective works at St. Joseph have been the most expensive. The C&O Railroad Company has spent over one million dollars in ongoing repair, reconstruction and general maintenance.[34] The shore adjacent to the railroad tracks has remained stationary since 1938. Likewise the Michigan Highway Department has rebuilt and modified their works for a sum in excess of $4 million in order to maintain a relatively stable shore position.[35] The Michigan Highway Department and railroad company, however, both have had to add considerable amounts of fill material in order to maintain these positions.

Bruun[36] considers artificial nourishment the "atomic weapon" against shore erosion. This writer would agree that nourishment is the answer where it can be provided economically and in sufficient quantities. Most

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[34]Personal communication with Mr. Leland Hill, City Manager, St. Joseph, Michigan.

[35]Personal communication with Mr. Thomas Coleman, Soils Engineer, Michigan Department of State Highways.

[36]"Coastal Protection," Florida Eng. Ind. Expt. Sta., 1963.

schemes for providing beach nourishment rely on either offshore dredging or land-based sites for this material. Offshore deposits of a gradation large enough to remain in the beach zone may be hard to find and if found they may prove hard to recover for various physical and environmental reasons. Land sites provide the best source in the long run but the decision must be weighed whether "robbing Peter to pay Paul" is the best long-term solution.

The most efficient method to accomplish sand nourishment is to insure that structures such as harbor jetties which form barriers to littoral drift are equipped with sand bypassing (sand transfer) devices.[37] Sand bypassing is a simple enough mechanical operation to accomplish while at the same time it provides the near normal amount of sediment to the downdrift beaches.

Hydraulic suction dredges which are permanently affixed to the jetty structures are the usual design. Bypassing facilities have been in operation for a number of years at Palm Beach and Daytona Beach, Florida, Virginia

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[37] Note 29 supra.

Beach, Virginia and several locations in California.[38] To the date of this writing no sand transfer facilities are in operation with the exception of the sand transfer-nourishment work being undertaken as an interim measure at the Cook Nuclear Plant's temporary harbor. Sand excavated from the site of the nuclear plant (on shore) is being hauled to the downdrift (south) side of a temporary safe harbor in order to nourish this segment of beach. The sand is piled near the south edge of the temporary harbor and bulldozed into the surf.

The harbor jetties at St. Joseph provide an extremely good example of an area where sand transfer must be put into operation. No amount of money put exclusively into protective structures such as groins or revetments will even begin to remedy the erosion problem. In this situation the property owners will be analogous to the ill-equipped retreating army. The army may stop, reform and fight temporary holding actions during the course of an overall retreat, but so are the private property owners fighting a temporary holding action against the wave's

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[38] Ibid.

energy. Without the natural protection of shoaling offshore bars the property owner is doomed to defeat as is the ill-equipped army.

The examples of the State Highway Department project and the C&O Railroad's efforts point to the conclusion reached by most observers, even with the expenditure of over $5.5 million for a portion of beach less than two miles long without the protection of offshore bars and natural bottom slope no long-term protection can be gained only from structural works. Money spent on protective works alone cannot hope to solve the erosion problems at St. Joseph, or any other location in the world for that matter, without provisions for maintaining an effective natural sediment flow across major impediments to littoral drift such as harbor piers.

CHAPTER V

APPLICATION OF THE PROCESS-RESPONSE MODEL TO PROVIDE FACTUAL LEGAL EVIDENCE

Introduction

The process-response model of shore conditions at St. Joseph, Michigan is the scientists' conceptualization of the interacting systems in evidence under the given set of boundary conditions. The boundary conditions include such factors as the overall areal extent of the area, the physical parameters such as material types, offshore slopes, bar configuration and the amount of littoral sediment, sediment in transit, and the engineering factors such as length, size, configuration and spatial relationship of structures. These factors when combined form the unique system expressed by the process-response model.

Applications of this model for planning, design and engineering of erosion control measures will rely on more

detailed analysis of each of these factors. For example, more information on the relationship of material type and bar size would be needed to plan and design a nourishment program for this area. The amount of quantification of these various individual and combined parameters is only constrained by the professional abilities of the research team and more fundamentally by the available research budget.

From the point of view of the physical scientists the process-response model is only the point of beginning for understanding the problems at St. Joseph. Many non-physical scientists will not understand the importance of this model in the planning, design and implementation of protective measures for the shore. The riparian owner is facing a dilemma because many of the people not understanding the overall significance of the problem are in the decision making position. And most decisions concerning shore protection methods are being made by these individuals.

The legal system has evolved, especially of late, to bring some of these policy makers to account when it becomes evident that their decisions are incompatible with

environmental systems. Likewise, the legal system is used to settle claims for damages arising out of changes in the near-shore conditions. The legal system can be used to settle disputes or bring about changes in policy but not without facts to support specific claims. The process-response model provides the framework for organizing the legal claim as well as for delimiting the types of scientific data needed to support the various claims. This chapter discusses the applications of the process-response model for obtaining the essential scientific information while the following chapter integrates this information into the legal context of three hypothetical cases arising out of actual situations found at St. Joseph.

To recapitulate and focus again on what has been discussed in a previous section, this process-response model describes two primary factors (alterations of natural processes) that are causing accelerated shore erosion in the study area. First, there is the physical barrier of the federal harbor piers that are blocking the natural flow of littoral sediment and, second, there are the individual structures at the shore. Both severely alter the natural shore process, with the response being destruction or

significant disruption of the natural offshore bar system. The disruption of the bars in turn has altered the process of wave energy dissipation, the further response being greater erosion at the beach and a landward migration of the bluff line. The most easily measured parameter for estimating the degree of disruption in the natural system is the rate of bluff line migration. A rate is based on quantification of a time related parameter. Aerial photographs allow the position of the bluff line to be plotted for a given point in time. Successive photos for different years yield the information on rates of bluff line migration.

Along the shore itself structural works impede the natural action of the waves, thereby constituting a change in process. The refraction of waves on the downdrift side of these structures causes break-back or flanking. Flanking is thus the response to structural change in the natural system. Specific small magnitude process-response conditions which lead to flanking are also time related and easily measured by time-based photogrammetric measurements of the bluff line recession.

The rates of bluff-line recession throughout the study area when compared with similar rates for essentially unaltered shores is the basis in fact for legal claims for damages against the Corps of Engineers. Specifically the difference in rates of bluff-line migration between respective riparian property, while considering the overall regional rate, is the basis for legal claims between private owners. The following information was gathered to provide the scientific information estimating overall change of the study area and small area changes on two unprotected segments of the shore which have undergone accelerated break-back during the period 1969-1973.

Areas for Erosion Rate Measurement Comparison

The broad scope of the study at St. Joseph has forced a limit on the writer's involvement in field measurements in areas outside the study area. For this reason, data concerning erosion rates in other areas which could help in background comparisons were obtained by reworking information from other sources. Data from four such

sources are used as a basis of comparison in this study. Three significant research papers provide the background rate information. The studies by Larson[1] on the Illinois shore north of Chicago for the periods 1860-1955 and 1946-1955 are especially useful here. With respect to the areas in Michigan that serve as a background the studies by Seibel,[2] and Seibel and Brater[3] proved most useful. The shore along the base of the Sleeping Bear Dunes is also referenced in the evaluation of background erosion rates. This information was supplied by the Water Services Section of the Water Resources Commission, Michigan Department of Natural Resources. The sites referenced in this large area comparison are depicted on the map in Figure 15.

Preliminary examination of the process-response model in a detailed manner predicted changes would occur

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[1] The Cultural Variable in Shore Erosion Along The Illinois Shore of Lake Michigan, Chicago: Lake Michigan Federation Report, December 1972.

[2] "Shore Erosion at Selected Sites on Lake Michigan and Lake Huron" (unpublished Ph.D. dissertation, University of Michigan, 1972).

[3] An Engineering Study of Great Lakes Shore Erosion in the Lower Peninsula of Michigan, Report of the Water Resources Commission, Michigan Department of Natural Resources, 1973.

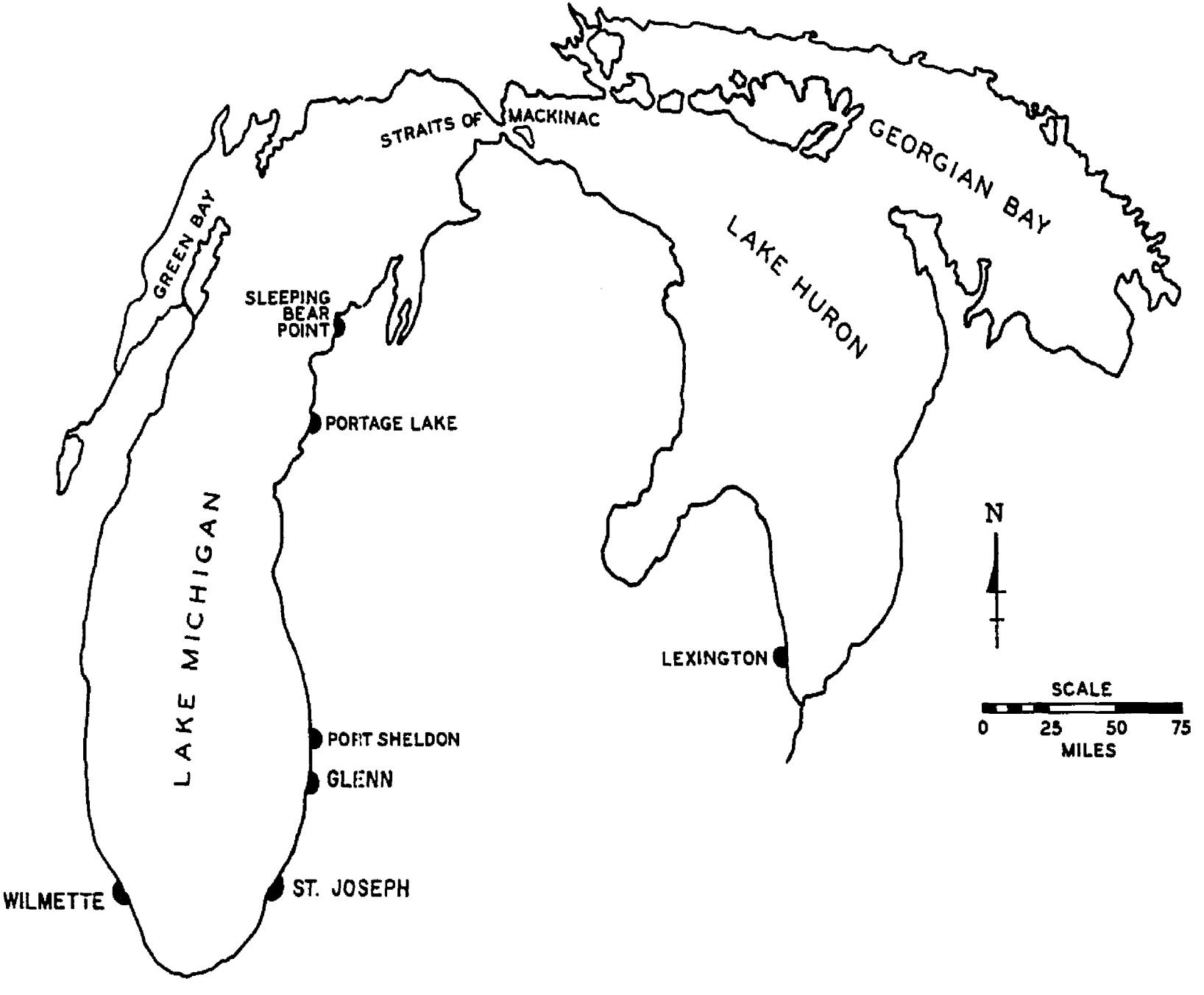

Fig. 15.--Areas where erosion rate information is available from other research studies, also noting St. Joseph locale.

on short segments of shore in response to particular structural works at the shoreline. Two specific unprotected segments of shore within the study area provide good examples of the process-response interaction. One segment approximately 1,000 feet along designated the Bluffs segment, is 500 feet south of the Michigan State Highway Department's protective works. A number of private structures are located in this 500-foot interval, south of the highway works. The Bluffs Apartment complex is located in this segment, Figure 16. The other unprotected segment is designated as the Asselin segment and is approximately 1,000 feet south of the Bluffs Apartments and also south of a line of extensive private protective works. The Asselin segment is 1,250 feet in length. It is named after the northernmost property owner in the segment.

Erosion Rate Measurements

The rate of erosion of headlands can be measured over time through the use of aerial photographs. Aerial photographs represent time-based two dimensional physical

Fig. 16.--Vertical aerial photographic view of two shore segments that have been erosing at an accelerated rate during the period 1969-1973. (Aerial photos courtesy of the Michigan Department of State Highways.)

models of the shore conditions at the time of the photography. Accurate photogrammetric measurements made from photomaps prepared from this record provide scientific information to substantiate and reinforce the interpretations of the process-response model for the Great Lakes. Thus they also provide some of the legal facts necessary for litigation pursued by riparian owners.

Photogrammetric measurements are those made from either scaled photo-mosaic maps or stereo models of the ground terrain. The erosion rate data gathered utilized scaled photo-mosaic maps of the St. Joseph study area.

The photographs used were the standard 9" x 9" format in color at a scale of 1:3000. The photos were made available through the Photogrammetric Section of the Michigan Department of State Highways. The State Highway Department used the photos to aid in the design of structures for protection of the Red Arrow Highway (B.L. I 94). The Department contracted with the Abrams Aerial Survey Corporation of Lansing, Michigan to provide vertical, 1:3000 scale color coverage of the coast south of the harbor piers to a point three miles south of the proposed highway protection on a yearly basis for the period

1969-1974. This vertical photography was augmented by low-angle color oblique photography of the same area. The vertical photography permitted the time-based controlled photo mosaic maps to be made for accurate measurements of the bluff-line recession. With the exception of the 1969 flight in June all of the photography was in April or May before foliage obscured the ground. The Highway Department photography was augmented by 1938 photography by the United States Department of Agriculture.

Mosaics are produced from two or more individual photographs laid down and fitted together. If the fitting is by eye the mosaic is uncontrolled. The measurement accuracy on uncontrolled mosaics is low due to scale discrepancies between individual photos. This type map is used in most investigations for qualitative information only. If the fitting of the photos is accompanied by the scaling off of accurate distances between control points on adjacent photos, then the mosaic is controlled. Controlled mosaics for this study were prepared by the writer through use of ground control information furnished by the Highway Department Photogrammetry Section.

By reference to controlled mosaics of the study area for the years 1969 and 1973 a quantitative comparison of bluff-line recession rates was made for all points along the shore within the coverage area of this photography. The control was available from accurate horizontal distances that had been laid out by Highway Department survey crews along the center line of the Red Arrow Highway. Yellow crosses marked the position of the control points along the center line. The flat terrain east from the bluff line and use of a large scale (1:3000) allowed ground-distance measurements to be made to an accuracy of within ± 2.5 feet. This value was determined from statistical checks of the measurements on the basis of four repeated measurements of the same distance.

Slight differences in flight altitude for the two mosaics used (1969 and 1973) necessitated that a common scale be used to which all data would be rectified. The scale of the 1969 photography was exactly 1:3000 while the 1973 photos were taken at a slightly lower altitude thus giving a slightly larger scale of approximately 1:2950. The 1973 base was used for all information.

Measurements to bluff-line recession were made by plotting the position of the 1969 bluff position on an acetate overlay on the 1973 controlled mosaic. The 1969 position of the bluff line was measured along line segments oriented between visible ground points, Figure 17. The visible ground points were used to plot east-west line segments on both the 1969 and 1973 mosaics. Repeated measurements along the line segments using a measuring scale with divisions 0.01 inch under 10X magnification gave a measurement accuracy of $\pm$ 2.5 feet. All measurements were repeated four times and the distances along line segments provided the average values.

