APPENDIXES III, VII, AND XII, OHIO SHORE LINE OF LAKE ERIE BETWEEN FAIRPORT AND ASHTABULA, BEACH EROSION CONTROL STUDY

LETTER

FROM

SECRETARY OF THE ARMY

TRANSMITTING

A LETTER FROM THE CHIEF OF ENGINEERS, UNITED STATES ARMY, DATED OCTOBER 22, 1951, SUBMITTING A REPORT, TOGETHER WITH ACCOMPANYING PAPERS AND ILLUSTRATIONS, ON A COOPERATIVE BEACH EROSION CONTROL STUDY OF THE OHIO SHORE LINE OF LAKE ERIE BETWEEN FAIRPORT AND ASHTABULA, APPENDIXES III, VII, AND XII, PREPARED UNDER THE PROVISIONS OF SECTION 2 OF THE RIVER AND HARBOR ACT APPROVED ON JULY 3, 1930, AS AMENDED AND SUPPLEMENTED

JANUARY 28, 1952.—Referred to the Committee on Public Works and ordered to be printed with illustrations

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Appendix 1. Aerial photographs.
Appendix 2. Ground photographs.
Appendix 3. Existing structures.
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LIST OF PLATES MADE IN CONNECTION WITH THE REPORT OF THE DISTRICT ENGINEER

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Plate 2, sheet 2: Comparative profiles.
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LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY,
Washington, D. C., January 25, 1952.

The SPEAKER OF THE HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am transmitting herewith a report dated October 22, 1951, from the Chief of Engineers, United States Army, together with accompanying papers and illustrations, on a cooperative beach erosion control study of the Ohio shore line of Lake Erie between Fairport and Ashtabula, Appendixes III, VII, and XII, prepared under the provisions of section 2 of the River and Harbor Act approved on July 3, 1930, as amended and supplemented.

A copy of the letter containing the views of the director, Department of Public Works, State of Ohio, is enclosed.

The Bureau of the Budget advises that, while there is no objection to the presentation of the report for the consideration of Congress, authorization of the project, which the Chief of Engineers considers inadvisable for the United States to adopt at this time, would not be in accord with the program of the President.

Sincerely yours,

FRANK PACE, Jr.,
Secretary of the Army.

COMMENTS OF THE BUREAU OF THE BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington 25, D. C., November 19, 1951.

The honorable the SECRETARY OF THE ARMY
(Through the Budget Officer for the Department of the Army).

MY DEAR MR. SECRETARY: This will acknowledge receipt of your letter dated October 30, 1951, submitting the proposed report of the Chief of Engineers on a cooperative beach erosion control study of the Ohio shore line of Lake Erie between Fairport and Ashtabula, prepared under the provisions of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented.

I am authorized by the Director of the Bureau of the Budget to advise you that, while there would be no objection to the presentation of the report for the consideration of Congress, authorization of the project, which the Chief of Engineers considers inadvisable for the United States to adopt at this time, would not be in accord with the program of the President.

Sincerely yours,

W. T. SCHAUB
(For Assistant Director for Estimates).

COMMENTS OF THE STATE OF OHIO

STATE OF OHIO,
DEPARTMENT OF NATURAL RESOURCES,
Columbus, Ohio, October 16, 1951.

Brig. Gen. C. H. CHORPENING,
Assistant Chief of Engineers, United States Army,
Washington 25, D. C.

DEAR SIR: Your letter of September 27, 1951, to the Director o the Ohio Department of Public Works, together with a copy of th proposed report of the Chief of Engineers and the reports of the Beac Erosion Board and the district and division engineers, in connectio with the cooperative beach erosion control study of the Lake Eri shore line between Fairport and Ashtabula, appendixes III, VII, an XII, has been referred to this office since the division of shore erosio has been transferred from the department of public works to th department of natural resources.

Please be advised that this office concurs, in general, in the view and recommendations of the Chief of Engineers as outlined in hi letter to the Secretary of the Army.

Very truly yours,

F. O. KUGEL,
Chief, Division of Shore Erosion.

APPENDIXES III, VII, AND XII, OHIO SHORE LINE OF LAKE ERIE BETWEEN FAIRPORT AND ASHTABULA

REPORT OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 22, 1951.

Subject: Beach erosion control report on State of Ohio, appendixes III, VII, and XII, Fairport to Ashtabula.

To: The Secretary of the Army.

1. I submit for transmission to Congress a report, with accompanying papers, on a beach erosion control study of a portion of the shore of Lake Erie in Lake and Ashtabula Counties, Ohio. The study was made by the Corps of Engineers in cooperation with the State of Ohio, under the provisions of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented.

2. After full consideration of the reports of the district and division engineers, the Beach Erosion Board concludes that the need for protection of the publicly owned sections of the shore within the study area is insufficient to warrant Federal aid under the policy established by Public Law 727, Seventy-ninth Congress. For the privately owned portions of the shore, the Board recommends that private owners adopt one of the plans of protection proposed by the district engineer, selecting that most suitable to the physical characteristics and desired use of their shore frontage, consistent with the effect on adjacent shore sections. As existing Federal law does not include a policy of Federal aid in the cost of protecting privately owned shores, no Federal participation in the cost of work is recommended. Accordingly, the Beach Erosion Board recommends that no projects be adopted by the United States at this time for protection of the shores of Lake Erie within the area studied.

3. The Beach Erosion Board states its opinion, as required by law, as follows:

(*a*) It is inadvisable for the United States to adopt projects authorizing Federal participation in the cost of protecting and improving the Lake Erie shores of Ohio within the area studied.

(*b*) Except for recreational benefits in connection with improvement of Perry Township Park and Geneva Township Park, the public interest in the proposed measures is small.

(*c*) No share of the expense should be borne by the United States.

4. After due consideration of these reports, I concur in the views and recommendations of the Beach Erosion Board. Because of their general interest to the public and their value to local authorities, I recommend that these reports with selected illustrations, be published.

LEWIS A. PICK,
Lieutenant General,
Chief of Engineers.

REPORT OF THE BEACH EROSION BOARD

BEACH EROSION BOARD,
CORPS OF ENGINEERS,
Washington 16, D. C., August 1, 1951.

Subject: Beach erosion control report on cooperative study of the Ohio shore line of Lake Erie, appendixes III, VII, and XII, Fairport to Ashtabula.

To: The Chief of Engineers, United States Army,
Washington 25, D. C.

1. This report is on a study of beach erosion made in cooperation with the State of Ohio under authority of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The purpose of the investigation is to determine the best methods of preventing further erosion of and stabilizing the existing shore, and of restoring and creating new beaches. The State desires that emphasis be placed on determining effective and economical methods of shore protection, and on the possibilities of development and improvement of publicly owned park and beach areas.

2. The area studied is located in Lake and Ashtabula Counties on the south shore of Lake Erie from about 30 to 57 miles east of Cleveland, Ohio. It extends from just east of the mouth of the Grand River to just east of the mouth of Ashtabula River, a distance of about 26.5 miles. Fairport and Ashtabula Harbors, which have been improved by the United States for navigation, are located at the mouths of these rivers.

3. Lake and Ashtabula Counties had populations of about 50,000 and 69,000 respectively in 1940. The principal centers of population are the cities of Painesville and Ashtabula which had populations in 1940 of about 12,000 and 21,000, respectively. Except for industrial development in Painesville Township, the property along the shore line of the study area has been developed mainly for private residential and recreational purposes. The population of the area is increased considerably by summer visitors. Inland areas are devoted mainly to agricultural uses.

4. The shore is publicly owned at parks in Painesville, Perry, Madison, Geneva, Saybrook, and Ashtabula Townships and in the city of Ashtabula. All are used for recreational purposes. The park beaches are generally narrow except at Walnut Park just west of Ashtabula Harbor west breakwater.

5. The shore line of the study area consists principally of eroding bluffs averaging about 40 feet high of clay, silt, sand, and gravel fronted by narrow beaches of sand and gravel. Analysis of samples of bluff material indicated that in general approximately 25 percent of the material is suitable for beach building. Rapid erosion of the bluffs makes available a considerable volume of beach material. West of Ashtabula Harbor a wide beach has formed by accretion caused by the harbor structures.

6. Miscellaneous groins and sea walls have been constructed in an attempt to prevent erosion of the shore. Short groins have generally caused accretion on their west sides and have reduced recession of the bluffs to some extent. The pronounced accretion west of the harbor structures and the accretion west of short groins indicate a marked eastward predominance of littoral drift.

7. The mean level of Lake Erie in the study area is about 2 feet above the established low-water datum. The highest stage recorded and the highest monthly mean are, respectively, about 5 and 4 feet above that datum. The greater fetch and movement of winds from the westerly quadrant account for the predominance of eastward littoral drift. Due to the limited size of Lake Erie, local storms are the sole cause of important wave action. Short waves rise quickly during storms and may reach heights of 8 or 10 feet in deep water. Due to the gently sloping off-shore bottom, waves of this height ordinarily break before reaching shore structures. The maximum wave height that need be considered in designing structures where no protective beach will remain is probably 4 feet. Existing groins with shore ends about 5 to 6 feet above low-water datum indicate that these elevations are generally adequate to impound a low protective beach without entirely preventing desirable distribution of available material along shore. However, during storms at high lake stages, waves may occasionally reach the toe of the bluff over beaches of this elevation and armoring of the toe may be desirable. Where a higher protective beach is desired, so that armoring will be unnecessary, an elevation of 8 feet for the top of the groin should be used. Ice forms a protective coating over beaches during winter months, but the lifting and battering action of shifting ice floes during the spring breakup must be considered in designing shore structures for structural stability.

8. The shore areas immediately east of the mouth of Grand River and Ashtabula Harbor are subject to pollution by sewage discharged untreated into those waters. The distance from Grand River to Painesville Township Park (2.5 miles) is considered sufficient to make bathing at this beach reasonably safe. Pollution at Lake Shore Park just east of Ashtabula Harbor is considered hazardous to the health of bathers under existing conditions. No apparent hazards from sewage contamination exist in the remainder of the study area under normal conditions.