Even though the mosaics were controlled there is a slight scale change from the principle point of any photograph, radially outward. This scale change error was minimized by utilizing the center portion of each photograph for the measurements and by graphical triangulation on several points between photographs, Figure 17. Triangulation of a number of points between individual photographs indicated that for the mosaic as a whole scale error was slight, i.e., on the order of $\pm$ 5 feet. This was the maximum error detected over the highway center line to bluff

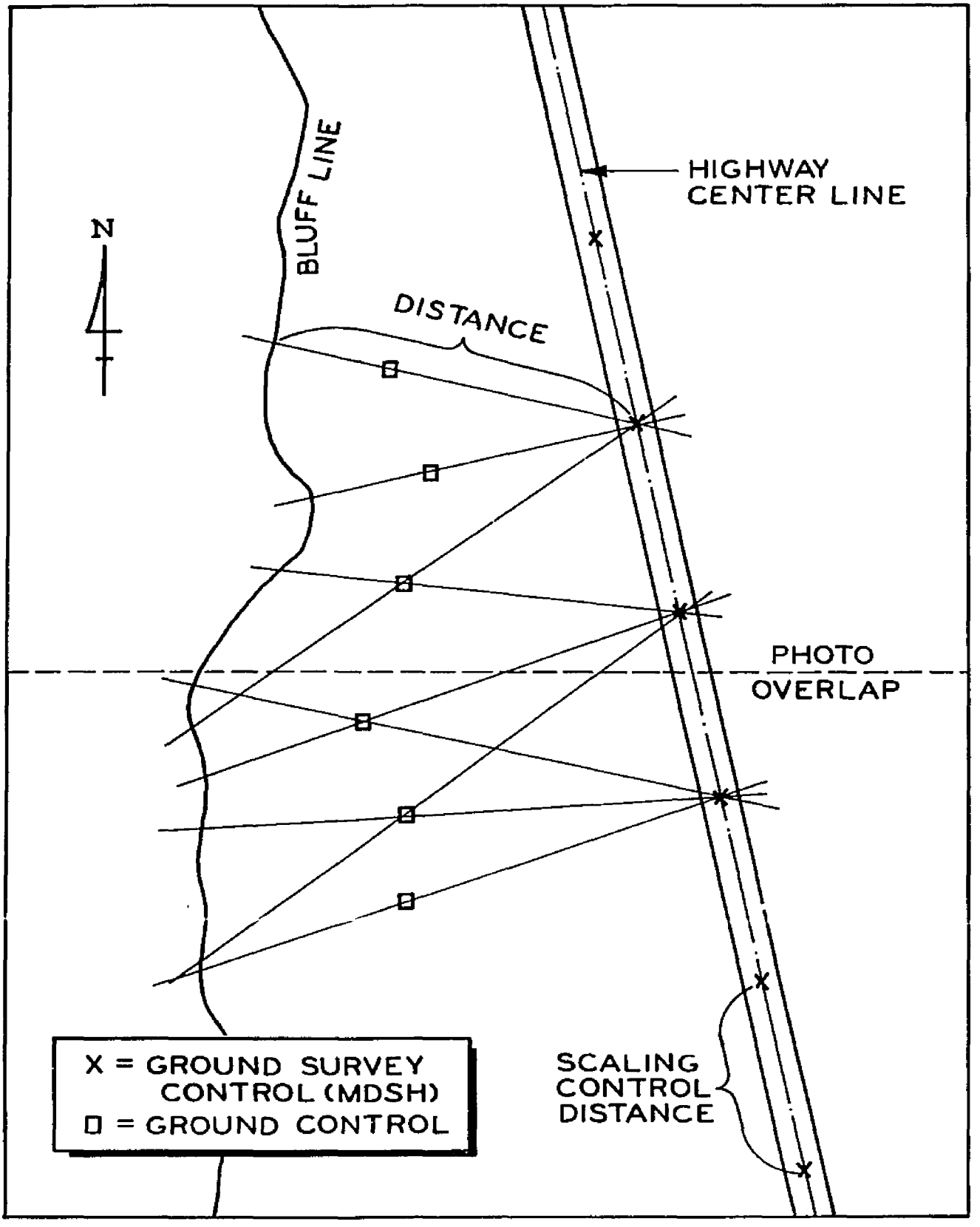

Fig. 17.--Method of control and photogrammetric measurement on 1:3000 vertical aerial photographs at St. Joseph, Michigan.

line distances ranging from 300 to 900 feet along the total length of the photo mosaic.

Total error attributed to measurement and scale changes is estimated to be ± 7.5 feet. No consideration was given to other factors such as terrain or lens distortion, because the relief is low and the camera equipment of high quality.

For comparison between short- and long-term rates of change of bluff-line positions aerial photographs from 1938 were used. Rectification of these photos to a common scale was somewhat more difficult than with the 1:3000 photography and also the scaling error was more difficult to rectify. To accomplish a somewhat higher degree of accuracy, however, control points and control distances were measured between identifiable natural or man-made features that were found on both the 1973 and 1938 photography. The distances were taken from the 1973 photography. A "semi-scaled" strip mosaic was then constructed for the same area covered in the 1969 and 1973 mosaics.

The smaller scale 1938 photographs have greater distortion from altitude variations that occurred between individual photos in the strip, and from lens aberrations

and other factors contributing to greater error in horizontal measurements. Error for horizontal distances from all causes was estimated to be ± 5 feet on the 1938 mosaics. Triangulation of common points on adjacent photographs and horizontal measurements from the road center line were undertaken on the 1938 mosaic in a similar manner as was done for the 1969 and 1973 mosaics.

Erosion Rates 1969-1973--The Basis for Private Damage Claims

The possibility of private riparians seeking damages for erosion caused by neighboring protective works is very real, especially considering the wide range in erosion rates in evidence along the St. Joseph shore. Law suits between adjacent owners provide a good application of the process-response model for small-magnitude changes in the near-shore environment.

The reconstruction of accurate bluff-line positions for the two dates, 1969 and 1973, allowed the rates of erosion to be calculated for protected and unprotected segments

of each. The results are presented pictorially on the map in Figure 16 and numerically in Tables 2, 3 and 4.

During the period 1969-1973 those areas protected by structural works suffered headland erosion at rates calculated to be 4.1 feet per year along the area north and updrift from the Bluffs segment of unprotected shore; and 5.0 feet per year north and updrift from the Asselin segment, Figure 16 and Table 2. The Bluffs segment during this same period eroded at a rate of 8.7 feet per year, over twice the rate of the adjacent area protected by structures. The Asselin segment was eroded at a rate of 14.4 feet per year during the 1969-1973 period, Figure 16 and Table 2. The rate of erosion at the Asselin segment was nearly three times the rate of the protected area immediately to the north.

The process-response model predicts accelerated erosion adjacent to projections into the lake which lead to changes in wave and current action. The small magnitude effect of lakeward structures is to redirect the angle of wave approach of incoming wave fronts as shown in Figure 13. Quantification of the degree of response is dramatic.

TABLE 2

EROSION RATES MEASURED AT ST. JOSEPH

St. Joseph, Michigan protected segment updrift from the Bluffs segment erosion rate measurements 1969-1973.	4.1 feet/year
St. Joseph, Michigan protected segment updrift from the Asselin segment erosion rate measurements 1969-1973.	5.0 feet/year

TABLE 3

EROSION RATES MEASURED AT ST. JOSEPH

St. Joseph, Michigan erosion rate for the unprotected Bluffs segment 1969-1973.	8.7 feet/year
St. Joseph, Michigan erosion rate for the unprotected Asselin segment 1969-1973.	14.4 feet/year

TABLE 4

BACKGROUND EROSION RATES

Erosion rate at Wilmette, Illinois for the period 1946-1955, after Larson 1972.	3.5 feet/year
Erosion rate at Lexington, Michigan for the period 1949-1955, after Brater and Seibel 1973.	4.1 feet/year
Erosion rate at Glenn, Michigan for the period 1950-1955, after Brater and Seibel 1973.	6.4 feet/year
Erosion rate at Port Sheldon, Michigan for the period 1950-1955, after Brater and Seibel 1973.	7.0 feet/year

The use of these measurements of erosion rates as evidence in a legal claim between respective riparian neighbors, however, must take into account the background rate of erosion.

A reasonable counter claim by a defendant in an erosion suit would be that the erosion rates sustained by unprotected owners were the normal rate to be expected. The protected owners received less erosion loss by virtue of the protection afforded by their works. In order to lend evidence to counter this statement, the erosion rates on the Great Lakes as a whole must be considered. This determination would be called the background rate. If the background rate along similar shores approaches the value determined for unprotected segments, then the validity of a legal claim could be in doubt.

In order to determine a feasible background rate as a "rule-of-thumb" for erosion, similar areas relatively free of major structural works were examined. These areas are similar in physical characteristics. This is important because areas having boulders or cobbles armoring the bottom and beach or which have been cut into bedrock would seriously affect erosion rates. Therefore, the areas

chosen for a background rate to compare with the St. Joseph area have similar bluff conditions and beach composition (i.e., sand and gravel). The only significant different parameter was the geographical orientation and expose of the coast which in a refined analysis probably could be shown to have a measurable effect.

Three areas north of St. Joseph on Lake Michigan, one area on Lake Michigan shore in Illinois between Wilmette and Waukegan, and one area on Lake Huron all have comparable physical characteristics. More important each has been the subject of studies conducted by other researchers. Like most sites on the Great Lakes these are not entirely free from man's works but they have had significantly less structural interference than the shore at St. Joseph. In fact none of these other locales have nearly continuous structures as does St. Joseph and none are located so near the sediment shadowing influence of long piers. Particularly the research work of both Larson[4] and Brater and Seibel[5] provides an excellent basis

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[4]Note 1 supra.

[5]Note 3 supra.

for background erosion rates along the less intensively developed shores of Lake Michigan-Huron.

The Brater and Seibel erosion studies involved four areas which have been used here as background: Glenn, Port Sheldon, Portage Lake and Lexington, Michigan, Figure 15. Larson's work at Wilmette, Illinois was equally applicable here. The time interval used by both researchers included the 1950-1955 period which encompasses the previous high water event on the Great Lakes. Their work also included longer time periods including the 1872-1946 period in Illinois and the 1938-1970 period for the Michigan locations. Information based on this longer period will be discussed later.

Some of the results of Larson and Brater and Seibel studies have been combined in Table 4. The erosion rate values range from 3.5 feet per year for the period 1946-1955 for the Illinois area, to 4.1 to 7.0 feet per year for the other Michigan locations. This range in values is probably due in part to the unequal time increments as well as their unmeasurable physical factors. Most of the intense erosion during the previous lake high occurred in the winters of 1951-1952 and 1952-1953; however, both Larson and

Seibel included a longer time span than this. It is conceivable that if the dates of the air photography had been more inclusive, as was in the case of the St. Joseph situation (1969-1973), the values would have been higher and perhaps with less of a range. In other words, several years in which little or no erosion took place were averaged in with the higher erosion years to give a lower mean. Brater and Seibel's sites at Glenn and Port Sheldon most closely bracket the high erosion period and these have higher values which lends some support to this assumption.

From the above, the background erosion rate for a nearly similar period of erosion intensity on a shore having less structural interference is estimated to be in the range of 5.0 to 7.0 feet per year which is somewhat less than the St. Joseph case study. The St. Joseph Bluff shore segment has a rate calculated at 8.7 feet per year, only slightly higher than the background. This rate was slowed considerably by the $250,000 worth of protective works that have been built over the period 1969-1973. These installations, however, were not started until after the 1969-1970 winter storms had begun to produce rapid flanking on the north edge of this shore segment.

The St. Joseph Asselin segment sustained a rate of 14.4 feet per year, at least twice the regional background rate. With the exception of the two parcels at the north end, no protective works were built along this segment. The Asselin's seawall bulkhead and fill provided some relief from the flanking caused by the structures immediately to the north but their actions were at the expense of their neighbors to the south who were forced to remove several homes. The erosion rate at the point immediately south of the Asselin's bulkhead was extremely high, i.e., nearly 40 feet per year for the period 1971-1973.

These data, therefore, lend support to the claims of riparian owners based on accelerated erosion and property damage. It is also clear that erosion has proceeded at a rate up to several times that which would be expected without the influence of structural works.

Erosion Rates 1938-1970--The Basis for Claims Against the Federal Government

The examination of the average erosion rate for the period from 1938 to 1970 at St. Joseph, Michigan points to

the degree of severity of this problem. There has been much discussion in this and other research studies about the mechanisms causing widespread erosion on the shores of the Great Lakes. The federal harbor works on these lakes have been given the blame for a large share of these damages. Of course, any court action to bring about a change in the policies of the Corps of Engineers with respect to erosion protection (or reduction in erosion rates) must be based on factual information. An analysis of erosion rates among several similar areas on the Great Lakes points to the St. Joseph area as being the most severely affected and establishes some scientific basis even for damage claims against the Corps of Engineers. The severity of the damages at St. Joseph which has been documented also provides a viable basis for claims for environmental damages.

The five areas in the region selected to provide a background erosion rate for the private claims discussed above also provide a suitable background to which the long-term erosion rate at St. Joseph can be compared. Additionally, data on the shore-line changes in the Sleeping Bear Dunes State Park can be used with some reservation.

The rate of bluff erosion, as stated previously, is a function of the process-response model. The accelerated erosion rate of the entire shore south of the federal piers is in turn a function of sediment starvation. The rate of erosion is, therefore, a direct quantifiable measure of the degree of severity of this starvation. In lieu of accurate bathymetric profiling of the offshore areas both north and south of St. Joseph harbor piers and much more detailed offshore studies that are beyond the scope here, the erosion rate is the single best indicator of damage.

The works of Larson and Brater and Seibel have been summarized in Table 4, while Table 5 is the summary of similar calculations with respect to the St. Joseph coast. The Brater and Seibel studies on Michigan's shores show the effects of basically one period of erosion (1952-53) and the beginning phase of the present period (1969-1970). The erosion rates, therefore, are the expression of one major period of high intensity erosion averaged with a number of years when essentially no erosion took place. The data tend to reflect this averaging variance of the data for different time increments.

TABLE 5

BACKGROUND EROSION RATES

Erosion rate at Wilmette, Illinois for the period 1872-1955 after Larson 1972.	1.1 feet/year
Erosion rate at Lexington, Michigan for the period 1938-1971 after Brater and Seibel 1973.	2.3 feet/year
Erosion rate at Glenn, Michigan for the period 1950-1970 after Brater and Seibel 1973.	2.7 feet/year
Erosion rate at Portage Lake, Michigan for the period 1938-1970 after Brater and Seibel 1973.	3.7 feet/year
Erosion rate at Port Sheldon, Michigan for the period 1950-1970 after Brater and Seibel 1973.	3.7 feet/year
Erosion rate at Sleeping Bear Point, Michigan for the period 1938-1972 determined by the Water Resources Commission staff.	0.2 feet/year

The data presented in Larson's paper have been reworked to include the time period 1872-1955. This time span records four high water periods including the all-time high level of 1886 and the lesser 1917, 1929 and 1953 peaks. This 83-year record provides a limited but still valuable record of the erosion rates on the lakes with essentially minor structural modification of natural conditions.

The data from the Sleeping Bear Dunes area are inclusive for the period 1938-1970 and was obtained from the Water Resources Commission of the Michigan Department of Natural Resources.

The numerical data with respect to all of these sites are presented in Tables 5 and 6. The Illinois site

TABLE 6

BACKGROUND EROSION RATES

Erosion rate for the St. Joseph, Michigan study area as averaged from several hundred individual measurements for the period 1938-1973.	5.0 feet/year

exhibited an erosion rate of 1.1 feet per year over the 83-year span, while for shorter time increments rates of 2.3, 2.7, 3.7, and 3.7 feet per year respectively were measured at the Michigan and Huron shore sites. The Sleeping Bear Dunes shore segment during the time period from 1938-1970 exhibited erosion rate of 0.2 feet per year, Figure 18. While the Dunes Park segment is slightly different in shore morphology the comparison of this area untouched by man's works with those on the southern end of the lake is probably a significant indicator of the degree of natural process interference by man's activities. The Dunes locality measurement, representing a pristine shore, indicates a rate of erosion approximately one twenty-fifth that experienced in the St. Joseph area, and from one-tenth to one-fifteenth that of the other sites measured by other workers.

The use of erosion rate information in itself is only a broad indication of the extent of damage at St. Joseph resulting from continued interruption of littoral drift by the federal piers. If all the data on erosion rates compiled by all researchers working on similar

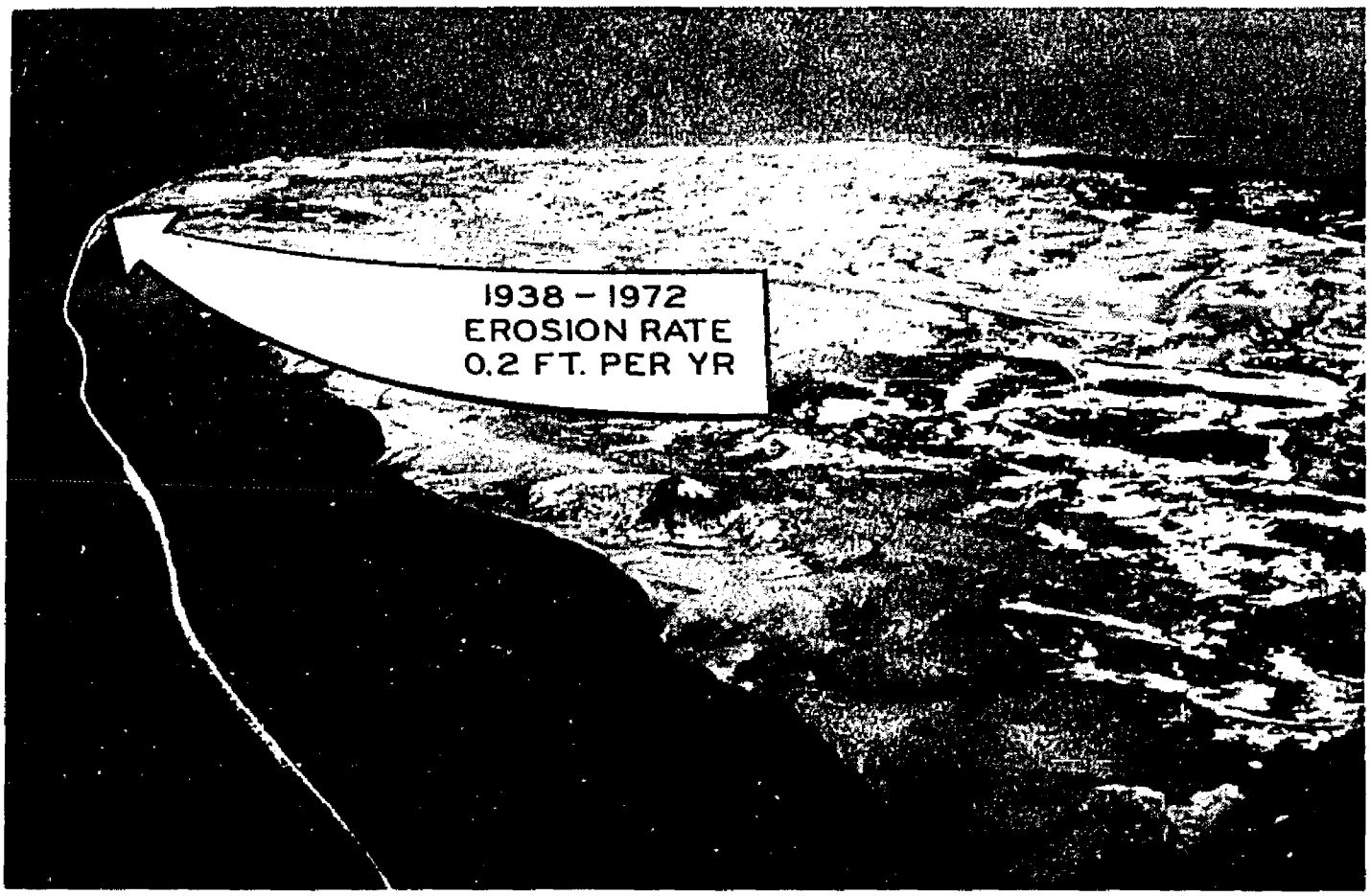

Fig. 18.--High oblique aerial view of Sleeping Bear Dunes showing the location where erosion rate measurements were made by the Michigan Water Resources Commission staff. (Photo by T. A. Herbert, April 1969.)

studies were placed in rank order the area of St. Joseph would occupy the first position.

Additional work is needed, however, to strengthen this statement. Additional basic data must be gathered on the stage-bar relationships, for example, before any definitive statement can be made. But for the purposes of the following chapters, which deal largely with the legal structure, this preliminary research on quantifying erosion rates is adequate for setting the stage for the hypothetical cases presented in Chapter VII.

CHAPTER VI

THE LEGAL FRAMEWORK GOVERNING THE USE OF RIPARIAN LAND ON THE GREAT LAKES

Introduction

The previous chapters have outlined the physical aspects of the erosion problem on the Great Lakes and especially the shore area at St. Joseph, Michigan. Solutions to the cases of man-induced erosion for the most part will lie in application of legal principles governing the use of riparian land. The need for a rightful and equitable apportionment of water and land along the sea and Great Lakes shore has led reasonable people to develop a legal framework governing the use of riparian land "so that progress may be made by one group without resultant loss to another."[1]

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[1] N. V. Olds, "The Law of the Lakes," Michigan State Bar Journal, XLIV, No. 2 (1966).

The legal framework governing the use of riparian land on the Great Lakes which spells out the rights, duties and obligations of the riparian owner is divided into four categories for purposes of discussion: (1) federal regulations, (2) state regulations, (3) local regulations, and (4) common law doctrines. This chapter is concerned with each of these categories of control over shore land use.

Federal Restrictions on Riparian Ownership

Two important restrictions on riparian use are outgrowths of federal control of the commerical waterways of the United States. As a doctrine, navigation servitude[2] controls the recourse of private riparians against the federal government. As a regulatory control the Rivers and

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[2] "Navigation servitude" is the shorthand expression for the rule that in the exercise of the navigation power certain private property may be taken without compensation. The rule is also spoken of as the "superior navigation easement," see, e.g., United States v. Grand River Dam Authority, 363 U.S. 229, 231 (1960) or the "dominant servitude," see, e.g., FPC v. Niagara Mohawk Power Corp., 347 U.S. 239, 249 (1954).

Harbors Act of 1899[3] provides that the Corps of Engineers has the authority under a permit system to control any structures placed in the navigable waters of the United States.

The concept of navigation servitude has its origins in the law of England where there were two important public rights--navigation and fishing. Through an ancient right the public had the right to free and unhindered passage on the country's navigable waterways.[4] In the same respect no private person could acquire an interest in water to the detriment of the public right of fishing and navigation. Similar ideas concerning public rights were developed in colonial America and were also recognized after the creation of the United States. Then the sovereign became the federal government rather than the English sovereign, but

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[3] 33 U.S.C. §§401-66K (1970) (originally enacted as Rivers and Harbors Act of 1899, ch. 425, §9, 30 Stat.1151).

[4] In English law, "navigable" waterways are those in which the tide ebbs and flows. As a small island nation this rule is valid since most waterways are near enough to the ocean to have tidal influence for most of their length. The United States adopted a different definition of "navigable" because of the differing geography with the rule of "navigable in fact--navigable in law" as stated in The Daniel Ball v. U.S., 77 U.S. 557 (1970).

regardless the public's right to free passage on navigable waters was guaranteed.

The doctrine of navigation servitude is based on the commerce clause of the United States Constitution, Article I, Section 8. Once adjudged "navigable in fact" the federal government's control and jurisdiction over the navigable waters of the nation becomes paramount.

In aid of navigation, Congress may:

> . . . order obstructions to be placed in the navigable waters of the United States, either to assist navigation or to change its direction.*** It may build lighthouses in the bed of the stream. It may construct jetties. It may require all navigators to pass along a prescribed channel, and may close any other channel to their passage.

Through the paramount interest of the public in navigable waters for the purpose of commerce the federal government has long held an easement in such waters extending to the ordinary high water mark (OHWM). In exercising this easement the federal government is immune from liability.[5] The following succinct statement of this is found

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[5]This "taking" of private property for public purposes normally as prescribed by the Fifth Amendment requires the payment or just compensation by Congress. According to Bartke (3 N.R.J. at p. 20):

> . . . where Congress exercises the navigation power, the basis inhibitory principle against

in United States v. Chicago, M., St. P. and P. R. Co.[6]

> The exercise of the power within these limits is not an invasion of any private property right in such lands for which the United States must make compensation. The damage sustained results not from a taking of a riparian owner's property in the stream bed, but from the lawful exercise of a power to which that property has always been subject.

The riparian land adjacent to navigable waters, therefore, is always subject to this continuing easement for navigational purposes and any damages pursuant thereto are not compensable because they were the consequence of legitimate acts of the sovereign.[7]

> taking of private property without compensation is said to break down.

[6]312 U.S. 592, 597 (1941).

[7]The test of legitimacy of the "taking" in individual cases would require that the federal government waive the ancient right of sovereign immunity. Sovereign immunity bars suits against the "sovereign" without his consent. Justice Holmes, speaking for a unanimous Supreme Court in a 1907 decision, Kawananakoa v. Polyblank, 205 U.S. 349, 353 (1907) explained the rational behind the doctrine as follows:

> A sovereign is exempt from suit, not because of any formal conception or absolute theory, but on the logical and practical ground that there can be no legal right as against the authority that makes the law on which the right depends.

The doctrine has long been subject to criticism by legal commentators.

Since 1899 the date of the enactment of the original Rivers and Harbors Act,[8] the Corps of Engineers of the United States Army has been the agency of the federal government in charge of maintaining the rivers, harbors, and waterways of the United States.[9] The Secretary of the Army is responsible for the overall administration of the Rivers and Harbors Act of 1899 as amended of which one of the most important aspects is the administration of Section 10 of that act. Under section 10 anyone desiring to build a structure in a navigable water of the United States, such as Lake Michigan, must have a federal permit.

An application for a permit is processed through a series of steps, in theory at least, so that all interested parties have an opportunity to respond. The application for a permit must be accompanied by engineering drawings of the proposed structure which are reviewed by those interested in the project which usually includes all federal agencies that have anything to do related with

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[8] Note 3 supra.

[9] See generally, Permits for Work in Navigable Waters, Corps of Engineers, Department of the Army, 1968.

water, state agencies, local officials and all known interested groups and individuals.[10]

The decision as to whether or not the permit will be issued rests on an evaluation of all relevant factors, including the effects of the proposed works on navigation, fish and wildlife, pollution, aesthetics, ecology and general public interest. The Corps uses other federal and state agencies for evaluation of these other related factors. If no negative response is forthcoming from the general public or any other agency then the permit is issued. If objections to the permit are received, the permit applicant is given a chance to resolve them. If objections from the general public are received in significant numbers to warrant a public hearing then one is scheduled.[11]

The public hearing process allows the interested parties to respond to various aspects of the project for which the permit is sought. The official record of the hearing is reviewed and taken into consideration. In

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[10] Ibid., p. 2.

[11] Ibid., p. 3.

actual practice, if the application for a permit is one that is extremely controversial then the Corps District involved forwards it to the Secretary of the Army for an ultimate decision.

The responsibility for the issuance of permits in many cases seems to be taken as a matter of procedure. The breakdown of the permit system occurs when these applications are "rubber stamped" rather than reviewed from a long-term management point of view.[12] The important consideration here is that the Corps' responsibility under the law transcends the limits of navigation and, in the writer's opinion, often promotes poor resource management in the shore environment.

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[12]The Corps of Engineers may be reluctant to expand its authority to take into account the environmental consequences of their actions. In Zabel v. Tabb, 296 F. Supp. 764 (1969) the court directed that a dredge and fill permit be issued where no interference with navigation could be shown. The Corps had withheld the permit on the grounds that fish and wildlife would be harmed (under the Fish and Wildlife Coordination Act of 1958, 48 Stat. 401, as amended, 16 U.S.C. § 661 et seq., (1964)).

State Regulation of Riparian Ownership

Title to bottom lands beneath the navigable waters of the Great Lakes was conveyed to the respective states upon their admission to the Union.[13] Similarly, along the seacoast of the United States the title to the sea bed was retained by those respective states.

It is the law of Michigan, as it is generally, that the ordinary high water mark (OHWM) of navigable waters forms the boundary with riparian property.[14] In Michigan, private ownership extends to the OHWM defined by the Submerged Lands Act.[15] Prior to the enactment of the Great Lakes Submerged Lands Act in Michigan the extent of lakeward ownership was a matter of question because the legal description of many of the original grants from the federal government extended to a meander line that may or may not

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[13] For a more detailed discussion of the question of riparian title and the extent of public trust ownership the reader is directed to Professor L. L. Leighty's article "The Source and Scope of Public and Private Rights in Navigable Waters--Part I."

[14] Submerged Lands Act, Act 247 of the Public Acts of 1955, Section 2.

[15] Ibid.

have been coincident with the shore at the time of the original government survey.[16] Numerous court decisions were needed prior to the enactment of the Submerged Lands Act to define the extent of private ownership.[17]

The shore processes at work on the Great Lakes may alter the geographic position of the OHWM. Erosion may cause a landward migration of the OHWM, or conversely, accretion may move this mark lakeward. Thus, a riparian owner's property under natural conditions may be gradually enlarged by accretion or gradually diminished or destroyed by erosion. Permanent structures, as detailed previously, cause entrapment of sediment and accretion. The Michigan State Legislature moved to establish title to this accreted land in 1968 with Section 11 of the Submerged Lands Act of

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[16]The problems of ownership up until the enactment of the Submerged Lands Act is presented in the American Law Reports Annotated at 7 ALR 1256, (Land Between Meander and Shore Lines).

[17]There have been several significant decisions on this question including: Kavanaugh v. Rabior, 222 Mich. 68, 192 N. W. 623; Kavanaugh v. Baird, 241 Mich. 240, 217 N. W. 2; Staub v. Tripp, 248 Mich. 45, 226 N. W. 667; Newman v. Bump, 245 Mich. 665, 224 N. W. 321; and Ainsworth v. Munoskong Hunting and Fishing Club, 159 Mich. 61, 123 N. W. 802 and others, see 71 ALR 1256 generally for a more complete review.

that year.[18] Title is granted to land accreted to riparian property by the placement of lawful permanent structures.[19] No legislation has been forthcoming which treats shore losses in an equitable manner.

The Submerged Lands Act as originally enacted in 1955 set forth provisions for permitting of structures placed on the public trust bottom land of the state below the OHWM.[20] State permits are required for any structure extending lakeward from the OHWM. Both State and Federal permits, therefore, are required before any structure can be placed offshore. Protective works,[21] such as have been described previously, that extend lakeward are under such permits.

The most recent move by the State of Michigan to regulate the use of riparian property came with the enactment of the Shorelands Protection and Management Act, Act

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[18] 1968 Submerged Lands Act, Section 11.

[19] In the case of St. Joseph, the land accreted to the shore north of the piers could be granted to the riparians in that area upon application under the procedures set forth under Sec. 11 of the 1968 Submerged Lands Act.

[20] The OHWM on Lake Michigan-Huron has been established at a datum of 579.8 feet above mean sea level.

[21] See Chapter IV under Engineering Aspects.

245, of the Public Acts of 1970. There are three important provisions of the Shorelands Protective Act.[22]

First, the Act provides for the zoning of all high-risk erosion and environmental areas by local government. These high-risk areas are to be delineated by studies conducted by the Michigan Department of Natural Resources (DNR). In the absence of the necessary zoning at the local level, the Water Resources Commission of the DNR is empowered to promulgate rules for the protection of these areas.

Second, the Shorelands Act authorizes studies to be conducted which are aimed at delineating the high risk erosion areas and areas of environmental concern. The zoning regulations described above are to be enacted pursuant to these studies by the Department of Natural Resources.

Third, the Shorelands Act requires the Water Resources Commission to develop a "comprehensive plan" for the overall management of Michigan's Great Lakes shorelands.

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[22]For a more detailed analysis of Act 245 the reader is directed to the report prepared by the Water Resources Commission staff titled A Plan for Michigan Shorelands, October 1972.

The Shorelands Act as it now stands will provide the tools to direct future development. However, the areas of real concern are those with presently existing development and the language of the Act does not lend much hope for these already developed reaches. The exception to this statement may be in the "comprehensive plan" section but plans do little to correct on-going erosion, or to rectify previous erosion damage.

Local Regulation of Riparian Land

Local governments regulate land use within their jurisdiction through the application of their police powers, by what is called zoning. Zoning ordinances are controls over land use that delineate the various types of uses to which the land may be put. Regulation of shore areas under existing zoning authority has recently been strengthened by the enactment of the Shorelands Protection and Management Act previously discussed.

Zoning as a legitimate power of government to control private land has its roots in the United States

Constitution as interpreted in the often cited 1926 United States Supreme Court case of the Village of Euclid v. Ambler Realty Company.[23] The Court held that zoning ordinances are constitutional in principle as a valid exercise of the police power of the state to regulate the activities of the people in the interest of the general health, safety, and welfare.

The zoning authority of local governments is vested by the state through what is commonly called enabling legislation. The local government under this legislation has the power to promulgate local zoning ordinances.

Zoning of shore areas in Michigan was initiated in 1952 with the enactment of Act 42, of the Michigan Public Acts of 1952, which amended the County Rural Zoning Act (Act 183, P.A. of 1943) making it possible for County Boards of Supervisors of those counties fronting on the Great Lakes to establish appropriate setback or building lines in areas outside of incorporated villages and cities.

The effectiveness of local zoning to insure proper setback from the shore has been minimal. This ineffectiveness can be measured roughly by the number of homes built

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[23] 272 U.S. 365.

in areas subject to erosion damage.[24] The Shoreland Protection and Management Act of 1970 was primarily the outgrowth of this inactivity at the local level and the recognition of the need for shoreland management. The zoning provisions of the Act state that counties, townships, cities or villages within three years after the effective date[25] of this Act may zone any shoreland and land to be zoned which is within their municipal limits for the protection of designated "environmental and high-risk erosion" areas. The shoreland as defined by the statute, means the land in the State which borders or is adjacent to a Great Lake or a connecting waterway situated within 1,000 feet landward from the ordinary high water mark as defined in Section 2 of Act 247, of the Public Acts of 1955, as amended.[26]

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[24]While no extensive study of actual dates on building permits was undertaken to substantiate this statement an airplane flight along the shore will confirm the fact that many homes have been built since 1952. Set back lines either have not been established or if established have not allowed enough setback in most instances.

[25]The important date is April 1, 1974.

[26]See Sec. 7-11, Act 245 of 1970.

An important new concept presented by the Shorelands Act is the provision for direct state action if local governments fail to zone those "environmental and high-risk erosion areas" designated by the Water Resources Commission study of the shore areas, a function provided in the Act.[27] The Water Resources Commission is authorized to set regulations to prevent unwise use of such areas if local governments fail to enact the necessary restrictions.

The legality of such a move by the Water Resources Commission probably will not fully be established until a test case has been decided. The long-range possibilities for controlling the development of the now undeveloped shores are good. The developed shore reach, however, will probably be only minimally affected since existing uses are responsible for much of the erosion damage that has occurred.[28]

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[27] Existing Regulatory Techniques for Managing Michigan's Shoreland, Water Resources Commission, Department of Natural Resources, August 1972, p. 2 (draft copy).