9. The district engineer has considered the desires of the cooperating agency, has determined the source and movement of beach material, the changes in the shore line and offshore bottom, the effects of winds, waves, ice, and storms, the effects of existing structures, and has developed plans for protecting and improving Perry Township Park, Geneva, Township Park, and Lake Shore Park, and four general plans for protecting privately owned shores of the study area.

10. The district engineer concludes that Perry Township Park and Geneva Township Park are the only publicly owned sections of the shore where protection and improvement are warranted at this time. He recommends, subject to certain conditions, that projects be adopted by the United States authorizing Federal participation in the amount of one-third of the first cost of groin construction at Perry Township Park and at Geneva Township Park.

11. The four general plans for protecting privately owned shores comprise (1) plan C which consists of grading and draining of the bluffs, revetment of the toe of the slope, and a cellular steel sheet pile sea wall; (2) plan D, similar to plan C except that it provides in lieu of the sea wall, maintenance of relatively narrow beaches by means of short groins; (3) plan E, which consists of groins to retain material eroded from the bluff; (4) plan F, which consists of revet-

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ment of the toe of the bluff. The district engineer recommends that owners of private property adopt one of the four proposed plans of protection best suited to the physical characteristics and desired utilization of their shore-front property.

12. The division engineer concurs in the conclusions and recommendations of the district engineer.

13. The Beach Erosion Board was not convinced that participation by the United States in the cost of construction of the recommended plans for Perry and Geneva Township Parks is justified, because the projects appear to be justified almost entirely by benefits which would accrue from creating additional recreational beach area, rather than from protection against erosion. Benefits from the prevention of damages due to erosion are inconsequential. In view of the foregoing, the Board was of the opinion that the development of these park beaches should not be considered eligible for Federal aid under Public Law 727, Seventy-ninth Congress, which provides for Federal contribution toward the construction of protective works. The Board so notified local interests. Communications received related to the recreational use of the parks, but did not furnish additional information concerning the need for protection.

VIEWS AND RECOMMENDATIONS OF THE BEACH EROSION BOARD

14. The Board has carefully considered the reports of the reporting officers. It concurs generally in their views and recommendations, subject to the comments contained in the following paragraphs.

15. The Board notes that the reporting officers present four methods for protecting the shore of privately owned property and recommend that owners adopt the plan best suited to the physical characteristics and desired utilization of their shore-front property. Typical protective measures are illustrated on plate 10 of the report. Plans C and D include grading and draining the bluff, protecting the toe of the slope by stone armoring and a cellular steel sheet pile sea wall, or in lieu of the sea wall, maintaining a protective beach by a system of short groins. Plan E comprises high, short groins. Under this plan the bluffs are to be permitted to recede with the expectation that eroded material will be retained by the groins and form a protective beach. Plan F, revetment, in its simplest form consists of a continuous belt of heavy riprap or stone pavement laid on a stable slope and covering the zone of destructive wave action. As shown on plate 10, the bedding course consists of unscreened crushed stone. This course should be decreased in thickness to permit placement of a layer of quarry spalls between the courses shown on plate 10.

16. The Beach Erosion Board concurs in the foregoing methods of protection, and in the manner of selection of the type best suited to each particular section of the shore, as proposed by the district engineer. It wishes to emphasize the desirability of coordinated action by owners within a section to protect a stretch of frontage under the plan of protection best suited for the privately owned shores in that section, and the necessity of adequately protecting the ends of the work to prevent flanking.

17. The Board recommends that private owners adopt one of the plans of protection proposed by the district engineer, namely, plan C, cellular steel sheet pile sea wall; plan D, armored slope and short

groins; or plan E, high, short, groins; or plan F, slope revetment or dumped riprap sea wall, selecting that most suitable to the physical characteristics and desired use of their shore frontage, consistent with the effect on adjacent shore sections. As existing Federal law includes no policy for Federal assistance in the cost of protecting privately owned shores, no Federal participation in the cost of any of the foregoing work is recommended at this time.

18. It is noted that the district engineer has evaluated benefits from prevention of direct damages and recreational benefits of increased public beach areas. The method of evaluating recreational benefits by assigning a per capita value for beach use, estimated as being equal to the charge made for the use of privately owned beaches, is noted. This per capita value is estimated at 25 cents per individual use. The Board considers that the value of 25 cents per individual use is a reasonable measure of the direct recreational benefit to the individual user of the beach and the indirect benefits that accrue to the community as a result of recreational use of the beach. The indirect benefits include general benefits to the health and welfare of the public.

19. In regard to the protection and improvement of Lake Shore Park at Ashtabula, the Board agrees with the reporting officers that the improvement of a recreational beach so close to the east side of this industrial harbor is inadvisable at this time. The existing pollution makes the beach unsafe for recreational use. The elimination of this pollution would remove this danger, but the question would still remain whether the beach cannot be more advantageously located elsewhere. Under these conditions the Board concurs with the reporting officers that development of a recreational beach at Lake Shore Park is inadvisable at this time.

20. The Board has reviewed the prospective benefits for the projects for Perry Township Park and Geneva Township Park. It notes that the value of the park land subject to erosion is low and that, at the past rates of erosion, the anticipated annual losses for these parks amount to only $310 and $100, respectively. The annual costs of protection are, respectively, $2,110 and $900. Because of the inconsequential protective benefits, the Board considers that the need for protection is insufficient to warrant Federal aid under the provisions of Public Law 727, Seventh-ninth Congress. The Board concludes that adoption of Federal projects for these parks is inadvisable but that local benefits, other than those from prevention of damages, may warrant construction of the projects at local expense substantially in accordance with the plans proposed by the district engineer and shown on plate 9 of his report. The Board considers it advisable, however, for local interests to make independent evaluations of prospective benefits from these proposed projects in determining justification for construction at local expense.

21. In accordance with existing statutory requirements, the Board states its opinion that—

(*a*) It is inadvisable for the United States to adopt projects authorizing Federal participation in the cost of protecting and improving the Lake Erie shores of Ohio within the area studied.

(*b*) Except for recreational benefits in connection with improvement of Perry Township Park and Geneva Township Park, the public interest involved in the proposed measures is small.

(*c*) No share of the expense should be borne by the United States.

22. The Board recommends that no projects be adopted by the United States at this time for the protection of the shores of Lake Erie within the area covered by this report.

For the Board:

E. E. GESLER,
Colonel, Corps of Engineers,
President.

At the time of adoption of this report the members of the Beach Erosion Board were: Col. E. E. Gesler, Corps of Engineers, President; Dean Thorndike Saville, State of New York; Dean Morrough P. O'Brien, State of California; Dr. Lorenz G. Straub, State of Minnesota; Col. W. P. Trower, Corps of Engineers; Col. D. S. Burns, Corps of Engineers; Col. R. W. Pearson, Corps of Engineers.

REPORT OF THE DISTRICT ENGINEER

SYLLABUS

The purpose of this cooperative beach erosion control study is to determine effective and economical methods of shore protection and beach stabilization of the Ohio shore line of Lake Erie between Fairport Harbor, Ohio, and Ashtabula Harbor, Ohio, with particular emphasis on the improvement of publicly owned property.

As a result of this study it is concluded that—

(1) The only publicly owned properties requiring additional protection and improvement at this time are Perry Township Park, Geneva Township Park, and Lake Shore Park at Ashtabula, Ohio.

(2) A plan of improvement for Perry Township Park suited to the needs and available resources is the construction of four groins to reduce and control erosion of the bluffs and to build a beach for protective and recreational purposes.

(3) The plan of improvement suitable for the further protection and improvement of Geneva Township Park is the landward extension of an existing groin at the easterly limit of the park and construction of a new groin near the middle of the park frontage.

(4) Revetment of the toe of the low bluffs to halt further erosion or the addition of sand fill to build an artificial beach for protection and recreational purposes are two possible plans of improvement for Lake Shore Park at Ashtabula.

(5) Four general plans of improvement are suitable for use in this study area for the protection and improvement of privately owned property. Plan C which provides a sea wall at the toe of the bluff and grading and drainage of the slope is suitable for use where the amount of sand supplied by littoral drift or contained in the bluff is small and where a bathing beach is not required. Plan D, which provides relatively low groins and slope revetment, is suitable for retaining an existing beach or building a beach in areas where there is a large amount of littoral drift. Plan E is suitable for controlling the erosion of bluffs which contain a high percentage of beach building material by the construction of groins to retain and build a beach of the coarse material derived from erosion of the bluffs. It is suitable for use only where some further recession of the bluffs can be allowed to furnish the necessary beach building material. Plan F, which provides stone revetment for protecting the zone of wave action at the toe of bluffs, is particularly suitable where there is no existing beach or none is desired.

It is recommended that the United States adopt projects authorizing Federal participation in the costs of the improvements at Perry Township Park and Geneva Township Park, subject to certain specified conditions. The Federal contribution is estimated at $15,000 for Perry Township Park and $6,600 for Geneva Township Park.

It is further recommended if local interests desire to improve Lake Shore Park at Ashtabula, Ohio, that they adopt one of the two plans considered in this report. No Federal participation in either plan is recommended at this time since protection alone is not economically justified and the development of an equivalent

bathing beach at a nearby location which is relatively free from pollution is considered more practicable.

It is also recommended that owners of private property adopt one of the proposed plans of improvement best suited to the shoreline characteristics of the location and the intended use of the shore front property to be improved.

CORPS OF ENGINEERS, UNITED STATES ARMY,
OFFICE OF THE DISTRICT ENGINEER,
BUFFALO DISTRICT,
Buffalo 7, New York, July 24, 1950.

Subject: Beach erosion control report on cooperative study of the Ohio shore line of Lake Erie, appendixes III, VII, and XII.