[28] Sec. 12, (1) (a) of Act 245 calls for: An inventory and identification of the use and development characteristics of the shoreland: the general physical and man-influenced shoreline features; the existing and proposed

Common Law

Riparian rights have developed out of the common law and of course directly apply to land adjacent to the Great Lakes. A riparian proprietor or riparian is one who owns land which includes the shore or bank of a lake or stream.[29] On the Great Lakes or the ocean these rights have been called "littoral rights."[30] The principles of law, however, are essentially the same regardless of the water body involved.[31]

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municipal and industrial water; intakes and sewage and industrial waste outfalls; and high risk and environmental areas.

The inventory which, of course, is the first step in identifying those areas of special concern on the shore is the only language in the act that mentions "general physical and man-influenced shoreline features." The critical areas are already of common knowledge such as at St. Joseph. The important question of funding for shore repair will hopefully be answered in subsequent state and federal legislation.

[29]See generally, 93 C.J.S. 605-620, §§ Waters.

[30]See generally, 93 C.J.S. 789-799, §§ Waters, IV Natural Lakes and Ponds.

[31]Riparian law has been generally interpreted to include all bodies of water, streams, ponds, lakes and the ocean. Riparian rights are those associated with flowing water in a stream while those same rights on land abutting a lake or the ocean are known as littoral.

In Michigan the rights of riparian owners have been defined by the Michigan Supreme Court to include:[32]

1. The right to use the water for general purposes, such as bathing, domestic use, etc.
2. The right to wharf out to navigable waters.
3. The right of access to the navigable waters.
4. The right to accretion.

The right to wharf out to navigable waters is not absolute and unrestricted because it is subject to the regulatory assent of the state because of public trust ownership of the bottom land[33] and the federal government because of the possible hindrance to navigation.[34]

The applications of riparian law are many, but in the context of this study the specific tenets of the doctrine are related to the right of defense against the lake water. In general, the riparian owner has the right to build a bulkhead or other structural works to protect his property, but he is answerable and accountable in

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[32] Note 1 supra.

[33] Note 14 supra.

[34] Note 3 supra.

damages if his protective works cause injury to other riparian owners.[35]

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[35]See 93 C.J.S. 623 § 19, Embankments, Levies and Other Works to Protect Property.

CHAPTER VII

ANALYSIS OF FOUR LEGAL AVENUES OPEN TO PROTECT RIPARIAN RIGHTS

Introduction

Previous chapters have analyzed the physical, cultural and historical aspects of the shore erosion problems at St. Joseph, Michigan. The Michigan location is prototypical of many other highly developed shore areas on the Great Lakes and seacoasts of the United States. It has been shown that man's interaction with the natural shore processes has greatly accelerated the rate of erosion. A chronological record of man's activities at St. Joseph reveals a greater and greater environmental influence from artificial structures along the shore. Damages to riparian property have increased with succeeding high water periods on the Great Lakes. Individual property owners, local and state government and the federal government, all

as riparian owners, have expended large sums of money in an attempt to protect shore property from the wave forces causing erosion. Most of these attempts have been futile because of the small scale at which the riparian owners can operate in relation to the tremendously large scale of the overall problem. Acting alone, riparian owners, neither private nor governmental, can muster the sufficient energy resources needed to "fight nature" on an even basis. The loss of this battle with nature has caused many scientists, engineers and laymen alike to begin thinking in terms of harmonious association with nature.[1]

These harmonious associations are easily planned in pristine areas by regulating the development of shore areas with the natural systems in mind before significant

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[1]This principle of natural harmony has been strengthened by a recent decision by the National Park Service to abandon attempts to "stabilize" and "protect" the barrier islands of the Cape Hatteras National Seashore. The decision was hotly opposed by some local shore owners who face property damage with upcoming storms but, in terms of the overall national seashore management plan, nature will provide its own best defense of the shore. Robert Dolan, a research scientist for the Park Service states in his report on the barrier island problem: "The best strategy for continued use of the land and water resources of barrier islands is, in most cases man with nature,not man against nature," "Park Service to Let Nature Reign," World Dredging & Marine Construction, Vol. 9, No. 14, December 1973, p. 63.

development takes place. In a sense, this connotes recognition of the natural servitude which nature demands on all shoreline property used by man, in effect an easement which can be invoked in due course through the inexorable processes of geomorphic evolution. Because of this very thing, in the populated coastal areas of the Great Lakes, and the world in general, man is faced with undoing, reevaluating and reconstructing many of his works along already developed shores. The task of bringing the structural works that have taken years to build back into harmony with natural shore systems will not be accomplished in a short time. Many riparian owners will continue to suffer erosion damage which will be a continued source of irritation and frustration. Law suits may be the last resort for many riparians seeking to recover for damages and to stop further activities that are leading to continued degradation of the shore environment.

This chapter is an analysis of four possible legal avenues that can be used by riparian owners to protect their rights and to direct future shore management decisions. In a general fashion the factual information that was developed for the St. Joseph case study area will be used as the

background for the discussion in each of the four alternative legal approaches.

This study was not undertaken to provide specific evidence for a series of law suits at St. Joseph but rather it was aimed at providing a rational, physical-and-legal basis for treating the shore erosion and shore management problems that arise when dealing with an already-developed shore condition. This chapter will provide a review of four legal avenues that would be applicable to guide the formulation of a case if all other channels of recovery fail.

The format of this chapter will be developed around the analysis of four different types of claims based on the analysis of the St. Joseph area. Using a hypothetical claim as the starting point, the legal basis for the claim and discussion of legal precedent will follow. The facts common to each claim as taken from the St. Joseph situation are summarized in a separate section immediately following this introduction. The last section will review the four alternatives in light of how they may best be applied to solving the shore erosion problem and ultimately

bringing about long-term shore management which reduces erosion risk and losses to a minimum.

Facts Common to Each Legal Claim

The discussion of the four types of legal action will be preceded by a summary of the basic facts from the information presented previously on the St. Joseph situation. All of the following information is more or less applicable to the development of any of the four court claims whether based on damages to riparian land or to the shore environment. However, in each individual argument certain facts will be emphasized more than others.

Historical Facts[2]

Prior to the settlement of the St. Joseph area in the 1820's the shore was in a state of near natural equilibrium. The St. Joseph River flowed over a shallow bar at its mouth and littoral sediment moved southward along

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[2]See, generally, "Chronology of Significant Events" in Chapter III.

the shore forming a spit of land that deflected the river to the south. Around 1835 the river mouth was reconstructed by placing a short pier on the north side of the channel cutting the spit in order to aid deeper draft boats in navigating the river. From this date in the nineteenth century until today the number of engineering works has steadily increased until the shore southward from the twin federal piers is a nearly continuous line of structures for a distance of five miles. By 1905 the Corps of Engineers had added length to the harbor piers several times and their present configuration was attained.

During high water periods on the Great Lakes in the 1880's and again in the early years of this century, very little erosion took place along the shore. By the 1920's or approximately 90 years after the first structure was placed at the river mouth, erosion caused damage to property south of the federal piers.

Since the 1920's millions of dollars have been spent by the City of St. Joseph, private firms, the State of Michigan and private riparian owners to protect the shore south of the federal piers from erosion. At the same

time land on the north side was accreting to the shore through littoral entrapment.

Subsequent to the 1950's high water period on the Great Lakes a study by the Corps of Engineers reported that 100,000 cubic yards of littoral sediment was being trapped each year by the federal piers. In 1968 the Congress of the United States authorized the Corps of Engineers to spend up to one million dollars without Congressional authorization to repair damages caused by navigational structures.

By the beginning of the present high water period on the Great Lakes in the late 1960's the shore south of the mouth of the St. Joseph River was buttressed by all forms of structural works built to protect the shore. The nearly five-year period since the firm storms of 1969 when shore erosion actively commenced has recorded a tremendous outlay of funds for repair and new construction of structural works. Most of the works have been totally ineffective in protecting the upland as intended and instead the erosion problem has been pushed southward along the shore by the presence of these works.

Scientific Documentation[3]

Through scientific inquiry certain facts concerning the physical disruption of the near shore environment were determined. The harbor mouth piers which extend outward 2,800 feet into the littoral zone along the shore provide an effective barrier to the southward moving littoral sediment. The effects of this sediment starvation on the shore area south of the piers are dramatic.

The offshore bar system has been severely affected. Lacking adequate sediment nourishment the bars which naturally regulate the wave energy reaching shore have not maintained a stable stage-bar relationship. Increased wave energy has been transferred farther landward in the absence of the bars. The increased energy and wave turbulence has led to accelerated erosion of the shore and headland. This response is best understood and predicted by the process-response model of the littoral environment.

A detailed study of aerial photos taken in 1938 and again in 1969, 1970, 1971, 1972 and 1973 reveals that erosion south of the river mouth has progressed at a rate

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[3]See, generally, Chapters IV and V.

several times that of other similar segments on the shores of the Great Lakes. On two short segments of unprotected shore at St. Joseph, erosion rates several times that of the overall rate for the St. Joseph area as a whole were measured. These rapid erosion rates on "undefended" segments within the nearly continuous line of engineering works was shown to be the result of small magnitude disruptions in the shore processes by specific structures along the shore.

Continued starvation of littoral sediment is predictable through an understanding of the process-response model. Erosion will continue on the south side of the piers until such time as the offshore bars are rebuilt to their natural condition. If allowed to continue unchecked, erosion of the headland will continue until the offshore bars are rebuilt with sediment derived from the eroded bluffs along the shore.

Regulatory Controls on Riparian Land[4]

Most of the shore south of the federal piers at St. Joseph is in a developed state. The regulation of the

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[4]See, generally, Chapter VI.

placement of dwellings on undeveloped riparian land was not stringent enough in the past to have prevented erosion damage from occurring. New land use controls are in effect which will surely prevent similar problems from arising in the future in other areas.

On this developed shore private riparian owners have sought through self help to protect their own property by placing structural works at the shore line. Those works constructed on the state-owned, public-trust bottom lands and those works which are built outward into the navigable waters of the United States are regulated by permit. In both instances prior approval for such structures must be secured from both the State of Michigan and the Army Corps of Engineers.

Authorization for Repair of Damages

The Army Corps of Engineers has long recognized the problems inherent with structural works such as piers, groins, jetties and seawalls.[5] The Corps maintains an

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[5] See, generally, Shore Protection Guidelines, Department of the Army, Corps of Engineers, Washington, D. C., August 1971.

active research program to determine the best methods to construct and maintain structural works along the water-land boundary. In 1968 an amendment[6] to the Rivers and Harbors Act of 1899 authorized the Corps to spend up to one million dollars to conduct studies and to repair damages to shore areas as the result of federal navigational works. The Corps of Engineers has been slow to act on the problem at St. Joseph with the exception that a study on the extent of erosion damages has been conducted but not yet released for public comment at the date of this writing.

Environmental Damage

The damages to the shores of Lake Michigan by accelerated man-induced erosion is damage to the total environment in the vicinity. The offshore areas have been disrupted, natural sand bars destroyed, the waters of Lake Michigan muddied by constant erosion and turbulence caused by structural works, and the natural vegetation on otherwise scenic bluffs has been lost.

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[6]Section 11 of the Rivers and Harbors Act of 1968, 82 Stat. 731.

While not a form of pollution per se this destruction of the natural shore conditions, a scenic natural resource, is environmental degradation. In similar situations along rivers and lakes polluted with waste and other effluents, and where government agency enforcement has been lax or non-existent riparian owners on their own behalf have sought recourse in law on both common law and environmental grounds.[7]

The environmentally degrading nature of the man-induced erosion at St. Joseph has reduced property values in the area subject to this erosion just as surely as if noxious industrial waste were constantly washed upon those shores. The anxiety of those faced with continued financial

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[7]Professor Sax's commentary on the environmental state of affairs is particularly poignant when he states:

> Private citizens, no longer willing to accede to the efforts of administrative agencies to protect the public interest, have begun to take the initiative themselves. One dramatic result is a proliferation of lawsuits in which citizens, demanding judicial recognition of their rights as members of the public, sue the very governmental agencies which are supposed to be protecting the public interest.

As quoted from "The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention," 68 Mich. L. Review 473 at p. 473.

loss without a doubt has led to the degradation of the quality of their lives. Many riparians at St. Joseph while moderately wealthy and able to afford an expensive home overlooking the lake have been pushed to near financial ruin. The costs of protective works, house moving, engineering consultants and attorneys have piled up to staggering sums often amounting to as much as the purchase price of the home and land originally.

The shore areas are owned collectively by all citizens of the State of Michigan and managed by public agencies of the State. All citizens who use and enjoy the beaches and offshore waters should have an interest in protecting this valuable resource, the shores of Lake Michigan.

The Common Law Tort Claim

The law of torts is an outgrowth of the Common Law which deals with the rights of property owners to use and enjoy their property. Under the Common Law, a property owner's rights are protected from both nuisance and

trespass.[8] Succinctly, a nuisance is a substantial and unreasonable interference with the right to use and enjoy one's property.[9] Trespass on the other hand is an "invasion of the property owner's exclusive right of possession of his land."[10] Trespass involves a physical interference with the use of property, while nuisance is a non-physical interference which annoys or disturbs the use of property.

The Claim

In a tort action the litigants would probably include adjacent or neighboring property owners with the legal basis being a demonstrated loss of property by one owner caused by the alleged acts of another. The conditions at St. Joseph along the two segments undergoing rapid erosion probably best illustrate the factual conditions needed to pursue a claim for damages. The actual tort claim would be a statement of the alleged acts, i.e., riparian A erected a structure at some point in time and

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[8] W. Prosser, The Law of Torts (2d ed., 1955).

[9] Ibid., p. 409.

[10] Ibid., p. 54.

riparian B suffered accelerated erosion as a result. The claimant B alleging these damages could seek to protect his rights by legal solutions under the common law of torts. The claimant, in this case B, would no doubt seek money damages for his losses and possible injunctive relief to remove the offending structure.

The Legal Basis

In the context of riparian law both nuisance and trespass could be used as basis for erosion damage claims. Between two property owners if A erects structures which divert the action of the waves so as to erode B's property then A is liable for trespass.[11] The agent of the trespass being the water. Riparian B in losing his property and the right to enjoy its use would also be suffering from a nuisance like act by A.

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[11] A legal point that is sometimes used as a defense is the claim that the tort was as the result of an "Act of God." The term "Act of God" (unforeseeable intervening force) is sometimes applied to such events as cloudbursts, floods and dam breakage. The question of the validity of such a defense in the context of the St. Joseph situation is beyond the scope of this study. For a more detailed review of this issue, the reader is directed to Prosser on Torts at pages 536 and 537.

The private tort action has the advantage that it does not depend upon state or local legislation. Consequently, the nuisance or trespass action gives the individual the opportunity to act in his own behalf where any other control legislation may not exist.[12]

Legal Precedent

The right of a riparian owner to protect his land from erosion by waves and currents is well established in Riparian Law.[13] This right to erect protective structures is, however, regulated by both state and federal government permits as has been discussed previously.[14] But the right of a riparian owner to protect his property cannot be at the expense of his neighbor's property. The erection and maintenance of protective works cannot infringe on the property rights of his neighbor's.[15]

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[12] "Private Environmental Legal Action," 7 Univ. of San Fran. L.R. 27 at p. 30.

[13] See 93 C.J.S. 623 Waters §§ 19, Embankments, Levees, and other Works to Protect Property.

[14] See Chapter VI for a detailed discussion.

[15] Note 13 supra.

In general, the distinction between riparian ownership on a lake or stream is not made from the legal standpoint. Littoral rights are those relating to proprietorship along the shore of a lake or the ocean. Littoral rights are for all practical purposes equal to riparian rights on flowing streams in that they are an offshoot of long established common law doctrine of riparianism. Most of the precedent for the common law tort action can be drawn from riparian law governing water flowing in a channel.

Under riparian law in a strict interpretation, the riparian owner's right to receive water unchanged in natural condition is guaranteed.[16] In a particular situation where the upstream or updrift riparian A has altered the

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[16]There have developed two general doctrines for allocating the use of water by riparian owners. First, in the absolute sense, natural flow must be maintained for subsequent downstream riparians. Therefore, no riparian may impair or diminish the flow of a stream to the detriment of other riparians. A more common interpretation is afforded in the second doctrine, that of reasonable use. Under this theory each owner has the right to make a reasonable use of the water taking into account the needs and uses of other riparians. The test of reasonability is made by the courts in the legal sense. The reader is directed to Professor Sax's, Water Law Cases and Commentary at pages 8-10 for a detailed discussion of these two doctrines.

shore configuration to the extent that natural flow (i.e., sediment flow) is not reaching the lower or downdrift owner B, in its natural state, then B has legal recourse under the common law for relief or damages from this act.

The allegation that A's structures are responsible for B's erosion losses where A's structures have diverted the action of the waves to the detriment of B's property must, of course, be documented. Assuming that the documentation of this relationship is established, then precedent would generally support A's riparian rights.[17]

Precedent can be cited from two western states where stream waters were diverted by structures to the detriment of lower riparians and where the courts supported the lower riparian's rights. In both Schlect v. Schiel[18] in Arizona, and Weck v. Los Angeles County Flood Control District,[19] the courts held that water could not be diverted onto a lower riparian's property to that owner's detriment.

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[17] Note 13 supra.

[18] 76 Ariz. 214, 262 P. 2d 252.

[19] 80 Cal. App. 2d 182, 181 P. 2d 935.

The Federal Tort Claim

The federal tort claim is a second method available to the riparian owners at St. Joseph and other locations in the United States where erosion damages have been caused by works of the federal government. In a federal tort claim the facts may be nearly identical to those in a common law action between private owners with the difference being that the respondent would be the federal government.[20]

The Claim

Given the factual information summarized at the beginning of this chapter the claim could include the allegations that the Army Corps of Engineers has been responsible for accelerated erosion on the shore south of the piers they erected and maintain for navigational purposes. The piers, as it can be documented, have caused the littoral currents and the nourishing sediment carried by

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[20] In the language of the Federal Tort Claims Act, 28 U.S.C.A. § 1346 [b], the Federal is liable "Under circumstances where the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred."

those currents to be blocked and diverted to the extent that erosion has accelerated to a rate far in excess of the natural erosion rate which occurs during high water stages on the Great Lakes.[21]

The loss of land and the infringement of the rights of individual riparians constitutes a tortuous act whereby the use and enjoyment of this land has been severely limited. Further, it could be claimed that this loss of land through the acts of the federal government would be an "inverse condemnation"[22] and would constitute a "taking" of land without the just compensation[23] that is due under the Fifth Amendment to the Constitution of the United States.[24]

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[21]See Chapter V under Erosion Rates 1938-1970--The Basis for Claim Against the Federal Government.

[22]Inverse condemnation is the taking of property by an actual interference with or disturbance of property rights, without an actual entry upon the property. See Ballentine's Law Dictionary for a more complete definition.

[23]See Chapter VI, note 5.

[24]U.S. Const. Amend. V.

In an actual case involving an inverse condemnation the amount of land taken would have to be documented and a value assigned.[25]

The Legal Basis

The federal government in the course of its operations such as those conducted by the Army Corps of Engineers undertakes certain activities which lead to infringement on the rights of private citizens. In the case of erosion damage at St. Joseph the actions of the Corps of Engineers have led to infringement on private riparian rights. The facts may be nearly identical to those involving private citizens in a common law tort claim. The legal mechanism for undertaking a tort claim involving the federal government is spelled out in the Federal Tort Claims Act.[26] The Judicial Code confers jurisdiction in the Court of Claims in Washington, D. C. to render judgment upon any

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[25] The measurement of compensation for damages is often the significant issue in Federal Tort Claims, see generally in Joseph L. Sax's Water Law, Cases and Commentary, beginning at p. 387 for a detailed discussion of compensation.

[26] 28 U.S.C.A. § 1346 [b].

claim against the United States founded in the Constitution. As stated in the claim above, this would be a case of "taking" without compensation, hence a constitutional issue. Under the so-called Tucker Act[27] the District Court is given concurrent jurisdiction with the Court of Claims for claims of less than $10,000. In any actual case situation the claims for damages would probably be for amounts greater than the $10,000 figure, so these claims would be made in the Court of Claims.

Legal Precedent

The discussion of precedent in this type of action centers around the doctrine of navigation servitude.[28] The facts in the case of accelerated erosion at St. Joseph are nearly identical to those in several other cases in which the facts involved were not disputed by the federal government but rather the basis for judgment was on the issue of navigation servitude.

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[27] 28 U.S.C.A. § 1346 [a].

[28] See Joseph L. Sax, Water Law, Cases and Commentary, beginning at p. 375 for a detailed discussion of navigation servitude, the reader is also directed to Chapter VI, note 2.

The right to recover for damages against the federal government would require that the plaintiff show that there exists a property right in the uninterrupted and natural flow of the waters of Lake Michigan. Under the riparian law as was discussed previously under the Common Law Tort Claim, this right has been supported many times over on other bodies of water and there is no reasonable doubt that this would be the holding here also if the federal government were not the defendant. Under riparian law, however, this right is accepted under all cases except against the federal government when the maintenance of waterborne commerce is involved.[29]

There are two "name" cases that have essentially the same set of circumstances as the situation at St. Joseph, Michigan, Pitman v. United States,[30] a 1972

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[29]Three rather extensive articles give an excellent review of the concept of navigation servitude--no compensation to which the reader is directed, they are: Eva H. Morreale's, "Federal Power in Western Waters: The Navigation Power and the Rule of No Compensation," 3 N.R.J. 1 (May 1963); Richard W. Bartke's, "The Navigation Servitude and Just Compensation--Struggle for a Doctrine," 48 Ore. L.R. 1, (1968); and Leighton L. Leighty's, "The Source and Scope of Public and Private Rights in Navigable Waters--Part I," 5 L. & W.L.R. 391, (1970).

[30]3 ERC 2057.

Florida case involving the federal navigation structures at Cape Canaveral, and a 1923 Oregon case, Southern Pacific Company v. United States,[31] involving the federal navigation structures at the mouth of Tillamook Bay. Much of the discussion of precedent for the Federal Tort Claim has been through an analysis of the citations presented in these two cases. Both Pitman and Southern Pacific focus on the same type of factual situation that is found at St. Joseph.[32] The minor distinction is between the bodies of water in question, the Atlantic and Pacific Ocean as against Lake Michigan; however, the governing physical principles are essentially independent of the size of the

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[31] 58 C. Cls 428.

[32] In Pitman v. United States (3 ERC 2057), the claim was made that 4.4 acres of land were lost through erosion as a result of the placement of the federal piers at the entrance to Canaveral Harbor. This property either lost or damaged was valued at $111,473 according to the "Plaintiff's Original Complaint" filed by E. L. Koepenik, attorney for the plaintiff.

The damages in Southern Pacific Company v. The United States, 58 C. Cls 418, on the other hand in a nearly identical set of circumstances was only for repair of damage to property in excess of $80,000 for the replacement of roadbed and track eroded by the water diverted by the federal structures at the entrance to Tillamook Bay, Oregon.

water body. From the legal standpoint most of the case law used in deciding both Pitman and Southern Pacific was drawn from cases involving navigable streams rather than the ocean.

In all of the cases that have been examined the plenary power of the United States over navigable waters for the purpose of regulating and improving navigation is so firmly established that it has become axiomatic. This constitutional authority is delegated to the Congress of the United States which has the power:

> to order obstructions to be placed in the navigable waters of the United States, either to assist navigation or to change its direction by forcing it into one channel of a river rather than the other. It may build lighthouses in the bed of a stream. It may construct jetties.[33]

The "Commerce Clause" of the Constitution further states that

> the United States has the power to improve its navigable waters in the interest of navigation without liability for damages resulting to private property within the bed of the navigable streams.[34]

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[33] From the opinion of the Supreme Court in South Carolina v. Georgia, et al., 93 U.S. 4, 11-12 (1876).

[34] U.S. Const. Art. I, § 8, Cl. 3, (emphasis added).

While this constitutional power is the broad basis for exempting the government from liability, it is rather the interpretation of the navigational servitude (easement) to which all land bordering navigable waters is subject that is the basis for most decisions.[35]

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[35]The scope of Commerce Clause of the U.S. Const. Art. I § 8, Cl. 3 is well defined in the various "name" cases relevant to this issue. The holdings in United States v. Kansas City Life Insurance Co. 339 U.S. 799, United States v. Willow River Power Co., 324 U.S. 499, United States v. Lynch, 188 U.S. 445, United States v. Criss, 243 U.S. 316, United States v. Chicago B. & Q. R. Co., 82 F. 2d 131, Jackson v. U.S., 230 U.S. 1, Tennessee Gas Transmission Company v. U.S., 383 U.S. 943, Coates v. United States, 93 F. Supp 637, in addition to the two cases of similar nature to the facts at St. Joseph, Southern Pacific Co. v. United States, 266 U.S. 586, and Pitman v. United States, 3 ERC 2057, all lend support to the federal government's right to maintain commerce without liability for damages to private property. In Joseph L. Sax's text, Water Law, Cases and Commentary at page 383, Professor Sax states the theory of servitude succinctly:

> It is not the broad constitutional power to regulate commerce, but rather the servitude derived from that power and narrower in scope, that frees the Government from liability in these cases. When the Government exercises this servitude, it is exercising its paramount power in the interest of navigation, rather than taking the private property of anyone. The owner's use of property riparian to a navigable stream long has been limited by the right of the public to use the stream in the interest of navigation. (emphasis added)

In Pitman v. United States 3 ERC 2057 and Southern Pacific Company v. United States 58 C. Cls 428 the two cases used

From the point of view of the possible plaintiffs in a claim against the federal government, the decision in United States v. Commodore Park[36] seals their fate, so to speak. In referring to the dominant servitude of riparian land the Supreme Court held that riparian or littoral owners have no vested rights in the flow of navigable waters as against the government. The Court said:

> It is well established that under the Riparian Doctrine a riparian owner has a right to have navigable waters come to him unchanged in their natural condition as against other riparian owners but the courts have held he has no such right against the paramount power of the United States to improve navigation.[37]

The weight of precedent involving the dominant servitude of riparian or littoral land to the power of the government to improve navigation fairly well establishes that there is scant possibility for recovery in such actions against the United States government. The concluding statement of the court in Pitman states this point rather well:

> There is no doubt that plaintiff has sustained damages and that a substantial portion of the

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extensively in this research, the basis for the defense was on the doctrine of navigation servitude.

[36] 324 U.S. 386, 1945.

[37] Ibid.

> damages he claims are due to the construction and maintenance of the Canaveral Harbor project. However, in order to permit recovery of this case, it would be necessary for us to overrule the cited decisions of this court and to ignore many controlling decisions of the Supreme Court.[38]

A Claim Under the Michigan Environmental Protection Act[39]

The riparian owners at St. Joseph, Michigan have an additional legal avenue open to them because of their residence in the State of Michigan. Michigan was the first state to enact an environmental law which specifically grants private citizens the right to file suit against anyone to protect the air, water or other natural resources.[40] The shore of Lake Michigan is one of the most valuable natural resources in the state.

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[38] 3 ERC 2057.

[39] The Thomas J. Anderson, Gordon Rockwell Environmental Protection Act of 1970, Act No. 127 of the Michigan Public Acts of 1970.

[40] At the time of this writing (December 1973), 14 states have passed legislation similar to Michigan's EPA.

The Michigan Act[41] opens a new area of law that is yet untested in the context of protecting the shore environment from degradation. To the date of this writing more than fifty suits have been filed in the State of Michigan using the Environmental Protection Act (EPA) as a basis. Most of these cases have treated the more traditional forms of pollution such as degradation of the air and water.

A problem in the context of the situation at St. Joseph where the destruction of the shore environment is involved has yet to be formulated into a legal argument.

The Claim

The language of the Michigan Act could be used to formulate two types of claims. First, the Act could be used as an alternative approach to remedies already provided under the common law. In such a situation the argument presented would probably rely on both traditional riparian law and the precedent of cases decided in the more recently developed field of environmental law as the basis

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[41]Act 127 of the Michigan Public Acts of 1970 referred to subsequently as the Act or the EPA.

for the claim. The second application of the Act could be to bring state government to task for failure to manage the public trust lands[42] in such a way as to prevent degradation of the shore environment.

The Legal Basis

The legal basis for making a claim for damages to the shore environment is found in the language of the Michigan Act itself. Section 2 of the Act is the legal basis under which a suit could be filed. Section 2 states:

> The Attorney General, any political subdivision thereof, any person, partnership, corporation, association, organization or other legal entity may maintain an action in the circuit court having jurisdiction where the alleged violation occurred or is likely to occur for declaratory and equitable relief against the state, any political subdivision thereof, any person, partnership, corporation, association, organization or other legal entity for the protection of the air, water and other natural resources and the public trust therein from pollution, impairment or destruction.[43]

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[42] See generally Joseph L. Sax, "The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention," 68 Mich. L. Rev. 473.

[43] Note 39, supra, Section 2.

The important feature of this Act is the granting of legal standing[44] to any citizen to file suit against any public agency, industry, citizen or any other legal entity to protect the "air, water and other natural resources and the public trust therein from pollution, impairment or destruction." As a procedural problem lack of legal standing prevented many suits from being heard in the past.

Legal Precedent

There is no actual legal precedent from court decisions at the appellate level to guide this research.

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[44]A party must have legal standing in court before the case will be heard. Standing has been generally interpreted to mean there must be enough interest in the case to have a substantial stake in the outcome. The Michigan EPA specifically grants standing in the language of the statute. Prior to EPA the standing issue blocked many class action suits by interested groups that lacked standing under the traditional test. At the federal level similar standing questions have been raised with the more liberal test of standing being commonly used (see Sierra Club v. Morton 405 U.S. 727, Justice Douglas' dissenting opinion). The most recent decision that may indicate a reversal of this trend was the December 17, 1973 decision of the Supreme Court affirming the lower court decision in Zohn et. al. v. International Paper Company 59 F2d 1033, Supreme Court docket No. 72-888. The court held that each plaintiff in a class action suit must satisfy the jurisdictional amount.

There is, however, a Michigan Law Review article by Joseph L. Sax,[45] the author of the original Michigan Environmental Protection Act.[46] Professor Sax's article is a detailed review of all cases tried in the first 16 months after the date of enactment. In this time period no case had reached the appellate level but through Professor Sax's research there is an accurate review of the circuit court decisions that would normally go unreported. It is on the basis of Professor Sax's research rather than actual reported case law that this discussion of precedent is made.[47]

Two basic types of court actions can be expected in a situation such as is present at St. Joseph. First, the EPA could be used as a substitute for or in conjunction with established common law remedies. And, second, the EPA could strike out on relatively new territory and bring

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[45] J. L. Sax and R. L. Conner, "Michigan's Environmental Protection Act of 1970: A Progress Report," 70 Mich. L. Rev. 1003-1097, hereafter cited as Sax.

[46] Note 39, supra.

[47] Case precedent is normally drawn from appellate or higher level decisions but lacking a test of the EPA by a higher court the Sax article remains the only report on the status of the Act.

public agencies to task if their administration of regulations regarding the air, water and other natural resources is felt to be inadequate.[48] Individual riparian owners may wish to exercise this right along or in conjunction with conservation oriented groups. Many of the previous cases under the EPA have been brought by conservation or citizen groups.[49]

The use of the EPA as a substitute for common law nuisance action among neighbors was first used in Crandall v. Biergans,[50] an action brought against the owners of an odorous hog barn. In Blunt v. Apfel,[51] Water Resources Commission (WRC) v. Chippewa County,[52] and Lakeland Property Owners Association v. Township of Northfield[53] and

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[48] Note 42 supra.

[49] The class action approach has been effective for many reasons but from a practical standpoint the financial resources of the larger groups are usually needed to carry out the environmental suit to the highest court, see note 44 supra.

[50] See Sax, note 45 supra, p. 1037, from a tape of the trial on file with Professor Sax.

[51] Ibid., p. 1049, from Decision and Order by Judge Brown (June 10, 1971).

[52] Ibid., p. 1008 and accompanying footnotes.

[53] Ibid., p. 1025 and accompanying footnotes.

several other cases the use of the EPA was used instead of established remedies. In Blunt the action was taken to stop impending water pollution from an allegedly inadequately designed septic tank system. The plaintiff sought to protect the waters of Torch Lake, one of the most beautiful lakes in the state. In WRC v. Chippewa County the issue was the pollution of the ground water by salts from a county-owned storage pile. The WRC entered the case on behalf of the local property owners whose wells were being polluted by the salts. In Lakeland the plaintiff property owner's association sought to stop stream pollution where the effluent levels were already under the restriction by the Water Resources Commission. The basic issues in each of these cases were ones that could have been tried as a nuisance claim.[54]

There seems to be no unwillingness on the part of attorneys to use the EPA in challenging actions that would in the past have been brought under the common law. There

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[54] In Crandall the court upheld the defendants right to maintain a hog raising operation on his property. Blunt and WRC are both pending at the time of this writing and in Lakeland the plaintiff property owner's claim but, according to Professor Sax, note 45 supra (at 1091, note 1) the case may be appealed.

have been enough cases tried in the lower courts using EPA as a basis to give the Act a certain amount of depth, even without a test of its constitutionality in the higher courts.

The second area where the Michigan EPA could be brought to bear could be in the situation where proper enforcement or protection of the natural shore areas was felt to be lacking by the respective agency charged with that duty. This is the area where the possible plaintiffs would be striking out on relatively new territory. The Water Resources Commission, the agency regulating structural works in public trust waters, could be a possible defendant in a suit brought to force more strict review of permits and permitting procedures. This claim against the very agency in charge of protecting the natural resources of the state would be similar to several that have been reviewed by Professor Sax.[55]

Roberts v. Michigan[56] represents the farthest extreme that the EPA has been taken in cases against state

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[55]Note 45 supra.