To: The Division Engineer, Great Lakes Division, Corps of Engineers, Chicago 16, Ill.

I. GENERAL

1. *Authority.*—This cooperative beach erosion control study was initiated by formal application from the State of Ohio for appendixes III, VII, and XII to the original agreement, dated March 5, 1942, for a cooperative beach erosion study of the Ohio shore line of Lake Erie, which was approved by the Chief of Engineers under authority conferred by section 2 of the River and Harbor Act of July 3, 1930, as amended and supplemented.

(*a*) Appendix III was initiated by formal application dated June 24, 1947, from the State of Ohio, and approved August 6, 1947, by the district engineer. Supplement A to appendix III, dated February 10, 1948, providing a greater cash contribution in lieu of services, was approved June 15, 1948, by the district engineer.

(*b*) Appendix VII was initiated by formal application dated March 24, 1948, from the State of Ohio, and approved May 13, 1948, by the district engineer.

(*c*) Appendix XII was initiated by formal application dated November 10, 1948, from the State of Ohio, and approved December 9, 1948, by the district engineer.

(*d*) Authority to approve the formal applications was delegated to the district engineer by the Chief of Engineers at the time drafts of formal applications were reviewed and returned to the district engineer.

(*e*) Authority to combine appendixes III, VII, and XII into one report was granted by the Chief of Engineers October 27, 1948, in fourth endorsement to letter dated September 13, 1948, from the district engineer to the Chief of Engineers, subject: Cooperative Beach Erosion Study, Ohio Shore Line of Lake Erie, Appendix XIV.

2. The study was prosecuted jointly by the United States acting through the Corps of Engineers, and by the State of Ohio, acting through the Department of Public Works.

3. *Purpose.*—The purpose was to make a comprehensive beach erosion control study of the shores of Lake Erie between Fairport Harbor and Ashtabula Harbor, Ohio. In this area the State desired effective and economical methods of shore protection for both public and private areas with special emphasis placed on the development of recreational beaches at public park areas.

4. *Prior reports.*—No prior beach erosion control reports have been written on this area. However, several navigation reports have been made on Ashtabula Harbor which is in the study area, and on

Fairport Harbor, which lies immediately to the west. A beach erosion report on a preliminary examination was also made at the latter place. Table 1 lists reports in which there are data pertinent to beach erosion or shore protection.

TABLE 1.—*Prior reports*

Title	Date	Document No.	Congress and session	Remarks
Beach erosion report on preliminary examination of Fairport Harbor.	Aug. 25, 1948	----------	----------	Considered protection of water works pumping station. Unfavorable to further study at this time.
Review report on Fairport Harbor, Ohio.	Oct. 17, 1945	706	79th, 2d	Discussed effect on shore processes of considered 400–1,000 feet lakeward extension of west breakwater and extension of east breakwater to shore. Improvements considered unwarranted.
Preliminary examination and survey report on Ashtabula Harbor, Ohio.	May 28, 1915 Feb. 11, 1916	997	64th, 1st	Discussed effect on shore line of recommended extension of west breakwater to shore.

II. LOCATION AND DESCRIPTION

5. *Location.*—The study area consists of 26.5 miles of the south shore of Lake Erie from the easterly limit of the village of Fairport to the easterly limit of Lake Shore Park immediately east of the city of Ashtabula, being parts of Lake and Ashtabula Counties, Ohio. The area is shown on United States Lake Survey Charts 3, 34, 342, and 346, and on plates and aerial photos [1] accompanying this report.

6. *Description.*—The shore line runs in a general east-northeasterly direction. It is devoid of headlands for at least 10 miles east and west of the study area, the only outstanding features being the harbor installations at Fairport and Ashtabula Harbors. The shore line, like that of most of Ohio, is characterized by bluffs ranging from 5 to 60 feet in height composed entirely of soil materials. In general, sand and gravel beaches, some of which are submerged during periods of high water, are found in front of the bluffs. A more detailed description of the beaches is given under "Geology," paragraph 29.

7. Fairport Harbor, immediately west of the study area, is located at the mouth of the Grand River, about 30 miles easterly from Cleveland, Ohio. The harbor consists of the lower 1.5 miles of the Grand River and an outer harbor of about 360 acres in area, protected by a system of breakwaters. A description of the harbor structures is given in paragraph 47. The village of Fairport, a subdivision of Painesville Township, is located on the east bank of the Grand River. Its easterly line is the western limit of the study area. From this point the first 1½ miles of the shore line within the study area are occupied by the Diamond Alkali Co. The Industrial Rayon Corp. occupies the eastern one-half-mile of shore line of Painesville Township. The intervening area is developed as a residential and park area. Painesville Township Park, located approximately 2 miles east of Fairport Village, is open to the general public and has a lake frontage of 975 feet. No charge is made for the use of the beach. Bathhouse facilities are available.

[1] Not printed.

8. Perry Township, situated immediately east of Painesville Township, is largely devoted to agriculture. The only recreational developments along the shore are Camp Roosevelt (a privately owned boys' camp), Perry Township Park, and North Perry Park. The latter two are open to the general public at no charge, have bathhouse facilities, and have lake frontages of 850 feet and 300 feet, respectively.

9. The Madison Township shore line immediately east of Perry Township is undeveloped in the first mile except for scattered private camps and Tuttle Park. Madison Township Park lies midway between Tuttle Park and the county line. To the east, as far as the Lake-Ashtabula County line the shore is developed with summer homes. Tuttle Park is open to residents of Madison Township only, while Madison Township Park is free to the general public. The parks have lake frontages of 340 feet and 600 feet, respectively, and both have bathhouse facilities.

10. Geneva Township, in Ashtabula County, has a well developed shore line. The village of Geneva-on-the-Lake is a summer resort with few year-round residents. Both east and west of the village the shore is being developed for residential use. There are numerous private camps and several private beaches as well as the pubicly owned Geneva Township Park which is open to the general public without charge. The park has a lake frontage of about 900 feet and is equipped with a bathhouse.

11. Saybrook Township development is varied, having summer homes in the westerly part and permanent year-round homes along the lake front near Ashtabula. The only park in the area open to the general public without charge is Saybrook Township Park with a 450-foot lake frontage. Bathhouse facilities are available. The mouth of Red Brook located about 3 miles west of Ashtabula Harbor has been improved by private interests as a small boat basin.

12. Ashtabula Harbor is located at the mouth of the Ashtabula River about 27 miles easterly from Fairport Harbor. The lower 1.9 miles of the river and an outer harbor of 185 acres, formed by a breakwater system described in paragraph 60, are maintained as a Federal navigation project. The city of Ashtabula is an industrial and shipping center, two railroads having constructed large ore and coal handling wharves in the outer harbor and river. The mile of shore line immediately west of the west breakwater is developed as a residential area. Walnut Park, which is owned by the city and located at the inner end of the west breakwater, is open to the general public without charge. Plans are being considered for providing bathhouse facilities and acquiring additional shore frontage principally to the west of the existing park. The west breakwater shore arm divides the existing frontage leaving over 75 percent within the harbor which is unsuitable for bathing.

13. Within the harbor area the westerly 1,000 feet of frontage adjoining the park is undeveloped, the next 4,000 feet is occupied by coal and ore wharves, and the 1,500 feet between the wharves and Lake Shore Park is undeveloped. Lake Shore Park, controlled by the Ashtabula Township Park Commission, has a shore frontage of 2,350 feet. Use of the park is free to the general public, and bathhouse facilities are available.

14. A summary of recreational developments in the study area is given in table 2.

TABLE 2.—*Recreational developments*

Name	Location, miles east of Fairport	Public or private	Bathhouse capacity	Lifeguard during bathing season	Width of beach, feet	Length of lake frontage, feet
Painesville Township Park	2.5	Public	500	Yes	70	975
Camp Wise	3.5	Private	(1)	(1)	20–50	1,400
Camp Roosevelt	6.5	do	(1)	(1)	40	700
Perry Township Park	6.8	Public	(1)	None	20–50	850
Gospel Workers Society	7.8	Private	(1)	(1)	60	2,700
North Perry Park	8.7	Public	40	None	50–70	300
Former Canton YWCA	10.1	Private	(1)	(1)	0–30	1,100
Former Mary Eels YWCA	10.7	do	(1)	(1)	70	1,650
Tuttle Park	11.3	Public	15	None	20–30	340
Madison Township Park	13.5	do	25	do	50	600
Chestnut Grove Park	17.8	Private	(1)	(1)		
Geneva Township Park	19.1	Public	(1)	(1)	30–100	900
Saybrook Township Park	22.7	do	48	None	50	450
Walnut Beach Park	26.3	do	None	do	400–600	700
Lake Shore Park	27.8	do	200	Yes		2,350

[1] No information available.

15. *Population.*—A great many of the camps and homes in the area are used only during the summer months; however, no data are available to show the extent of the fluctuations in population between summer and winter. Table 3 gives the poulation of the study area, and table 4 gives the population of the area tributary to the Lake Erie shores from Sandusky to the Ohio-Pennsylvania line.

TABLE 3.—*Population of study area (1940 census)*

Political subdivision	Population [1]	Political subdivision	Population [1]
Lake County:		Ashtabula County:	
Painesville, township	3,404	Geneva, township	1,688
Fairport, village	4,528	Geneva, village	4,171
Painesville, city	12,235	Geneva-on-the-lake, village	172
Richmond, village	305	Saybrook, township	2,883
Perry, township	1,350	Ashtabula, township	3,037
North Perry, village	318	Ashtabula, city	21,405
Perry, village	645		
Madison, township	2,725	Total	50,845
Madison, village	979		

[1] Population of townships are exclusive of cities and villages.

TABLE 4.—*Population, tributary to beaches, Cedar Point to Ohio-Pennsylvania line (1940 census)*

County	Population	County	Population
Ashtabula	68,674	Lorain	112,390
Cuyahoga	1,217,250	Medina	33,034
Erie	43,201	Portage	46,660
Ceauga	19,430	Trumbull	132,315
Huron	34,800		
Lake	50,020	Total population	1,757,774

16. *Pollution.*—In commenting on the quality of the waters along the shore of Lake Erie between the mouth of the Chagrin River and the Ohio-Pennsylvania line, which includes the entire shore line covered in detail by this report and the shore line from 10 miles west to 15 miles east of the study area, the State of Ohio Department of Health reports as follows:

* * * The water along the lake front between these points is relatively uncontaminated, except for areas in the immediate vicinity of sewer outlets from

the large municipalities, which are rather widely separated. The normal direction of flow along the shore in the lake is toward the east and the wind is generally from the west. Hence, bathing beaches located west of municipalities are generally relatively safe except under abnormal weather and adverse wind conditions.

When the provisions of a new law recently passed by the legislature become effective, it will be illegal for municipalities to discharge untreated sewage into the streams and lakes in the State and a penalty is provided for violation of this statute. This law should give an impetus toward the construction of adequate sewage-treatment facilities by communities along the lake. Already a number of cities and villages along the lake have taken preliminary action on this problem. It is not to be anticipated that there will be a rapid elimination of all of the sources of pollution entering the lake. However, there will be a gradual improvement. When adequate sewage-treatment facilities are installed, devices will be provided for special treatment during the bathing season. There are relatively few existing bathing beaches along the lake where it would not be possible by the installation of feasible improvements to eliminate the potential sources of contamination of the beaches.

Many thousands of people are now using the various beaches along the lake front and the public is beginning to recognize the importance of conserving these points of recreation. Hence, there is an increasing demand for protection of bathing beaches from even occasional contamination. In general, we anticipate a marked improvement in the conditions of the water of the bathing beaches along Lake Erie.

17. The principal potential source of pollution in the study area is from the discharge of untreated sewage and waste from the industrial centers at Fairport Harbor and Ashtabula Harbor. The village of Fairport, the city of Painesville, and the Diamond Alkali Co. at Fairport Harbor, now discharge untreated sewage and industrial wastes into the Grand River which empties into Lake Erie at Fairport Harbor, near the westerly limit of the study area. The predominant currents in the lake and alongshore normally move in an easterly direction, as stated in the health department's report, and only those areas easterly of and close to sources of pollution are normally subject to serious contamination. Painesville Township Park, which is located approximately 2½ miles east of the mouth of the Grand River, is the only publicly owned bathing beach in the study area where pollution from this source is questionable. It is considered that its distance from the mouth of the river is sufficient to make the use of the beach reasonably safe.

18. There are no sources of pollution likely to endanger the health of bathers at the township parks of Perry, Madison, Geneva, and Saybrook Townships or at the North Perry Village Park.

19. The plans of the city of Ashtabula for the future development of Walnut Park contemplate acquisition of additional shore frontage west of the shore arm of the west breakwater to enlarge the bathing beach, and contemplate eventual development of the frontage inside the breakwater as a small boat basin. The proposed beach area west of the breakwater is relatively free from pollution inasmuch as the city's principal sanitary sewer outlet discharges into the lake near the inner end of the east breakwater. The city has no sewage treatment facilities at the present time.

20. Samples of water from the Walnut Park beach were taken by city health authorities at approximately weekly intervals during the bathing seasons of 1946 and 1947 and at intervals of approximately 2 weeks during the bathing season of 1948. Fifteen of the twenty-eight samples tested indicated a *Bacillus coli* count of 1.0 or less per milliliter. Ten samples had a *Bacillus coli* count of 10 and three con-

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secutive samples taken between June 3 and June 16, 1947, had a *Bacillus coli* count of over 100. Study of these results in conjunction with wind directions shows that the samples taken between June 3 and June 16, 1947, were taken immediately following or during periods of strong easterly and northeasterly winds. The remainder of the samples were taken under various conditions including times when the wind direction was northeasterly but of milder intensity. The *Bacillus coli* content is an indication of human or animal pollution and the numbers are rougly a measure of the intensity of sewage pollution. While no standards have been adopted for determining the suitability of water for bathing, proposed standards of water quality for desirable conditions are not over 1.0 Coliform bacteria per milliliter (average) and not over 10.0 per milliliter (maximum). On the basis of the proposed standards the beach at Walnut Park should be relatively safe except during, or immediately following, prolonged periods of winds of high intensity from an easterly direction. The average total bacteria count for the 28 samples tested from the Walnut Park beach was 1,530 per milliliter.

21. Similar tests of water samples from the Lake Shore Park beach on the east side of Ashtabula Harbor taken between June 26, 1946, and August 11, 1947, show that, of the 22 samples tested, 4 samples contained 1 or less *Bacillus coli* per milliliter, 9 samples contained 10 *Bacillus coli* per milliliter, and 9 samples contained over 100 *Bacillus coli* per milliliter. The average count of total bacteria present in the 22 samples was 39,700 per milliliter. The relatively high intensity of pollution is due to the discharge of untreated sewage into the lake near the inner end of the east breakwater. Inshore pollution was aggravated during 1948 by a break in the sewer outfall near the shore line. Repairs were completed in 1949. Because of its proximity to the normal sewer outlet, the use of Lake Shore Park beach is considered hazardous to the health of bathers under existing conditions.

III. GEOLOGY AND COAST CHARACTERISTICS

22. *General.*—The bedrock of the south shore of Lake Erie from Sandusky, Ohio, eastward to the Ohio-Pennsylvania line consists of limestone, dolomite, and shale of Devonian age. The rocks are little disturbed from the nearly horizontal position in which they were deposited. All of the rock units lie east of the crest of the Cincinnati Arch and have a general regional dip toward the southeast of 15 to 20 feet to the mile although there are exceptions in parts of the Cleveland district where the surface rocks dip southwest.

23. From Sandusky eastward to approximately 3.7 miles northwest of the Huron River the uppermost rock is Columbus and Delaware limestone. There are no outcrops along the lake shore but the bedrock is close enough to the surface to be encountered in basement excavations in the Sandusky area. Lying stratigraphically above the limestone a narrow belt of Olentangy shale covered by a few feet of glacial drift intersects the Lake Erie shore line about 2 miles northwest of Huron. From this point eastward to the Pennsylvania State line some unit of the Ohio shale underlies the entire shore line region. Occasionally one or more of the three members of the Ohio shale known as Huron, Chagrin, and Cleveland shale are exposed to the top of the shore escarpments, sometimes they are found occupying the

lower part of the cliffs or just offshore beneath water level, but more commonly they are covered by glacial material and can be found only by drilling. No bedrock is exposed along the shore or in the bluffs within the study area except at one point in Lake Shore Park at Ashtabula.

24. The formation of the Lake Erie Basin and the geologic characteristics of the surface materials in the Erie Basin are the result of glacial action during the Pleistocene age. During this period at least two ice sheets advanced from the north-northeast to about 75 miles south of the present shore line, scouring the preglacial soil and bedrock, and then depositing glacial soils. Thus, in general, the material overlying the bedrock is a glacial till composed of native material ground up beneath the glacier mixed with material from the Canadian regions to the east and northeast. The composition of the till varies widely from place to place but, in general, is a hard, compact, boulder clay with the included rock fragments varying from sand size to pebbles, cobbles, and large boulders. The average analysis of boulder clay found along the Ohio shores of Lake Erie indicates that approximately 75 percent is silt and clay, 15 to 20 percent is sand, and the remainder is coarser material. Analyses of bluff samples from the study area are included in appendix 4 of this report.

25. Lake Erie is the shallowest of the Great Lakes and is the only one whose bottom does not extend below sea level. It has an average depth of 58 feet and a maximum depth of 210 feet. During the glacial period, water impounded between the ice fronts and the high land forming the divide between the St. Lawrence River and Ohio River drainage basins formed lakes of higher elevations than the present Lake Erie. Beach ridges roughly paralleling the present lake shore and located from 5 to 10 miles inland outline the boundaries of the former lakes. There is also evidence that lakes at lower levels than the present one existed. Lacustine clay and silt deposited in the bottom of the glacial lakes forms the surface material throughout most of the Ohio shore line. In localized areas the surface material is sand probably deposited as outwash from streams of the retreating glaciers. The characteristics of the bluffs in the study area are described in more detail in the following paragraphs.

26. *Coast characteristics.*—The bluffs in the immediate study area vary in height from less than 5 feet up to a maximum of approximately. 60 feet. The average height is in the neighborhood of 40 feet. Between the Diamond alkali plant at Fairport Harbor and Perry Township Park the bluffs are nearly vertical and average over 45 feet in height. They are composed almost entirely of boulder clay although in the vicinity of Painesville Township Park the clay is overlain by a 4-foot stratum of medium gravel and sand. Between Perry Township Park and North Perry Park the bluffs are approximately 45 feet high and are composed of boulder clay in the lowest stratum overlain by a stratum of lacustrine silt and clay which increases to a maximum thickness of approximately 32 feet near North Perry Park. A stratum of fine sand and gravel from 4 to 7 feet in thickness lies near the top of the bluffs between the two parks.

27. Between North Perry Park and the Perry-Madison Township line, the bluffs decrease in height, the slope flattens and is covered with vegetation. In the vicinity of Mercers Harbor, just west of the Town Line Road, the top of the boulder clay stratum is only 2 or

3 feet above lake level and is overlain by a stratum of sand and gravel less than 1 foot thick. Immediately east of the Town Line Road the bluffs reach a height of approximately 60 feet decreasing to approximately 40 feet at Tuttle Park. The upper stratum, 30 feet to 35 feet in thickness, is composed of sand. Below the sand is a layer of silt and clay 14 to 22 feet in thickness overlying the harder clay, the upper surface of which is only 1 to 3 feet above lake level. Between Tuttle Park and Madison Township Park, the bluffs decrease in height to approximately 20 feet. The composition of the bluff varies, but in general, the upper 2 feet is sand and a layer of lacustrine clay approximately 10 to 15 feet thick overlies the boulder clay at the base of the bluff.