[56]See Sax, note 45 supra, p. 1017.

agencies. In Roberts the plaintiff sought to bring the Michigan State Highway Department to task for failing to deal with automotive air pollution. Because the Highway Department's main task is building and maintaining the public roads rather than controlling the automobile traffic and emissions, the suit was dismissed. In Payant v. DNR[57] the plaintiff brought suit against the Michigan Department of Natural Resources to ban antlerless deer hunting. The DNR had been under fire for its antlerless deer hunting season which it was claimed by the plaintiff was the reason for the decline in the deer herd in the upper peninsula. The case was directed at a policy of the DNR's Game Division. Rapid response by the judiciary allowed the upcoming hunting season to continue with the taking of antlerless deer being upheld as a legitimate game management technique of the DNR.

The cases in point which have been mentioned serve to illustrate that the state's EPA is a viable tool (at least pending a constitutional test) to be used to protect the natural resources of the state. In the first 16 months

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[57] Ibid., p. 1016.

after enactment some 36 cases were brought under this act.[58] This number indicated no reluctance in any way on the part of individuals, conservation groups, agencies and other public bodies in pursuing an action using the EPA.

In the context of the St. Joseph situation the EPA of Michigan could be used two ways. First, the riparian owners who may seek to pursue a common law tort claim against neighboring riparians should add strength in their claims for physical damages by including reference to environmental degradation. And, second, on the question of opposing state agency actions, a more useful approach in this writer's opinion may be to use the Act as a tool to secure a moratorium on permits until further environmental and engineering alternatives are forth coming. The application of Michigan's EPA could be used with equal effectiveness in other situations where further permitting of structures would lead to compounding of shore erosion and shore management problems.

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[58] Note 45 supra.

A Claim Under the National Environmental Policy Act (NEPA)[59] and Administrative Procedure Act (APA)[60]

The erosion problem at St. Joseph, Michigan is primarily the result of actions by the Corps of Engineers, an agency of the federal government. The federal tort claim was shown to be a method of securing damages or relief from the federal government. Unfortunately, however, the authority of the Congress to regulate commerce, hence navigation, in deference to private property makes the federal tort claim nearly useless in cases where riparian owners attempt to obtain damages and relief from damages resulting from government actions.[61]

The National Environmental Policy Act (NEPA) was enacted at the end of the last decade (1969) after several years of political pressuring by environment, ecology and

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[59] 42 U.S.C. §§ 4321-47 (1970).

[60] 5 U.S.C. §§ 701-06 (1970).

[61] The issue of navigation servitude has been discussed previously in this chapter.

conservation oriented groups.[62] The NEPA has given valuable strength to the environmental and ecology movement by providing the means for judicial review of government actions where environmental harm is possible.

Unlike the Michigan Environmental Protection Act, the NEPA does not allow citizens to sue for relief or enjoin an action causing pollution or environmental degradation directly, but rather it is legislation that lays down a set of environmental guidelines.[63] It requires that prior to any "federal action"[64] which might "signif-

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[62]The NEPA was the first of several environmental laws passed by Congress in the first two years of this decade. Other environmental laws included The Clean Air Amendments of 1970 (Pub. L. No. 91-604, 84 Stat. 1676 Amending 42 U.S.C. §§ 1857-571 (Supp. V, 1970)), the Federal Environmental Pesticide Control Act of 1971, (Pub. L. No. 92-516 (Oct. 21, 1972), amending 7 U.S.C. §§ 135 et. se (1970)), and the Federal Water Pollution Control Act Amendments of 1972, (Pub. L. No. 92-500 (Oct. 18, 1972), formerly 33 U.S.C. §§ 1151-75 (1970)).

[63]The Federal Water Pollution Control Act Amendments of 1972 grants standing and allow direct intervention in pollution cases and congressional amendments have been proposed for NEPA to grant standing.

[64]The definition of "federal action" is generally defined under 42 U.S.C. § 4332(2) (c) (1970) and specifically in the Interim Guidelines § 5 (a) (hereinafter cited Interim Guidelines) in Environment Rep., Federal Law 71: 0301 which state:

icantly (affect) the quality of the environment"[65] the filing of a "detailed statement"[66] which must include:

i) the environmental impact of the proposed action,

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i) Recommendations or favorable reports relating to legislation including that for appropriations . . . . Agency recommendations on their own proposals for legislation and agency reports on legislation initiated elsewhere . . . .
ii) Projects and continuing activities; directly undertaken by Federal agencies; supported in whole or in part through Federal contracts, grants, subsidies, loans or other forms of funding assistance; involving a Federal lease, permit, license, certificate or other entitlement for use;
iii) Policy, regulations, and procedure-making.

[65]The Interim Guidelines § 5(a) generally define the environmental parameters which must be examined to determine if the "actions" will have any "significant affects" on the environment. The Guidelines state:

> Those (actions) that degrade the quality of the environment, curtail the range of beneficial uses of the environment, and <u>serve short-term, to the disadvantage of long-term, environmental goals</u> (emphasis added). Significant effects can also include actions which may have both beneficial and detriment effects, even if, on balance, the agency believes that the effects will be beneficial. Significant adverse effects on the quality of the human environment include both those that directly affect human beings and those that indirectly affect human beings through adverse effects on the environment.

[66]The "detailed statement" has become known as the "Environmental Impact Statement" or simply the EIS.

ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,

iii) alternatives to the proposed action,

iv) the relationships between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and,

v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.[67]

In addition to the five points listed above, the NEPA requires that prior to any significant action by the federal government a multidisciplined study of all environmental factors be undertaken.[68] The NEPA sets forth environmental quality as a national policy and directs all federal agencies and departments critically to examine all ecological parameters before making any decisions that might adversely affect the environment.

Failure to comply with these requirements has brought many government projects to a halt until the environmental studies and environmental impact statement

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[67] 42 U.S.C. § 4332(2)(c) (1970).

[68] The level of inquiry and the details which the study must include are outlined in Section 102(c) of the NEPA, 42 U.S.C. § 4332(c) (1970).

(EIS) were completed.[69] Many of these federal projects were never completed because the environmental studies drew attention to previously overlooked detrimental impacts. The Corps of Engineers was a favorite target of early court battles using the NEPA as a basis.[70]

The Administrative Procedures Act (APA) has been used in conjunction with the NEPA where the question of standing[71] for various conservation groups has been raised. The APA sets forth the procedure for granting

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[69]All projects fitting the Interim Guidelines criteria outlined in note 64 had environmental impact statements filed not all of which were challenged for their inadequacy by citizens groups. Several projects such as the Cross Florida Barge Canal were stopped after a large portion of the project was finished, EDF v. Corps of Engineers, 324 F. Supp. 878.

[70]Three early suits filed under NEPA were those involving the Corps of Engineers and the Environmental Defense Fund (EDF). These cases are discussed below in the text and include: EDF v. Corps of Engineers, 324 F. Supp. 878 (D.D.C. 1971) involving the Cross Florida Barge Canal project of the Corps, EDF v. Corps of Engineers, 325 F. Supp. 749, (1971) involving the damming of the Cossatot River in Arkansas, and EDF v. Corps of Engineers, 331 F. Supp. 925 (D.D.C. 1971), involving the Corps Tennessee-Tombigbee Waterway project.

[71]See note 44 supra.

standing to persons (or groups) aggrieved by agencies of the federal government.[72]

The Claim

Lacking the authority to sue directly for damages or relief under the NEPA, the claim would have to be directed at showing that the Corps of Engineers has failed to comply with the procedures set forth in the Act. The fact that the Corps permitting procedure for shore protection structures placed in the navigable waters represents a "federal action"[73] which "significantly (affects) the quality of the environment."[74] The irreversible disruption of the shore environment by structural works has been documented previously in this study. Numerous structures have been constructed under Corps of Engineers' permits subsequent to the NEPA without the required "detailed statement" of the impact of the proposed action on the shore environment. Failure to comply with the provisions of the

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[72]The actual procedures are discussed subsequently in the section titled "The Legal Basis."

[73]See note 64 supra.

[74]See note 65 supra (emphasized portion).

NEPA could be grounds for the court to review existing permits and enjoin future permit applications for lake work along the St. Joseph shore until such time as the necessary environmental impact studies are conducted. The claim under the set of facts at St. Joseph would be a further test of the limits to which the courts are willing to extend the definition of a "significant federal action."[75]

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[75]There has been a broad range in interpretation of the "significant action" clause of NEPA by the courts. The Second Circuit Court of Appeals has recognized that the construction of a jail in a narrow space across two apartment houses would have a "peculiar environmental impact" which might fall within the purview of NEPA Section 102(2)(c) Handy v. Mitchell, 460 F. 2d 640, 4 ERC 1152. The court has held that the action of the Army Corps of Engineers in issuing a discharge permit under the Refuse Act of 1899 requires an environmental impact statement, Sierra Club v. Sargent, 3 ERC 1905 (W.D. Wash. 1972). In Citizens for Reid State Park v. Laird 336 F. Supp. 783, 3 ERC 1580, the Court held that the Department of Defense was right in determining that the amphibious landing of 900 Marines in a state park was not a significant action. Highway widening from two-lane to four-lane over a distance of 12 miles was a significant action requiring and EIS, Scherr v. Volpe, 336 F. Supp. 882, 3 ERC 1586 (W.D. Wis. 1971), aff'd Scherr v. Volpe 466 F. 2d 1027, 4 ERC 1435 (7th Cir. 1972). In SCRAP v. United States, 4 ERC 1312, it was held that Interstate Commerce Commission action on a temporary freight rate increase would be a major action and if it arguably would have an adverse impact on the environment an EIS is needed. In the situation at St. Joseph the significance of the federal action (in permitting structures) would require an EIS. It would seem, therefore,

The Legal Basis

The legal basis for a suit against the Corps of Engineers can be found in the language of the National Environmental Policy Act of 1969.[76] Specifically, section 101(c) states: "The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

Should the plaintiff in a suit under the NEPA not be a directly aggrieved party in which a question of standing would arise, then the Administrative Procedure Act[77] could be used. In a long, involved court battle where appeal is certain, local property owners alone probably would not be in a financial position to sustain such a battle. A common tactic has been that the financial resources of a larger group are brought into play when groups

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that in the resource management field any action which enables a major undertaking with significant impact on the environment would be a "major" action "significantly" affecting the quality of the human environment.

[76] Note 59 supra.

[77] Note 60 supra.

such as the Sierra Club or the Environmental Defense Fund initiate suits on behalf of many individuals and groups.[78]

The APA could be used as a legal basis for granting standing to a conservation or environmental group such as the Lake Michigan Federation,[79] for example, to handle this function. The APA grants the right of standing to any person "adversely affected or aggrieved by agency action within the meaning of a relevant statute."[80]

The standing requirements under the APA are met when a two-part test is satisfied. First, the plaintiff must show that he is "aggrieved"[81] by the agency action

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[78]Such class action tactics have been useful in generating more broadly-based support for lawsuits. As was discussed in note 44 supra this tactic has its limits.

[79]The Lake Michigan Foundation is a Chicago-based group whose goal is preservation of the waters and shores of Lake Michigan. This group could in turn seek support from local groups such as individual citizens or property owners, groups and larger organizations such as the Sierra Club or the Environmental Defense Fund.

[80]5 U.S.C. § 702 (1970). The APA allows the use of any statute which expresses an intent to consider the environmental consequences of a federal action. For a more detailed analysis of the APA's application in standing issues see Comment, "The Engineers," 8 Cal. Western L.R. 488.

[81]Because most conservational enactments are intended to benefit man, any member of the public can be

and second, a "relevant statute"[82] must be found which has enunciated conservational goals. In general, the APA allows the use of any statute which expresses an intent to consider the environmental consequences of a federal action. The NEPA and the Rivers and Harbors Act both provide the language expressing environmental goals to satisfy this test.

Legal Precedent

The boundaries of the National Environmental Policy Act (NEPA) have yet to be firmly established by the courts. The action which has been suggested as a possibility for helping the St. Joseph riparians in the claim stated above

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shown to be aggrieved by the violation of such a statute. A few cases that support this theory are: Association of Data Processing Service Organizations v. Camp 397 U.S. 150 (1970); Barlow v. Collins, 397 U.S. 159 (1970); Flast v. Cohen, 392 U.S. 83 (1968); Environmental Defense Fund v. Hardin, 428 F. 2d 1093 (D. C. Cir. 1970); Scenic Hudson Preservation Conference v. Federal Power Commission, 354 F. 2d 608 (2d Cir. 1965), cert. denied, 384 U.S. 941 (1966).

[82] Note 80 supra.

would go further in establishing limits for the Act.[83] Three cases involving the Environmental Defense Fund, Inc., (EDF) and the Corps of Engineers indicate a liberal trend in the interpretation of the NEPA. These three cases provide significant precedent for an action to protect the St. Joseph shore environment.

The first of the famous EDF cases was centered around the Cross-Florida Barge Canal. In EDF v. Corps of Engineers[84] the plaintiffs sought preliminary injunctive relief against the Corps to prevent further construction on the Cross-Florida Barge Canal. While conceding that the canal was duly authorized, they argued that it was being built in violation of several statutes designed to preserve the natural resources of the nation. In EDF the plaintiffs alleged violations of NEPA, the Fish and Wildlife Coordination Act and the Act of July 23, 1942. Even though the barge canal project was well underway at the time, the court granted the injunction, and in doing so it stated that: "(t)he public interest in avoiding, if

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[83] Note 75 supra.

[84] 324 F. Supp. 878.

possible, any irreversible damage to the already endangered environment is paramount."[85]

Further, the court said: "The NEPA recognizes a 'continuing responsibility of the federal government' to strive to preserve and enhance the environment, and requires a detailed and systematic consideration of the environmental impact of federal actions."[86] The need for a detailed and multi-disciplined statement on the impact of the Corps action was thus strengthened by this holding.

A second EDF v. Corps of Engineers[87] case further defined the completeness of the required environmental statement. In this second EDF case the plaintiffs sought to enjoin the construction of a dam across the Cossatot River in Arkansas for failure to file a detailed environmental impact statement in accordance with the NEPA. The project at the time was two thirds complete. The Corps had submitted statements on the impact of the project on the environment on two occasions. The first was rejected

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[85] Ibid. at p. 880.

[86] Ibid.

[87] 325 F. Supp. 749.

as being incomplete and the second was similarly rejected as "a 'recast' (of) the information already in their files."[88]

The court granted the injunction against the Corps and the Secretary of the Army thus stopping a project nearly two thirds complete. In granting an injunction on an on-going project the court established precedent for the application of the NEPA to projects already approved and under construction prior to the enactment of the NEPA.

A third case, also EDF v. Corps of Engineers,[89] was initiated to stop the planning, development and construction of the Tennessee-Tombigbee Waterway. An injunction was sought to stop the Corps from turning the free-flowing Tombigbee River in a channelized stream system with low water flow. The court granted the injunction prior to the awarding of the construction contracts for the first phase of the project. In granting the injunction the court held that the planning, design and development of the waterway project required the filing of a

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[88] Ibid. at p. 758.

[89] 331 F. Supp. 925.

detailed environmental impact statement pursuant to the NEPA.

The three cases discussed above specifically related Corps activities under the NEPA. The range of federal government activities which might significantly affect the environment has subsequently been expanded to include a wide variety of actions. The government-wide agency response has been to provide an environmental impact study for a wide variety of projects and activities. The Corps routinely provides impact studies for harbor maintenance dredging, harbor works, beach nourishment and erosion control projects.

The precedent for developing an impact study prior to the granting of a federal permit is already established for activities such as mining, offshore oil exploration and timber cutting.[90] This precedent could be used to force applicants for permits for shore structures as in the case

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[90] Note 75 supra; and for a recent discussion of NEPA application to agency activities see Donald L. Humphreys' article, "NEPA, and Multi-Agency Actions--Is the Lead Agency Concept Valid?" 5 NRL 257, (1973).

of the St. Joseph shore area to provide similar environmental impact studies.

If the citizens at St. Joseph were to bring suit under the NEPA they would no doubt need adjunct support in their cause. The support would no doubt be forthcoming from other conservation or environmental groups active in the Great Lakes area.[91] The precedent for allowing a citizens group or conservation organization the necessary legal standing has been developed through cases in which the Administrative Procedures Act was used as the legal basis. As was discussed earlier, the use of the APA requires satisfaction of a two part test, first, showing that the party is "aggrieved" and, second, finding a "relevant statute." The NEPA alone provides the "relevant statute" for enunciation, conservational or environmental goals. The requisite standing needed for intervention by an environmental group has been developed over the past eight years. Standing to sue traditionally was based on a narrow interpretation of that point.[92] The Michigan

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[91] Note 79 supra.

[92] Note 44 supra.

Environmental Protection Act previously discussed handles the standing question directly. It grants standing in the specific language of the Act. On the federal level, the interpretation of the rules of standing have expanded greatly in the eight years since the federal court of appeals held in Scenic Hudson Prevention Conference v. Federal Power Commission[93] that incorporated conservation organizations were "aggrieved parties" within the meaning of the Federal Power Act.

The court in Scenic Hudson provided the first interpretation of standing where a conservation group was allowed to intervene on the basis of widespread harm to the environment rather than protecting an economic interest. The concept of non-economic public interest was strengthened with the Supreme Court decision in Association of Data Processing Service Organization, Inc. v. Camp.[94] Justice cited Scenic Hudson for authority that the legal interest to be protected "(may) at times . . . reflect 'esthetic,

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[93] 354 F. 2d 608 (2d Cir. 1965).