28. Between Madison Township Park and Cowles Creek, in Geneva-on-the-Lake, the bluff is 10 to 12 feet high and composed almost entirely of silt and clay overlying the boulder clay, the upper surface of which is just above lake level. Between Geneva-on-the-Lake and Walnut Beach Park, just west of Ashtabula Harbor, the bluffs gradually increase in height from 30 to 50 feet and are composed almost entirely of boulder clay.

29. *Existing beaches.*—At the time of the survey when the lake level was at approximately 2.5 feet above low-water datum, over 60 percent of the shore line of the study area within Lake County and 20 percent of the shore line within Ashtabula County had a beach over 10 feet in width; however, all but three of the beach areas have been created or augmented by artificial means. The location and the existence or nonexistence of beaches is closely connected with the amount of sand available for littoral drift found in the bluffs to the west of each beach area as well as to the existence of structures capable of trapping the drift. The bluffs immediately west of Tuttle Park contain a thick deposit of sand and a continuous beach extends nearly 3 miles eastward. In the other extreme, the lack of beaches between Geneva-on-the-Lake and Ashtabula Harbor, except in scattered areas where existing harbor structures or groins have gradually accumulated beaches over a long period of time, can be attributed to the nature of the boulder clay bluffs in this area which contain a low percentage of beach building material. Although no information is available on the depth of sand on the beaches, the location and extent of existing beaches are shown in table 5, located by reference to structures or natural features shown on plates 5 to 8.[1] Analyses of sand from existing beaches throughout the study area are given in appendix 4.[1]

[1] Not printed.

TABLE 5.—*Existing beaches*

Location	Length, feet [1]	Width, feet [1]	Structures contributing to accretion
Lake County:			
Structure 11 to structure 18	4,000	10–80	Groins at Painesville Township Park.
Structure 19 to structure 21	1,200	10–40	Breakwater.
500 feet west of structure 22 to structure 56	2,100	10–40	25 short groins.
1,300 feet west to 700 feet east of structure 59	2,000	10–90	Sewer outlet structure and groins.
1,100 to 6,200 feet east of structure 59	5,100	10–80	None.
Structure 66 to 2,400 feet west	2,400	10–40	Shore protection structures.
900 to 7,900 feet east of structure 66	7,000	10–100	None.
800 feet west of North Perry Park to Town Line Rd.	8,300	10–100	Structures at Mercers Harbor.
1,900 feet east of Town Line Rd. to Bennett Rd.	19,500	10–150	Groins.
Division Rd. to Arcola Creek	5,600	30–50	Do.
Ashtabula County:			
700 feet west of County Line Rd. to 250 feet east of structure 145.	7,100	10–150	Do.
Padanarum Rd. to structure 151	7,000	10–100	Do.
Structure 160 to structure 171	2,100	10–80	Do.
800 feet west to 2,300 feet east of structure 172	3,000	10–150	None.
Structure 192 to 150 feet east of structure 203	1,200	10–70	Groins.
Structure 204 to 3,200 feet east	3,200	10–100	Do.
1,500 feet west to 1,000 feet east of Red Brook	2,500	10–120	Piers at creek mouth.
Stowe Rd. to Walnut Blvd	5,000	10–100	Groins.
Ashtabula west breakwater to 2,500 feet west	2,500	10–600	West breakwater.

[1] The above-water dimensions of beaches which are shown on plates 5 to 8 were determined at a lake stage approximately 2.5 to 3 feet above low-water datum.

30. *Streams.*—The source of the Grand River is located about 40 miles south of Ashtabula. In general, the river flows due north for about 30 miles, then turns abruptly west to flow through a deep ravine which follows the top of the escarpment for 19 miles. Near Painesville it turns north through the rock barrier to the Erie Plain, then continues 9 miles to enter the lake at Fairport. The lower 1.5 miles have been improved for deep-draft navigation. The river has a drainage area of approximately 760 square miles.

31. McKinley Creek, a small stream entering Lake Erie about 4 miles east of the Grand River, drains an area of only 2 square miles.

32. There are two unnamed streams rising about 5 miles inland and entering the lake 7.2 and 10 miles east of the Grand River. They drain areas of 8 and 4 square miles, respectively.

33. Arcola (Big) Creek rises about 5 miles south of the lake, flows northerly for 3 miles, turns easterly for about 4 miles, then runs northerly for 4 miles to enter the lake about 16 miles east of the Grand River. It has a drainage area of approximately 22.5 square miles.

34. Wheeler Creek rises about 7 miles from the lake, and flows north, draining an area of 10 square miles and enters the lake about a mile east of Arcola Creek.

35. Cowles Creek rises about 6 miles inland, flows northerly for 1.5 miles, westerly for 4 miles, then northerly for 5 miles to enter the lake at Geneva-on-the-Lake, about 18 miles east of the Grand River. It has a drainage area of 23 square miles.

36. Indian Creek, about 6 miles in length, flows northwesterly to the lake entering it about 20 miles east of the Grand River. It drains an area of 17 square miles.

37. Red Brook enters the lake 24 miles east of the Grand River, after flowing in a general northwesterly direction for about 4 miles. It has a drainage area of 10 square miles. The lower one-half mile is

used as a small boat harbor by the Red Brook Boat Club. Parallel piers have been constructed to improve the entrance.

38. Ashtabula River drains an area of 137 square miles, rising about 6 miles inland on the plateau. It flows westerly for 12 miles, then winds in a general northerly direction through a deep gorge for 3 miles, then westerly in a similar manner for 3 miles to emerge on the plain where it flows northwesterly and enters the lake at Ashtabula Harbor. The lower 1.9 miles of the river forms the Ashtabula inner harbor, a Federal deep-draft navigation project.

39. *Probings.*—Twenty-five probings, spaced throughout the study area, were taken at the water's edge. (See pl. 1 for location.) A ¾-inch diameter steel rod was used for probing. An anvil, formed by bolting two steel blocks to the rod, received blows from a hammer weighing approximately 40 pounds. The hammer, a steel block with a hole running through its center to allow it to slide up and down the rod, was operated by two men who grasped thongs attached to the hammer and raised it 4 or 5 feet, and exerted extra force on the downward stroke. The degree of resistance offered to penetration was used for determining the type of material being penetrated. The material was assumed to be rock when 80 to 100 blows failed to drive the rod one-tenth of 1 foot. The approximate limits of the various strata thus determined are indicated in table 6.

TABLE 6.—*Probings*

Location, profile No.	Top elevation [1]			Location, profile No.	Top elevation [1]		
	Soft material	Hard material	Rock		Soft material	Hard material	Rock
4	+2.1	−3.5	−16.9	61	+2.7	----------	−2.2
11	+3.0	−1.5	−15.2	63	+4.7	----------	−3.7
21	+3.0	0.0	−13.9	68	+1.8	----------	−5.7
25	+1.9	−1.3	−10.4	71	+1.9	−0.8	−1.3
32	+2.4	−1.1	−11.3	73	+2.0	----------	−4.3
39	+3.5	----------	−9.7	75	+1.4	----------	−6.8
44	+2.1	−6.7	−9.1	77	+2.2	−8.4	−8.9
46	+1.8	−3.4	−5.7	80	+2.2	−7.0	−8.8
49	+4.7	----------	−5.0	82	+2.6	−3.6	−9.5
52	+2.7	−4.6	−6.4	84	+3.6	−4.4	−5.5
54	+2.5	----------	−4.8	87	+2.1	−5.3	−8.9
57	+3.5	----------	−2.2	91	+3.6	----------	−2.4
60	+3.7	----------	−9.7				

[1] Elevations in feet, referred to low-water datum, elevation 570.5 feet above mean tide at New York City.

40. *Sources of beach building material.*—Three possible natural sources of beach building material for any particular section of shore line are erosion of the bluffs and beaches updrift of the area, material brought down by streams, and under-water sand and gravel deposits close to shore. To determine the size of material that can be expected to remain on the beaches in the study area and thus estimate what quantities of material suitable for beach building are furnished from the above sources, analyses of sand from the beaches at the water's edge and from under water at the 6-foot depth contour were made. Samples of the material in the bluffs and under-water samples at the 18- and 30-foot depth contours were also taken. Locations of the samples are shown on plate 1 and analyses of the individual samples of beach, bluff, and bottom materials are given in appendix 4.[1]

[1] Not printed.

41. *Composition of existing beaches.*—Analyses of 35 samples taken at the water's edge from beaches throughout the study area indicate that an average of 99 percent of the material is retained on the No. 140 sieve and approximately 95 percent is coarser than the No. 60 sieve; only 7 sand samples were obtained at the 6-foot depth due to the prevalence of rock at or immediately below the lake bottom. Analyses of these samples show an average of 69 percent coarser than a No. 140 sieve and 84 percent coarser than a No. 200 sieve which is approximately the lower limit of grain size of material customarily classified as fine sand.

42. *Offshore deposits.*—With available equipment, samples could be obtained only at scattered locations at the 18- and 30-foot depths. Seven samples of shale were actually obtained at the 18-foot depth and one shale sample was obtained at the 30-foot depth indicating at least some localities have little or no silt or sand cover.

43. *Composition of bluffs.*—Little material can be supplied to the study area from erosion of the bluffs or beaches outside the study area, since the harbor structures at Fairport prevent material entering from the west and those at Ashtabula prevent material entering from the east. Thus beach material derived from such erosion must originate within the limits of the study area.

44. Samples were taken from eroding bluffs throughout the area. In sampling operations, an attempt was made to obtain an amount of material from each stratum in the same ratio as the thickness of the stratum to the total height of the bluff. In many cases, this could only be estimated since the contact line between the lacustrine material and the boulder clay was indistinct. Analyses of these samples show a wide variation of from 7 to 88 percent of the material tested retained on a No. 200 sieve. This is due to the wide variation of material exposed in the face of the bluffs within the limits of the study area. The average of the bluff analyses shows that approximately, 29 percent is retained on the No. 200 sieve.

45. *Material supplied by streams.*—As described in paragraphs 30 through 38, there are numerous small streams entering the study area. With the exception of Indian Creek which is west of profile No. 71, these streams cannot be considered significant sources of beach-building material. Local residents claim that during flood periods Indian Creek carries small amounts of shingle and gravel to the lake. Aerial photographs and visual inspection of the stream bed and adjacent shore line confirm this statement. Analyses of material removed by annual maintenance dredging at Fairport and Ashtabula Harbors indicate that the amount of beach-building material carried to the lake by the Grand and Ashtabula Rivers is negligible. The very fine silts and clays carried by these rivers settle out in the offshore depths and may account for some of the accretion found at these depths.

IV. EXISTING STRUCTURES

46. The protection of the beaches and bluffs in the study area has been attempted by the construction of many types of structures including groins, sea walls and breakwaters. Locations of the structures are shown on plates Nos. 5–8.[1] The structures at public and semipublic areas and their effects on the shore line are discussed

[1] Not printed.

in the following paragraphs. For ease in identifying the structures, a number or letter has been assigned to each structure. In the following paragraphs the number or letter in parentheses refers to the structure so identified on the plates. Brief descriptions of all structures are given in appendix 3.[1] Ground photographs of typical and unusual structures are given in appendix 2.[1] The widths of beaches given in the following paragraphs were existing beach widths at the time of survey but are subject to seasonal variations.

47. Fairport Harbor is protected by a breakwater system. The west shore-arm (A) of rubble mound construction, extends 1,478 feet due north. The west breakwater (B), a rubble mound structure 1,800 feet long, is deflected 25° to the east. The outer end of the rubble mound section forms an arrowhead entrance with the east breakwater. The entrance is 600 feet wide and is protected for 600 feet on the west side by a cellular steel sheet pile extension (C) to the west breakwater. The east breakwater (D), a rubble mound structure runs in a southeasterly direction for 1,300 feet from the entrance, then runs in an easterly direction for 5,450 feet terminating 2,500 feet from shore. The easterly end of the harbor is open.

48. The shore frontage of the Diamond Alkali Co. suffered severe erosion prior to 1939. In that year construction was started on the stone sea wall (1), and the stone-capped cellular steel sheet pile sea wall (2), and five stone block groins (4) to (8), 60 to 100 feet in length, were constructed east of the sea wall. Later a cantilever steel sheet pile sea wall (3) was built. It is now up to 100 feet lakeward of the water's edge and erosion of the bluff behind it is still active.

49. The improvements at Painesville Township Park include three multiple-row stone block groins (14)–(16) about 80 feet long. The westerly one was originally built in the form of an "L". The two easterly ones are "T" shaped. The outer ends of the groins are in poor repair but the inner ends of the groins are maintaining a low beach 50 feet wide between them and for several hundred feet to the west. At the easterly end of the park, a multiple-row stone-block breakwater (17), 330 feet long extends westerly from a stone-filled timber crib groin (18) 80 feet long. The breakwater is in poor repair but the groin maintains a 50-foot beach to the west. The breakwater and groin are being rebuilt and an additional groin added by the State of Ohio and park board. Erosion is active to the east of the structures.

50. Camp Wise has constructed 25 short concrete groins (22)–(46) on 50-foot centers. These assist the longer groins (47) and (49) in maintaining a beach which is 70 feet wide at the groins and tapers to a 10-foot width about 3,000 feet to the west. Erosion of the bluff still continues but at a slower rate than farther west where the shore is entirely unprotected.

51. In 1941, the Industrial Rayon Corp. built toe protection consisting of a single row of stone blocks (57) set on a brush mat paralleling the shore and groins (58) of the same construction extending 15 feet lakeward of the parallel wall and 10 feet shoreward of the wall to the base of the then existing bluff. Erosion of parts of the bluff has continued and the inner ends of the groins are now 10 feet or more from the toe of the existing bluff. About in the center of the property a structure consisting of parallel rows of steel sheet piling (59), filled with stone and gravel, built to protect a sewer outlet, acts as a groin

[1] Not printed.

extending 200 feet lakeward from the bluff. This groin has caused a beach 100 feet wide to form to the west, which tapers to a width of 20 feet in 1,600 feet. Bluff erosion has ceased for 600 feet west of this structure.

52. At Camp Roosevelt, a concrete sea wall (61) protecting a water intake has formed a beach 40 feet wide which tapers to zero width 1,500 feet to the west. A concrete groin (60) lies within the impounding area of the sea wall and consequently is practically buried.

53. At Perry Township Park, a stone-block sea wall (62A) and three concrete groins (62)–(64) are all flanked and ineffective. A permeable timber and steel sheet pile pier (65) with a stone-block inner section is holding a narrow beach to the west.

54. Mercer's small boat harbor, was constructed with an offshore rubble mound breakwater (67), parallel to and 200 feet from the shore, a west shore-arm (67A) and an east shore arm (67B). A gap left at the outer end of the east shore arm formed an entrance. The west shore arm has acted as a groin which is now filled to capacity and sand has spilled over the top. The beach extends for some distance to the west. Sand has now almost completely filled the harbor and is moving eastward under the influence of wind and wave action.

55. Private property owners at Madison Lakelands have constructed closely spaced concrete groins (80)–(90) some of which are built of 2- by 2- by 8-foot precast concrete blocks. The groins are from 30 to 150 feet in length. Each groin is effectively maintaining a beach of a width nearly equal to the length of the groin. The two stone-filled timber cribs at Madison Township Park (114) and (115) are being extended and the county is building a stone-filled timber crib groin at the foot of Hubbard Road.

56. The Madison Township sewage disposal plant is protected by a cantilever steel sheet pile sea wall (131A) and a short steel sheet pile groin (133) and three multiple-row stone-block groins (131), (132) and (134).

57. At Geneva Township Park, the 80-foot groin (171) of parallel rows of steel sheet piling, gravel-filled and concrete-capped, has accumulated a beach immediately to the west, which has partially buried two stone-filled timber crib groins (168)–(169), which were built in 1928. Groins (165)–(167) of the same construction, and also built in 1928, are helping to maintain a narrow beach at the westerly end of the park frontage. These short groins have deteriorated to such an extent that such protection as they have furnished in the past will be lost in the near future.

58. There is one 90-foot concrete groin (205) at Saybrook Township Park. The groin is located at about the center of the beach which is practically the same width on both sides of the groin.

59. The Red Brook Boat Club has constructed two 150-foot long concrete piers (212) and (213), as an entrance to the harbor. A beach 150 feet wide tapers to zero width at a point 1,600 feet to the west, while a beach 100 feet wide and 400 feet long extends to the east.

60. The west breakwater at Ashtabula Harbor (228), 7,200 feet in length extending in a northeasterly direction, is an impermeable structure of rubble mound or timber crib with stone superstructure construction. A narrow gap at its inner end separates it from the more permeable rubble mound shore return (227) which is nearly normal to shore and 580 feet in length. Sand has accumulated and formed a

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wide beach to the west of the shore arm and also inside the harbor. That portion inside the harbor has been deposited by wind and wave action which has carried sand over the inner end of the shore return. The east breakwater (229) which with the outer end of the west breakwater forms an arrowhead entrance to Ashtabula Harbor, has a total length of 4,400 feet. Its inner end is approximately 2,400 feet off shore. An inner breakwater (230), (231) protects the ore docks of the New York Central Railroad from waves which enter the harbor through the entrance gap but has no appreciable effect on shore processes affecting littoral movement of sand.

61. Approximately 1,200 feet of the Lake Shore Park frontage is protected by a concrete sea wall and promenade (232) and (233). Erosion is active along the remainder of the park frontage between the easterly end of the sea wall and the water intake and shore protection structures of the Cleveland Electric Illuminating Co.'s power plant located immediately east of the park.

V. FACTORS AFFECTING SHORE LINE PROCESSES

62. *Wind.*—Wind records were obtained from the United States Coast Guard Lifeboat Stations at Fairport and Ashtabula Harbors, Ohio. The resulting data have been converted to yearly averages which are shown diagramatically for each station on plate 1. The wind duration for each direction is classified in three groups of velocities; 0–12, 13–24, and 25 miles per hour and over. The length of each bar on the perimeter of the diagrams represents the percentage of the total wind duration for these velocities. The percentage of the total wind movement and duration for each direction are shown in the center of the diagrams.

63. The wind records of Fairport Harbor, Ohio, have been compiled for the 10-year period from February 1932 to January 1942, inclusive. Similar wind records have been compiled for Ashtabula, Ohio, for the period from January 1937 to December 1948, inclusive, with the exception of 1944. Ashtabula wind records for that year are incomplete and for that reason have been excluded from the Ashtabula summary.

64. The shore line under consideration is exposed to storm waves from the southwest through the north to the northeast. In the higher velocities (25 miles per hour and over) winds of the greatest duration came from the northwest and west at Fairport Harbor; and from the northwest, southwest, and west at Ashtabula Harbor. In the lower velocities, winds of greatest duration are from the southwest at both Fairport and Ashtabula Harbors. The maximum wind movement, which is a function of the combined effect of velocity and duration, is also from the southwest. Winds from the southwest are nearly parallel to the shore and the resulting waves create currents along shore in an easterly direction.

65. Comparison of wind data at Fairport and Ashtabula Harbors, shows that the maximum variation of duration and wind movement for each direction is less than 3 percent. For ease in discussion, wind data are summarized and averaged in table 6 below.