[94] 397 U.S. 150 (1970).

conservational and recreational' as well as economic values."[95]

The most recently decision which strengthens the guidelines laid down Scenic Hudson and Data Processing was the Supreme Court's April 1972 decision in Sierra Club v. Morton.[96] In this decision the dissenting opinion of Justice Douglas again stresses a liberal interpretation of the standing issue.

The Legal Avenues in Perspective

Suits Among Neighbors

The lawsuit is not the best tool by which lasting neighborly relations are established and maintained. The use of the common law tort remedy the Michigan EPA may be the best "quick action" remedy available to individual riparian owners.[97] The threat of legal action through

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[95] Ibid. at p. 154, quoting from Scenic Hudson Preservation Conference v. Federal Power Commission, 354 F. 2d 608 (2d Cir. 1965).

[96] 405 U.S. 727 (1972).

[97] The court system is sometimes notoriously slow moving because of the volume of cases being heard. In the

these established remedies may place added weight on the decision to grant a permit by the respective agencies before structural works are put in place. More realistically, threat of legal action may force the riparian owner who seeks to build protective structures to mentally weigh the costs of legal battles against the cost of losing his property. The balance sheet may very well show that absorbing the physical loss or economic loss is the most expedient alternative.

The Michigan EPA gives the private riparian owner a method of bringing to task his private riparian neighbor, the private corporation or the public body or agency before the next bulkhead, groin or jetty is installed. The record of circuit court action and especially their attentiveness to EPA decisions is further insurance that court action can be used expediently and effectively to manage the developed shore area from the standpoint of the private riparian. He can act in his own behalf before the damage occurs with

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sense of "quick" response to a problem situation the common law or EPA avenue may prove useful in forestalling the installation of a particularly harmful structure for example. In Payant v. Department of Natural Resources, the controversial issue of antlerless deer hunting saw a rather quick response by the court.

good expectation of a rapid hearing. This is a valuable tool when crisis oriented programs are often rushed through without proper study.

The Weight of Precedent

The weight of legal precedent justifying Corps of Engineers' activities in maintaining the navigation channel at the mouth of the St. Joseph River in Michigan is nearly insurmountable, save a reversal of many Supreme Court decisions, a situation unlikely to occur. The federal tort claim is the only avenue now open to the riparians at St. Joseph to attempt recovery for the damages that have already occurred. The factual basis of a suit against the Corps may be valid in the physical and scientific sense[98] but the legal precedent on commerce clause grounds weighs heavily in favor of the Corps of Engineers' position. So,

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[98]Even the weight of scientific evidence may not sway the court as was exemplified in a recent Maryland decision. In Finley v. Teeter Stone, Inc. (251 Md. 428, 248 At. 2nd. 106), the court disregarded scientific evidence when it refused to accept that hydrostatic pressure in the groundwater system "supports" to a certain degree the overlying soil. Subsidence after withdrawal of underground fluids is well documented in scientific sector.

even though the task of fighting the weight precedent on a broad well-established issue such as navigational servitude may seem hopeless, it remains a necessary function if ever a change is to come about.

The value of a federal tort claim made at St. Joseph may well be the "name case" which begins a new trend.

Review of Future Activities

The shore erosion conditions present (in 1973) along the coast at St. Joseph, Michigan are the result of 140 years of man's intrusion on nature. The erosion and property damages have been progressively building to this point in time so it can be expected that solutions to the problem will not be rapid. A period of from ten to thirty years may be needed to rebuild the shore area and to adjust human activities to the natural system if ever this task can be accomplished.

The value of the federal and state environmental acts will be shown when plans for management and reconstruction in the shore environment run afoul of "common sense." Failure to prepare a comprehensive EIS for any

federal reconstruction program can be remedied through the NEPA. This legal procedure would be equally applicable on the Great Lakes or any navigable waters. Similarly, the Michigan EPA can be invoked for all lesser problems which may arise with shore management in the St. Joseph or other similar areas of environmental concern.

The federal and state agencies' past experience with the NEPA and EPA, especially when highly motivated conservation groups are forcing court action, has taken its toll on many of the "old line" bureaucrats. Much new thinking has been infused by these legal encounters with the result being that more comprehensive impact studies are being developed. All of this augurs well for the future.

It follows that the future activities of the Corps and of the Michigan Water Resources Commission will surely have environmental impacts set forth before plans are made public. Lack of adequate study and documentation of the adverse environmental affects will be the basis for direct intervention by riparians and concerned citizens to insure that further damages do not result if this environmental concern is not shown.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Physical Aspects

1. The breakdown of the natural shore system and the resulting high erosion rates is primarily the result of sediment starvation. The process of littoral drift which under natural conditions supplies sediment to offshore bars and maintains the important stage-bar relationship has been altered by the federal piers at the mouth of the St. Joseph River. Under conditions of rising lake stages with an adequate supply of littoral sediment the natural response maintains a stable stage-bar relationship. Offshore bars move landward and are built higher to maintain the stable stage-bar relationship. The overall importance of the offshore bars is to regulate wave energy. A small amount of erosion under natural conditions is predicted

by the process-response model of the shore system because a certain amount of sediment is lost to deep water at extreme low stages. The amount lost to deep water is replaced by erosion at the beach.

The breakdown of the natural system can be blamed on the sediment entrapment by the harbor piers and by the presence of a bulkheaded shore which stops the process of natural nourishment through erosion of the beach and headland bluffs. Shore erosion will continue as long as man-made alterations of the natural system continue in operation. The problem of rapid erosion will be pushed southward as more and more structures and bulkheads are built as shore protection.

2. The erosion problem can be solved largely by re-establishing the natural littoral drift thus allowing the offshore bars to act as nature's own defense of the shore. This process can be re-established by transferring the trapped sediment across the harbor piers to rebuild the offshore bars downdrift from the piers.

3. The present high stages on the Great Lakes will probably recede but no doubt will return in 15-20 years if current long-term trends continue. The period of low-water

stages should provide ample time for man to aid the rebuilding of the natural system. The low water stage also exposes a wide strip of sand beach which will provide good working conditions to repair the shore areas already damaged.

4. The establishment of near natural offshore morphology will provide the best protection to upland riparian property. The amount of energy needed to sustain the adequate natural conditions is minimal. Sand transfer by mechanical or suction dredge would be the only major long-term energy and fiscal expenditure needed to provide adequate protection for the beach and upland. Some additional sediment may be needed in the future in which case offshore or land-based deposits of sand can be excavated to provide this material.

Legal Aspects

1. The enactment of recent legislation for managing the shore environment should be the solution to the long-term aspects of the problem of shore erosion. Areas that are not yet developed will be regulated to minimize

the possibility that the natural shore processes will be disrupted thus causing erosion.

2. In the developed areas such as at St. Joseph common law suits among neighboring riparians may be undertaken, if needed, but in general a proliferation of these private suits may prove to be counter-productive to the overall effort needed to solve the erosion problem. A coordinated approach to solving the immediate erosion problem may be slowed by a series of law suits brought by private riparians.

3. Under the Federal Tort Claim Act the federal government can be sued for the damages resulting from the entrapment of sediment by the harbor piers. The weight of previous decisions in favor of the federal government based on the commerce clause and navigational servitude generally precludes much chance of recovery. This is not meant to suggest that the case against the government is hopeless because the courts have been known to change their thinking, but rather that this avenue should not be counted on too heavily as an immediate solution to the problem.

4. The agencies of state government or any other public or priva·e entity could be sued for damage to the natural environment under Michigan's EPA. Standing in court has been granted by statute. Suits against the agencies generally regarded as acting in behalf of all citizens in natural resource matters have been tried and have been successful under the new EPA. A brief analysis may lead some citizens to believe that state agencies may in fact have been lax in their administration of shore areas. Local government, federal agencies and many private riparians have done little to enhance the shore environment if analyzed in that same vein. At St. Joseph, for example, few of the involved parties could enter court with "clean hands" in this matter with the possible exception of those few owners who have not done any development work at all. The Michigan EPA will be useful as a legal tool to remedy specific problems which may arise with regard to many of the actions and decisions that will surely be forthcoming as all parties attempt to remedy the erosion problem at St. Joseph and other areas of Michigan's Great Lakes shore.

5. The NEPA and the ensuing precedent open a new legal avenue, the importance of which is in the regulation, monitoring and review of future governmental activities which might affect the environment. Environmental impact statements must be prepared prior to any federal action along the shore which might affect the environment. The important legal avenue open to riparians and conservation groups interested in preserving the natural shore environment is that of prior review of any proposed action. Environmental studies must accompany plans to rebuild and repair the shore areas at St. Joseph. For example, if the proposed actions are found deficient in the EIS report, riparians or conservation groups can enjoin the action until these deficiencies are answered or remedied. This legal avenue would ensure an impartial review of the repair measures before they are started, thus preventing a stop-gap or crises approach to solving the erosion problem. The anticipated low water stage on the Great Lakes should provide a 10-20 year interlude when fruitful restoration measures can be undertaken without the haste bred by the current emergency.

Recommendations

The recommendations that follow are aimed at achieving the goal of re-establishing the natural shore system as simply as possible. To achieve this goal, scientific, legal and political advice must be sought and citizen group pressure applied when needed. Cooperation must be achieved among citizen groups, local and state government and most of all with the agencies of the federal government. With such a spirit of cooperation the problem of restoring the natural system and of providing more effective long-term management of the developed shore can be solved.

Suggested major steps needed to begin implementing restoration and shore management at St. Joseph are listed as follows:

Environmental Assessment

The primary task is to assess on more detailed scientific grounds the total physical environment of the area. It is from this assessment that the overall management plan will evolve. The St. Joseph study presented in

this work may prove beneficial in the beginning phase of this assessment.

Beach Nourishment

The key factor in rebuilding the shore system is sediment. Nourishment of the shore south of the harbor piers should begin as soon as possible. Offshore or land-based sites may be considered as alternate sources of material but the primary source should be the wedge of accreted material now situated north of the harbor piers. This material is the most stable in the high-energy littoral zone. Offshore sources may prove to be too fine in gradation to remain in this high-energy environment, and in addition, recovery of this material from deeper water in Lake Michigan may be too costly. Land-based material too would be costly especially in terms of fuel to transport material. This is because all land sources will require trucking to move the material to the shore areas.

A sand-transfer system to move material across the harbor piers is the only low-cost and energy efficient method of providing the required sediment. The establishment of an adequate and effective sand-transfer system should be of high priority.

Strict Control of Structures

Until such time as the natural conditions are restored, all new permit applications for structures along this shore should be reviewed in light of established shore management practices so as to minimize further damage. The haphazard array of privately installed engineering works has obviously not been effective. Additional structures will probably be a waste of money as well as a continued cause of local erosion damage.

Removal of Offending Structures

Certain existing structures may be identified from preliminary studies as being responsible for unusual erosion damage. It is suggested that agency review of the permits for the structure be sought and that these structures be removed whenever possible to minimize further damage.

Group Effort

One of the most powerful forces available to the property owners along the St. Joseph shore is collective action. There are established associations which could

be strengthened to gain a louder political voice and a stronger negotiating position. It should be recognized that political pressure may be the only way the needed special legislation will be implemented so that shore restoration work can begin. Once the environmental impact statement is prepared for the reconstruction work, the citizen group can better afford the cost of the technical experts needed for their own review of the statement. It may be at this point that legal action may be contemplated and expert legal and technical assistance will be required. Also citizen's group probably would have more funds available to retain these experts than individual riparian property owners.

The citizen groups or associations should provide an additional important function as a clearing house for information. The importance of such a clearing house is, of course, that all members and affiliates will be better informed, the key to effective action.

Monitoring Program

The citizen's group, local government and the state all have an important role to play in the long-term

management of this coastal area, including the monitoring of effects of any engineering installation. The official monitoring program no doubt will be carried out by the Michigan Water Resources Commission and the Corps of Engineers, but input from all riparian owners is also needed. Changes in the shore conditions should be reported to the shore association and forwarded to the respective agencies. This function of on-site monitoring by property owners could be extremely valuable to these agencies. A monitoring program by private owners which is carried out to the extent that the owners contract for their own aerial photography that could be certified as to correct date could prove valuable as evidence in future years.

Special Legislation

Special legislation to allow funding and development of erosion control procedures should be initiated as soon as feasible. At the time of this writing, House Bill No. 5468 has been filed in the Michigan House of Representatives to amend the Public Works Act of 1957 (Act 185 of the P.A. of 1957). This legislation is a first step at

the state level in providing the funds needed to begin implementing effective erosion control procedures. Briefly, H.B. No. 5468 allows counties to acquire erosion control funding through a bonding program, to provide for special tax assessments and for condemnation of certain lands needed to carry out erosion control measures.

The Federal Congress should be prodded to enact the required fiscal legislation to begin erosion control and repair through the Corps of Engineers. Funding of the National Coastal Zone Management Act whose monies are now partially impounded by presidential directive will aid the State of Michigan in pursuing the coastal management programs now pending.

BIBLIOGRAPHY

BIBLIOGRAPHY

Books

A Uniform System of Citation. Cambridge, Mass.: Gannett House, 1967.

Ballentine's Law Dictionary. 3rd ed. Rochester, New York: The Lawyers Co-Operative Publishing Co., 1969.

Beebe, William. Adventuring with Beebe: Selections from the Writings of William Beebe. New York: Duell, Sloan, and Pearce, 1955.

Dorr, J. A., and Eschman, D. F. The Geology of Michigan. Ann Arbor: University of Michigan Press, 1971.

Engineering Manual 2nd Edition. New York: McGraw-Hill, 1967.

Environment Reporter. Washington: The Bureau of National Affairs, 1970.

Fairbridge, R. W., ed. The Encyclopedia of Geomorphology. New York: Reinhold Book Company, 1968.

Friedman, Lawrence M., and Macauley, Stewart. Law and the Behavioral Science. Indianapolis: Bobbs-Merrill Company, 1969.

Glossary of Geology. Washington, D.C.: American Geological Institute, 1973.

Griffiths, John C. Scientific Method in the Analysis of Sediments. New York: McGraw-Hill Book Company, 1967.

Guilcher, Andre. Coastal and Submarine Morphology. London: John Wiley & Sons, 1958.

Holmes, A. Principles of Physical Geology. 2d ed. New York: Ronald Press, 1965.

Hough, J. L. Geology of the Great Lakes. Urbana: University of Illinois Press, 1958.

Johnson, D. W. Shore Processes and Shoreline Development. New York: John Wiley, 1919.

King, C. A. M. Beaches and Coasts. London: Edward Arnold, Ltd., 1959.

Krumbein, W. C., and Graybill, Franklin. An Introduction to Statistical Models in Geology. New York: McGraw-Hill Book Company, 1965.

Landau, Norman J., and Rheingold, Paul D. The Environmental Law Handbook. New York: Ballantine, 1971.

McHarg, Jan L. Design with Nature. Garden City, New York: Doubleday & Company, Inc., 1969.

Prosser, W. L. Handbook of the Law of Torts. St. Paul, Minn.: West Publishing Co., 1955.

Sax, Joseph L. Defending the Environment: A Strategy for Citizen Action. New York: Alfred A. Knopf Co., 1971.

_____. Water Law Cases and Commentary. Boulder, Colo.: Pruett Press, 1965.

Snow, C. P. The Two Cultures and a Second Look. Cambridge: Cambridge University Press, 1954.

Strahler, A. N. Physical Geography. 2d ed. New York: John Wiley & Sons, 1960.

Turabian, Kate L. A Manual for Writers of Term Papers, Theses, and Dissertations. Chicago: The University of Chicago Press, 1967.

Yannacone, Victor J., Jr., and Cohan, Bernard S. Environmental Rights and Remedies. Rochester, New York: The Lawyers Co-Operative Publishing Co., 1971.

Articles, Booklets, Reports

Bajorunas, L. Natural Regulation of the Great Lakes. Detroit: U.S. Lake Survey, Corps of Engineers, 1963.

_____, and Duane, D. B. "Shifting Offshore Bars and Harbor Shoaling." Journal Geophys. Research, Vol. 72, No. 24 (1968), 6195-6205.

Bartke, Richard W. "The Navigation Servitude and Just Compensation: Struggle for a Doctrine." Oregon Law Review, Vol. 48, No. 1 (1968), p. 1.

Beach and Bluff Erosion on Lake Michigan. Kalamazoo, Michigan: Gove Engineers, Inc., April 13, 1970.

Brater, E. F., and Seibel, E. An Engineering Study of Great Lakes Shore Erosion in the Lower Peninsula of Michigan. Lansing: Water Resources Commission, Department of Natural Resources, 1973.

Bruun, P. Coastal Protection. Florida Eng. Expt. St., 1963.

_____. "Sea Level Rise as a Cause of Shore Erosion." J. Waterways, Harbors Div., Am. Soc. Civil Engineers, Vol. 88, 1962, p. 117.

Chorley, Richard J. Geomorphology and General Systems Theory. U.S. Geological Survey Professional Paper 500B. Washington, D.C.: U.S. Government Printing Office, 1962.