TABLE 6.—*Yearly average winds at Fairport and Ashtabula Harbors, Ohio*

Direction	Wind duration [1]			Wind movement [1]		
	Fairport, Ohio	Ashtabula, Ohio	Average	Fairport, Ohio	Ashtabula, Ohio	Average
North	5.0	4.8	4.9	5.6	4.8	5.2
Northeast	14.4	15.8	15.1	16.2	16.5	16.3
East	6.6	4.3	5.5	5.2	3.4	4.3
Southeast	10.5	9.8	10.2	6.5	8.2	7.4
South	12.8	12.5	12.6	6.9	9.3	8.1
Southwest	23.9	23.3	23.6	22.2	22.7	22.4
West	13.0	13.5	13.2	17.1	13.6	15.4
Northwest	13.8	16.0	14.9	20.3	21.5	20.9

[1] Percent of total.

66. *Lake levels.*—Variations in lake levels greatly influence the rate of erosion within the study area. During periods of low lake levels, the resulting beach areas are sufficiently wide to reduce wave attack at the base of the bluffs. Wave attack occurring during high lake stages is more damaging because of the reduced width of the protecting beach.

67. Minimum lake levels during any particular year usually occur in February when the precipitation throughout the Great Lakes watershed is being stored in the form of ice and snow. Maximum levels occur in midsummer when the full effect of the runoff from the watershed of Lake Erie and the upper lakes is felt. Fluctuations of considerable magnitude, but of short duration, are caused by winds, and also by seiches, which are the large waves induced by sharp barometric gradients moving rapidly across the lake. Northerly and northeasterly winds raise lake levels in the study area, while westerly winds tend to lower the lake level. In 1859, the United States lake survey established water level gages on all the Great Lakes. One of these is located at Cleveland Harbor, Ohio. Continuous records of monthly mean elevations of all the lakes are available for the period from 1860 to date, and are published by the United States lake survey district of the Corps of Engineers. Pertinent data on the fluctuations of levels of Lake Erie are shown in table 7.

TABLE 7.—*Water level fluctuations*

Item	High stage, feet [1]	Date	Low stage, feet [1]	Date	Variation, feet	Elevation [2]
Extreme stage	+4.01	June 1876	−1.07	February 1936	5.08	--------
Extreme stage, instantaneous 1900–1949	+5.05	June 1946	−2.85	do	7.90	--------
Maximum seasonal variation in calendar year	+3.83	June 1947	+1.08	March 1947	2.75	--------
Minimum seasonal variation in calendar year	+1.08	June 1895	+.21	November 1895	.87	--------
Mean lake level from January 1860 to December 1949, inclusive	--------	--------	--------	--------	--------	572.29
Mean lake level from January 1900 to December 1949, inclusive	--------	--------	--------	--------	--------	571.96
Average lake level, April to November, inclusive: 1900–1949, inclusive	--------	--------	--------	--------	--------	572.22

[1] Referred to low water datum, 570.5 feet above mean tide at New York City. All stages computed from monthly means, except instantaneous high and low.
[2] Referred to mean tide at New York City.

68. *Ice action.*—Under suitable conditions, ordinarily in the late fall, spray freezes and forms a coating of ice on the shore to heights up to 15 feet above lake level, thereby armoring the beach and bluffs against further wave action. As soon as solid ice forms offshore, the shore line is protected from further wave action for the period in which the ice is intact. Early in December of average winters, ice starts to form in the shallow water along the shore of Lake Erie. During the most severe winters, the entire lake may freeze over and the ice attain a maximum thickness of approximately 3 feet. In average years, the warmer weather of early March weakens and honeycombs the ice. Subsequently, the ice breaks up and forms floating ice fields that shift with the winds. If the break-up extends to the shore, floating ice cakes batter the shore structures. Frequently ice is shoved up on shore causing additional damage to weak structures.

69. While ice has both detrimental and beneficial effects, the latter are believed to predominate because of the protection provided to the shore line during the winter when storms are most severe and wave action would otherwise be most destructive. The protective effect of ice was illustrated during the storm of March 25, 1947. At that time, the east end of Lake Erie, which was protected by ice, was undamaged, while serious damage occurred in the Cleveland, Ohio, area and to the west where the lake was free of ice.

70. *Littoral drift.*—In the study area, winds from the southwest through the west to the northwest set up currents along the shore in a general west-to-east direction. Those from the north and northeast set up currents in the opposite direction. Offshore winds from the south through the southeast to the east have little effect on the littoral current. The wind diagrams of Fairport and Ashtabula Harbors, Ohio, on plate 1 and the data in table 6 show that winds from the southwest, west, and northwest account for approximately 52 percent of the total wind duration and 59 percent of the total wind movement. Only 20 percent of the wind duration and 22 percent of the wind movement is accounted for by north and northeast winds. Predominant winds of high velocity are from the southwest through the west to the northwest and the northeast. Under the influence of this wind pattern, the prevailing and predominant littoral currents are from the west to the east, with temporary reversals in direction due to winds from the north and northeast. Accretion adjacent to shore structures confirms this analysis. Outstanding examples are the sand beaches which have accumulated west of the west breakwater at Ashtabula Harbor and west of Mercer's Harbor in Perry Township, Lake County.

71. *Water seepage and frost action.*—The rate of erosion caused by slumping of material from the face of the silt and clay bluffs is hastened by the action of ground water, surface run-off, and frost action. Although in some sections of shore line the bluff material is relatively impervious, it contains enough thin lenses of sand to allow percolation of ground water to the face of the bluff. Shrinkage cracks occur near the surface, both at the top and along the face of the bluff, which allow surface water to enter and further soften the bluff material. Freezing of the water in the cracks near the face of the bluffs hastens the disintegration and large chunks fall off and slide down to the base of the bluff where wave action removes the fine materials. Unprotected bluffs cannot attain a stable slope and the process of slumping

and removal of material by wave action goes on in a continuous cycle, the rate dependent to a large extent upon the severity of wave attack.

72. In some sections the lacustrine material is covered by a layer of sand or gravel. Rain falling upon the highly pervious sand percolates through to the less pervious lacustrine material below. Part of the water emerges along the cliff face, at the point of contact between the sand and lacustrine material in the form of a contact spring. This water flowing down the face of the bluff removes some of the easily eroded lacustrine material. Some of the water soaks slowly through the lacustrine materials increasing the weight and reducing the friction between the fine particles. This causes movement of the lacustrine clay over the impervious boulder clay below. This viscous mass acts like the material commonly called "quick sand". Ordinarily there are other contact springs in the face of the bluff at the top of the boulder clay.

VI. SHORE LINE AND OFFSHORE CHANGES

73. *Available data.*—Only two complete surveys have been made from which a comparison of the location of the shore line and changes in the offshore depths can be made for the entire study area. These surveys were made by the United States Lake Survey in 1876 and 1948, the latter in connection with the present study. Comparisons between the 1948 survey and the 1876 survey are subject to considerable doubt because of uncertainties regarding lake stage correction, lack of sufficient common control points, and the lack of detail inherent in the earlier lead-line method of sounding. There are partial navigation surveys covering the area at and in the vicinity of Fairport and Ashtabula Harbors, but these are of insufficient scope to be of material use in this study.

74. The 1948 hydrographic survey was made with the use of an echo sounder which charted a true reproduction of the lake bottom as the survey boat moved along the profile line. In order to obtain similar profiles from the 1876 survey, the 1948 profile lines were located on the 1876 chart and profiles were interpolated from the nearest 1876 soundings. Echo sounder records indicate sharply changing depths at places in this area leading to the conclusion that an interpolated profile has but little value for comparison, and that the only true test of erosion or accretion would be profiles rigidly controlled to follow identical lines.

75. *Comparative profiles.*—Profiles of the bluffs were not obtained during the 1876 survey. To obtain comparative profiles, the 1876 hydrographic profiles were extrapolated shoreward assuming that the outline of the beach and bluff between the water's edge and the top of the bluff was similar in contour to that shown at corresponding locations by the 1948 survey. In view of these facts, any conclusions drawn from the comparative profiles must necessarily be approximate. The locations of all profile lines are shown on plate No. 1. However, only 30 of the comparative profiles shown on plates Nos. 2 to 4,[1] are included in this report to illustrate typical conditions throughout the study area.

76. *Shore line changes.*—Since it has been the practice of the United States Lake Survey to record only the existing water's edge of the

[1] Not printed.

time of survey, sufficient inshore data are lacking to permit reducing the shore line of the 1948 and earlier surveys to a common datum necessary for comparison. However, an approximation of the changes in the shore line was deduced by comparing 1948 profiles with the 1876 profiles. The distance between profile lines varies from approximately 440 feet between profiles 77 and 78 to 3,350 between profiles 79 and 80. The average distance between profile lines is approximately 1,460 feet. In some areas, the movement of the shore line varies greatly in short distances and in view of the fact that the average distance between profiles is approximately 1,460 feet, the shore line changes that occur at the profile line may not be representative of the entire stretch of shore line between the profile lines. In the area between the western limit of the study area and profile 29, there has been an average 165-foot landward movement of the shore line between the 1876 and 1948 surveys. The rate of recession of the shore line in this area has varied due to the influence of protective structures, intensity of wave attack, and composition of the bluff material. The shore line in the immediate vicinity of profile 26 has been protected by a concrete breakwater and by groins. The comparative profiles indicate only a slight movement of the shore line at this point. A similar condition exists in the vicinity of profile 14. A groin immediately adjacent to the profile line has impounded a wide beach. While comparative profiles indicate a 10-foot landward movement of the shore line between the period of surveys, it is believed that a far greater recession had occurred prior to the construction of the groin. The maximum landward movement of approximately 340 feet occurred in the vicinity of profile 9. Aerial photographs [1] of the area show the bluff to be almost vertical and devoid of vegetation. This together with the fact that the extremely narrow beach fronting the bluff offers little protection to it, leads to the belief that the landward recession of the shore line has been accompanied by an equal recession of the bluff line.