Cohen, Bernie S. "The Constitution, Public Trust Doctrine, and the Environment." Utah Law Review, June, 1970.

Crampton, Roger C., and Boyer, Barry B. "Citizens Suits in the Environmental Field: Peril or Promise." Ecology Law Quarterly, Summer, 1972.

Davis, Kenneth Culp. "The Liberalized Law of Standing." The University of Chicago Law Review, Vol. 37, No. 3 (Spring, 1970).

Davis, R. A., Jr. "Sedimentation in the Nearshore Environment, Southeastern Lake Michigan." Unpublished Ph.D. dissertation, University of Illinois, 1964.

_____, and Fox, W. T. Beach and Nearshore Dynamics in Eastern Lake Michigan. Kalamazoo, Michigan: Western Michigan University, June, 1971.

_____. "Coastal Processes and Nearshore Sand Bars." Journal of Sed. Pet., Vol. 42, No. 2 (June, 1972), 401-12.

Davis, R. A., Jr., and Fingleton, W. G. Systematic Beach Profile Study of Eastern Lake Michigan (1971-1972). Kalamazoo, Michigan: Western Michigan University, August, 1972.

Davis, R. A., Jr., ed. Coastal Sedimentation of Southeastern Lake Michigan. Kalamazoo, Michigan: Western Michigan University, Studies in Geology No. 1, Field Trip Guidebook, November, 1970.

El Ashry, M. T. "Causes of Recent Increased Erosion Along United States Shorelines." Bull. Geol. Soc. America, Vol. 82 (1971), pp. 2033-38.

Everett, A. Gordon. "Geology in Public Decision Making." The Professional Geologist, December, 1972.

Fox, W. T., and Davis, R. A., Jr. Computer Simulation Model of Coastal Processes in Eastern Lake Michigan, Tech. Report No. 5. Williamstown, Mass.: Williams College, 1971.

_____. Fourier Analysis of Weather and Wave Data from Lake Michigan, Tech. Report No. 1. Williamstown, Mass.: Williams College, 1970.

Humphreys, Donald L. "NEPA and Multi-Agency Actions--Is the Lead Agency Concept Valid?" Natural Resources Lawyer, Vol. 5, No. 4 (1973), p. 257.

Hunt, I. A. Winds, Wind Set-Ups and Seiches on Lake Erie. Detroit: U.S. Lake Survey, Corps of Engineers, 1959.

Kirshner, L. D. "Effects of Divisions on the Great Lakes." Miscellaneous Paper 68-7, U.S. Lake Survey, November, 1968.

Korkigian, I. M. "Channel Changes in the St. Clair River Since 1933." Proceedings of the American Society of Civil Engineers. Journal of the Waterways and Harbors Division, May, 1963.

Krumbein, W. C. "A Geological Process-Response Model for Analysis of Beach Phenomena." Bull. Beach Erosion Board, Vol. 17 (1963).

Larkin, David Morse. "The Assault Against Nature: Ecology and the Army Corps of Engineers." Comment. California Western Law Review, Vol. 8 (1972).

Larson, C. E. The Cultural Variable in Shore Erosion Along the Illinois Shore of Lake Michigan. Chicago: The Lake Michigan Federation, 1972.

Leighty, Leighton L. "The Source and Scope of Public and Private Rights in Navigable Waters--Part I." Land and Water Law Review, Vol. 5, No. 2 (1970), p. 391.

_____. "Public Rights in Navigable State Waters--Some Statutory Approaches." Land and Water Law Review, Vol. 6, No. 2 (1971), p. 1.

Leopold, L. B., and Langbein, W. B. The Concept of Entropy in Landscape Evolution. U.S. Geological Survey Professional Paper 500A. Washington, D.C.: U.S. Government Printing Office, 1962.

Low Cost Shore Protection. Ann Arbor: Engineering Research Institute, University of Michigan, 1959.

McHarg, Ian. "Best Shore Protection: Nature's Own Dunes." Civil Engineering, September, 1972, pp. 66-70.

Miller, M. M. "Entropy and the Self-Regulation of Glaciers in Arctic and Alpine Regions." Geoscience Abstracts, East Anglia, England, December, 1973.

_____, et al. "A Principles Study of Factors Affecting the Hydrological Balance of the Lemon-Ptarmigan Glacier System, S. E. Alaska, 1965-1969." Inst. of Water Research, Tech. Report 33. Michigan State University, 1972.

Morreale, Eva H. "Federal Power in Western Waters: The Navigation Power and the Rule of No Compensation." Natural Resources Journal, Vol. 3 (May, 1963), p. 1.

Olds, N. V. "The Law of the Lakes." Michigan State Bar Journal, Vol. XLIV, No. 2 (February, 1966).

"Park Service to Let Nature Reign." World Dredging and Marine Construction, Vol. 9, No. 14 (December, 1973), p. 63.

Ropes, G. E. "Vertical Control of the Great Lakes." Proceedings of the American Society of Civil Engineering Surveying and Mapping Division, April, 1965, pp. 39-49.

Sax, Joseph L., and Conner, Roger L. "Michigan's Environmental Protection Act of 1970: A Progress Report." Michigan Law Review, Vol. 70, No. 6 (May, 1972).

Sax, Joseph L. "The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention." Michigan Law Review (January, 1970).

Saylor, J. H., and Hands, E. B. "Properties of Longshore Bars in the Great Lakes." Proceedings of the Twelfth Coastal Engineering Conference, Washington, D.C., September, 1970.

Schwartz, M. L. "The Bruun Theory of Sea Level Rise as a Cause of Shore Erosion." Journal of Geology, Vol. 75, No. 1, 76-92.

_____. "Laboratory Study of Sea Level Rise as a Cause of Shore Erosion." Journal of Geology, Vol. 73, No. 3 (1965), p. 528.

Seibel, E. "Shore Erosion at Selected Sites on Lake Michigan and Lake Huron." Unpublished Ph.D. dissertation, University of Michigan, Ann Arbor, 1972.

Soucie, Gary. "Where Beaches Have Been Going: Into the Ocean." Smithsonian Magazine, June, 1973, p. 56.

Trumbull, Terry A. "Private Environmental Legal Action." University of San Francisco Law Review, October, 1972.

General References

Borsuk, Alan J. "Lake Erosion: Complex Problem." Milwaukee Journal, May 27, 1973.

"Erosion Control Debate for Lake: Can Anything Be Done to Stop It?" Bulletin of the Lake Michigan Federation, Chicago, March-April, 1973.

Flawn, Peter J. Environmental Geology. New York: Harper & Row, 1970.

Hassett, Charles M., ed. Environmental Law. Ann Arbor: The Institute of Continuing Legal Education, 1971.

Ingersall, Bruce. "Link Erosion Toll, Beach Buildings." Chicago Sun Times, May 29, 1973.

Krueger, Robert B. "Coastal Zone Management: The California Experience." California State Bar Journal (September-October, 1972), 402-53.

Lueder, Donald R. Aerial Photographic Interpretation Principles and Applications. New York: McGraw-Hill Book Company, 1959.

McKenzie, Garry D., and Utgard, Russel O., eds. Man and His Physical Environment. Minneapolis: Burgess Publishing Company, 1972.

Moffitt, Francis H. Photogrommetry. Scranton, Penn.: International Textbook Company, 1959.

The Earth and Human Affairs. Committee on Geological Sciences. National Academy of Sciences, Canfield Press, San Francisco, 1972.

"To Fill or Not to Fill." League of Women Voters, Lake Michigan Inter League Group. Chicago: January, 1973.

White, Bertram C. "Coastline Crisis." Pacific Law Journal, Vol. 2 (1971), 226-44.

Wilkes, Daniel. "Consideration of Anticipatory Uses in Decision on Coastal Development." San Diego Law Review, Vol. 6 (1969), 354-74.

Yabush, Donald. "We Need to Understand Lake Michigan More." Chicago Tribune, May 31, 1973.

Public Documents

Marks, William D. "Statement to the International Joint Commission on Behalf of Michigan Governor William G. Milliken," May 8, Detroit, Michigan, May 10, Sault Ste. Marie, Ontario.

Michigan Water Resources Commission. A Special Report on Great Lakes Shore Erosion. Department of Natural Resources, March, 1972.

_____. Existing Regulatory Techniques for Managing Michigan's Shoreland. Department of Natural Resources, Lansing, August 1972. (Draft Copy.)

_____. Status Report: Great Lakes Shore Erosion. Department of Natural Resources, Lansing, Michigan, 1969.

_____. A Plan for Michigan's Shorelands. Department of Natural Resources, October, 1972.

U.S. Army Corps of Engineers. Great Lakes Shoreline Damage Causes and Protective Measures. North Central Division, September, 1969.

_____. Help Yourself. North Central Division, Detroit, 1973.

_____. Shore Management Guidelines. Washington, D.C.: 1971.

_____. Permits for Work in Navigable Waters. Washington, D.C., 1968.

_____. Shore Protection Guidelines. Department of the Army. Washington, D.C., August, 1971.

_____. Water Levels on the Great Lakes, Report on Lake Regulation, Appendix A, Hydraulics and Hydrology. Detroit District, 1965.

U.S. Army Coastal Engineering Research Center. Shore Protection, Planning and Design, Technical Report No. 4. 3rd ed. Washington, D.C.: U.S. Government Printing Office, 1966.

Unpublished Material

Asselin, Donna. "Newsletter of the Lakeshore Property Owners Association." St. Joseph, Michigan, June 7, 1973.

Knight, H. Gary. "Organizations to Deal with Coastal Zone Problems: The Local Perspective." Speech presented at the First Annual Institute of Ocean Law, December 10, 1969.

GLOSSARY

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accretion--The increase in riparian land by the gradual deposit by water of solid material so as to cause to become dry land which was before covered by water. (Ballentine)

aggradation--A building up of the land surface by deposition of sediment. (AGI).

avulsion--A sudden and perceptible loss or addition to land by the action of water, or a sudden change in the course of a stream. (Ballentine)

background erosion rate--The erosion rate which would occur naturally on the Great Lakes even in the absence of man's activities along the shores. (Author)

backwash--The seaward return of water down the foreshore of a beach following an uprush of a wave. (AGI)

beach--The zone extending from the low water line to the first change in vegetation or landform. (AGI)

beach drift--Material on the beach moved by the swash and backwash of waves. (AGI)

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*The terms listed below have been defined by various other publications, primarily Ballentine's Law Dictionary (Ballentine) and the Glossary of Geology (AGI). Where this writer felt terms were not defined well enough in the context of this study, his definition is listed as (Author).

breakback--See flanking.

bulkhead--A linear shore structure or seawall made of wood, steel or concrete piling. (AGI)

coast--The strip of land of indefinite width that extends from the coastline landward to the first major change in landform features. (AGI)

coastline--The extreme landward limit of the highest storm waves. (AGI)

cobbles--A rounded rock 2.5 to 10 inches in diameter. (AGI)

cobble beach--A beach made up of cobble size material 2.5 to 10 inches in diameter. (Author)

commerce clause--The third clause of the eighth section of the first article of the United States Constitution providing that Congress shall have the power to regulate commerce with foreign nations, and among the states. (Ballentine)

common law--The system of rules and declarations of principles from which our judicial ideas and legal definitions are derived, and which are continually expanding; the system being capable of growth and development at the hands of judges. (Ballentine)

degradation--A lowering of the lands surface by erosion. (AGI)

dynamic equilibrium--A condition of a system where there is a balanced inflow and outflow of materials. (AGI)

easement--A servitude imposed as a burden on land. Precisely, a liberty, privilege or advantage in land without profit, existing distinct from the ownership of the soil. (Ballentine)

EDF--Environmental Defense Fund, Inc., an environmental action group.

EIS--Environmental Impact Study, a report required by NEPA detailing the impacts of federal actions on the environment.

erosion--The removal or loss of earth material from a certain location by the action of the forces of water, wind, or ice. (Author)

erosion--(legal)--The gradual eating away of the soil by the operation of currents or waters so that the portion of land which is eaten away is lost to the riparian or littoral owner. (Ballentine)

EPA--Environmental Protection Agency, a federal agency created pursuant to NEPA in 1970.

ephemeral bar--The short-lived offshore bar nearest shore which self-regulates to various wave energy regimens. (Author)

eustatic--Pertaining to world-wide changes in sea level or in the Great Lakes system basin-wide changes in water level based on the absolute quantity of water. (Author)

flanking--The process of rapidly accelerating erosion on the lee side of a structural or natural impediment to wave action. A synonym for breakback. (Author)

foreshore--The strip of land which slopes upward from the water's edge to the crest of the first landward berm. (AGI)

general systems theory--The formulation of systematic framework of a scope that allows for an understanding of correlations and associations that otherwise would be impossible. (Chorely 1962 and Miller 1972)

grade--An equilibrium profile afforded by a condition of balance in the system, usually applied to streams. (AGI)

groin--A low, narrow rigid jetty constructed of timber, stone, concrete or steel, usually extending roughly perpendicular to the shoreline, designed to protect the shore from erosion or to trap sand for the purpose of building a beach. (AGI)

groin field--A series of groins.

injunction--A writ, process, or restraining order issued pursuant to an order or decree. (Ballentine)

jetty--A short pier extending out from the shore into a body of water and designed to direct or confine the current. (AGI)

littoral--Bordering on the shore; pertaining to the shore of the sea or a lake. (Ballentine)

littoral belt--In the Great Lakes system, the zone between the beach and the lowest limit of wave action offshore. (Author)

littoral current--A current flowing parallel to the shore caused by the approach of waves to the coast at an angle. (AGI)

inverse condemnation--The taking of property by an actual interference with or disturbance of property rights, without an actual entry upon the property. (Ballentine)

littoral drift--Material that is moved along the shore by a littoral current. (AGI)

littoral proprietor--The owner of premises on the shores of the sea or lake. (Ballentine)

littoral rights--The rights of a littoral owner or proprietor. (Ballentine)

longshore drift--Littoral drift. (AGI)

mud beach--A beach composed of predominantly clay size material. (AGI)

navigation easement--See navigation servitude.

navigation servitude--The long established federal doctrine whereby land abutting the navigable waters of the United States has a perpetual easement for navigation purposes of the government, by authority of the commerce clause of the U.S. Constitution. (Author)

NEPA--National Environmental Policy Act (1969), a federal law proclaiming environmental policies and goals.

offshore--Pertains to a directive seaward or lakeward from the shore. (AGI)

offshore bar--An elongate mound of sediment paralleling the shore that is formed by wave turbulence and in turn regulates wave energy. (Author)

OHWM--Ordinary High Water Mark, the levels or datums set by statute as the boundary between private and public ownership along the Great Lakes. The Lake Michigan datum is 579.8 feet above sea level.

pier--A breakwater structure used to protect a harbor or shore. (AGI)

reliction--The withdrawal of waters, exposing as land that which was previously under water. (Ballentine)

revetment--A stabilized and armored beach slope covered with rip-rap, interlocking concrete blocks or paving material. (AGI)

riparian--An owner or proprietor of land that adjoins a water body such as a flowing stream, lake, or the ocean. (Ballentine)

riparian land--Land bounded or traversed by a natural stream of water. (Ballentine)

riparian proprietor--An owner of land which is bounded or traversed by a natural stream. In loose usage, inclusive of an owner of land on the shores of the sea or of a lake. (Ballentine)

riparian rights--The rights of a riparian owner. (Ballentine)

sovereign--A ruler; a king; the supreme power in a government. (Ballentine)

sovereign immunity--The principle that the sovereign cannot be sued in its own courts or in any other court without its consent and permission. (Ballentine)

seawall--A general term for linear structures placed at the shoreline to maintain a stable position. (Author)

sediment shadow--The sediment starved zone which occurs on the lee side of structural or natural barriers to littoral drift. (Author)

seiche--Short period oscillation in the water level in an enclosed or semi-enclosed basin. On the Great Lakes it often connotes a sudden rise in water level whether oscillatory or not. (AGI)

self-regulation--The ability of a system to adjust to energy input in order to maintain a dynamic equilibrium condition. (Author)

shingle beach--A beach covered with flat slabs of rock oriented by wave action into a shingle-like pattern. (AGI)

shore--The strip of land that is alternately exposed or covered by water, the zone between high and low water. (AGI)

shoreline--The boundary between land and water along a beach. (AGI)

stratigraphic--A layered or stratiform sequence of rock and sediment. (Author)

swash--Uprush of a wave up the foreshore of a beach. (AGI)

taking--Within the meaning of the constitutional provision that private property shall not be taken for public without just compensation, the term includes any action, the effect of which is to deprive the owner of all or most of his interest in the subject matter, such as destroying or damaging it. (Ballentine)

turbid--Discoloration or cloudiness caused by suspended material such as fine sediment. (AGI)

turbulence--Water flow where the flow lines are confused and heterogeneously mixed. (AGI)

WRC--Water Resources Commission (Michigan), state agency which administers water resources of the state.

wind set-up--Wind tide.

wind tide--Wind set-up, or a rise in water level caused by meterologic forces. (AGI)

zoning--The creation and application of use restrictions imposed on the owners of real estate within prescribed districts or zones. (Ballentine)