77. Between profiles 30 and 41, there has been an average landward movement of only 35 feet and in general the bluffs have reached a stable slope. The maximum landward movement of approximately 190 feet occurred in the vicinity of profile 34 and the maximum lakeward movement of 90 feet occurred in the vicinity of profile 38. The wide sand beach which protects the bluffs between profiles 35 and 41 attains its maximum width in the vicinity of profile 38.

78. Between profiles 42 and 44, the comparative profiles indicate an average landward movement of approximately 200 feet in the period between surveys. The bluffs are low between these profiles, the beach fronting the bluff is quite narrow, and bluff erosion is now active.

79. Exclusive of profiles 87 and 88, which were taken at the beach immediately west of the west breakwater at Ashtabula Harbor, there has been an average 55-foot landward movement of the shore line between profiles 45 and 93. The maximum landward movement of 190 feet occurred in the vicinity of profile 75. There is no beach at this location, and wave attack at the base of the bluff continues unimpeded. A slight lakeward movement of the shore line has occurred in the vicinity of profile 82, but it is localized at this point and erosion

[1] Not printed.

has been experienced on either side of the profile. The lakeward movements of 240 feet and 530 feet occurring at profiles 87 and 88, respectively, are due to the impounding action of the west breakwater at Ashtabula Harbor.

80. *Offshore changes.*—As explained in paragraphs 73 to 75, the 1948 profiles obtained by echo sounding show the lake bottom to be quite rough, and although the corresponding 1875 profiles obtained by interpolation from lead-line soundings are shown as smooth lines, it is probable that the lake bottom was equally rough at the time of the earlier survey. Errors of considerable size between the 1875 and 1948 profiles could easily occur as a result of interpolating from individual soundings taken on lines about 700 feet apart. It is therefore considered impracticable to determine and describe the offshore depth changes in detail. However, in general, deepening of the offshore areas between the shore line and the 10-foot depth has occurred wherever erosion and recession of the bluffs has taken place. In general, slight accretion has occurred between the 10- and 30-foot depths.

81. *Volumetric changes.* Any attempt to compute the amount of erosion of the bluffs, shore, and beach to the 10-foot depth, or the amount of accretion between the 10- and 30-foot depths from the available, unsatisfactory data would lead only to questionable conclusions. The survey control points used in the 1948 survey have been permanently monumented and can be used for orienting future surveys at any point in the study area to determine the rates of erosion or accretion.

VII. PLANS OF IMPROVEMENT

82. *Improvements desired.*—The applications for the cooperative study requested the determination of effective and economical methods of shore and beach protection for private and public shore frontages and the possibility of recreational development of public park frontages. During the preparation of the report, State officials consulted local officials charged with the administration of the public parks in the area to determine their erosion problems and the need for further development or improvement of park frontages. This information was supplemented by questionnaires sent to park officials by the district engineer which requested information on damage from erosion and on considered improvements. Comments of local officials in response to the questionnaire are briefly summarized as follows:

(*a*) *Painesville Township Park.*—Protection is needed from extensive erosion on easterly half of frontage.

(*b*) *Perry Township Park.*—Protection for the beach and bluff along the entire park frontage is required. If erosion continues at its present rate, within a few years park buildings located near the bluff will be lost if not moved back.

(*c*) *North Perry Park.*—There is no erosion problem and no improvements are required.

(*d*) *Tuttle Park and Madison Township Park.*—Very slight erosion has occurred and no improvements have been considered.

(*e*) *Geneva Township Park.*—No reply to the district engineer's questionnaire was received from local officials. However, in a subsequent interview, park officials indicated that additional protection is needed in the westerly half of the park frontage and additional beach area is

needed to accommodate peak day attendance. Attendance during 1949 was reported by park officials as approximately 300 persons daily on week days, 1,500 persons on week ends, and 5,000 persons on the Fourth of July holiday.

(*f*) *Saybrook Township Park.*—Slight damage from erosion has occurred and further protection is not required.

(*g*) *Walnut Beach Park.*—There is no erosion problem. A wide sand beach impounded by the west breakwater at Ashtabula Harbor extends across the entire existing park frontage and the proposed 500-foot extension to the west.

(*h*) *Lake Shore Park.*—Erosion of the bluff at the westerly end of the park is being controlled by dumping slag from the top of the bluff. Protection against erosion is needed at the east end of the park where the shore line has receded from 40 to 50 feet in 10 years.

83. *General methods of protection.*—In general, erosion due to wave attack at the base of an unprotected bluff may be reduced either by building a beach of suitable profile to prevent direct wave attack on the bluffs or by erecting a sea wall capable of resisting wave attack at the toe of the bluff. There are two methods of building and improving beaches in areas where those provided by natural forces are not of sufficient width and height to protect the bluffs. In areas where the supply of sand transported by littoral currents or furnished directly to the beach by erosion of bluffs landward of the proposed beach area is plentiful, groins may be built to arrest the movement of the sand and accumulate it in a chosen location. In areas where there is a very limited natural supply of sand, beaches may be created by adding sand artificially. When material is removed from an area faster than material is brought into the area, groins are employed to reduce the rate of removal. These general principles have been considered in the plans of improvement discussed in the following paragraphs.

84. *Analysis of principal features of the problem.*—As indicated in paragraph 43, no beach building material is supplied from outside the immediate study area. A small amount of sand and gravel is brought down by Indian Creek but the principal natural source of beach building material is from erosion of the bluffs. The amount of suitable material in the bluffs varies widely in various sections of the shore line. As additional sections of the shore are protected less material will be supplied to downdrift beaches. Groins constructed to build beaches by arresting littoral drift should be designed to hold the minimum amount of sand required for protection of the immediate area and to allow sand in excess of this amount to move downdrift. This practice leads to the most economical and equitable use of the limited natural supply of sand. Such a general plan should be followed in areas where erosion of the bluffs containing thick deposits of sand in undeveloped and unprotected areas is supplying sand to beaches to the east where the shore is developed for residential use.

85. *Painesville Township Park.*—The State of Ohio, in cooperation with the Painesville Township Park Board, has prepared plans for improvement of the easterly half of the park frontage. The proposed work consists of repairing and raising the elevation of the existing timber crib groin (structure No. 18) to elevation 7.5 feet above low-water datum, repairing and raising the elevation of the offshore breakwater (structure No. 17) to the same height and constructing

a new groin approximately 145 feet long varying in height from 7.5 feet above low-water datum at the shore end to 1.5 feet above low-water datum at the outer end. The locations of the structure are shown on plate 5.[1] It is expected that sand and gravel will accumulate at a slow rate west of the groin and extend the width and height of the existing narrow beach to provide protection for the bluff as well as adding to the available bathing area. The existing semi-permeable groins in the park have maintained a beach up to 100 feet in width. Erosion of approximately one-half mile of unprotected bluffs west of the park is the principal source of beach material supplied to the park frontage. The rebuilt breakwater and groin on the east and downdrift side of the new groin will provide protection against erosion of this portion of the park frontage.

86. The proposed work is now under construction, and is considered adequate for the protection and improvement needed at Painsville Township Park at this time. Following completion of the new groin, sand fill could be placed on the west side to provide full protection and additional beach area immediately. No Federal aid is involved in this improvement, two-thirds of the costs of which are being paid by the State and one-third by local interests.

87. *Perry Township Park.*—The most economical plan for the protection and improvement of the Perry Township Park frontage is the construction of groins to hold sand supplied to the park frontage from the west by littoral drift, and the sand and gravel supplied by controlled erosion of the bluffs along the park frontage. There is considerable beach-building material in the bluffs in the 4-foot thick strata of sand at the top of the bluff and in the lower strata of boulder clay which extends from below lake level up to approximately 8 feet above low-water datum. Park officials have stated that further controlled recession of the bluff line will not seriously damage the park property or interfere with proposed improvements. By the use of groins to retain the sand and gravel portion of the bluff material at the toe of the bluffs, a beach of sufficient height and width to protect the shore line would gradually accumulate. The rate of recession of the bluff would be progressively reduced but full stabilization of the bluff and beach would probably require a period of several years. Immediate stabilization could be obtained by adding sand fill but it is believed to be more economical to allow littoral drift and further erosion of the bluff to furnish the beach material. Existing stone and concrete structures should be removed and the salvaged stone and broken concrete used as riprap toe protection just east of the most easterly of the proposed groins.

88. The proposed locations and general design features of the proposed groins are shown on plate 9. Since shale bedrock is found at depths of 10 feet or less below low-water datum, gravity type structures will be required. The inner ends of the groins should be extended into the face of the bluff, a minimum distance of 10 feet at the time of construction. Further extensions of the shoreward ends of the groins to maintain contact with the face of the bluff may be required as recession of the bluff occurs. This is an essential item of maintenance since the eventual success of the proposed plan depends upon preven-

[1] Not printed.

tion of flanking of the inner ends of the groins and consequent loss of beach material.

89. *Geneva Township Park.*—Since its construction in 1940, the existing groin near the easterly limit of Geneva Township Park has maintained a beach of sufficient width and height to protect the easterly half of the park frontage. Between the inner end of the steel sheet pile structure and the concrete sea wall at the base of the bluff there is a space 50 feet wide occupied by ruins of an older stone-filled timber crib and a concrete groin. The top height of the timber crib and concrete groin varies from 4 feet above low water datum at the outer end where they join the steel sheet pile structure, to 7.6 feet at the inner end. During storms and high lake stages, sand is washed through this low opening between the inner end of the steel sheet pile structure and the base of the bluff. Since the predominant drift is from the west, closure of this gap by construction of a higher section at the inner end of the existing sheet pile groin would hold sand in the park area until the beach builds up to the top of the relatively low existing groin. Excess sand would pass over the top of the existing groin which has a top height of approximately 5 feet above low-water datum near its junction with the proposed extension. General plans of the proposed extension are shown on plate 9. Extension of this groin should be the first step in further improvement of the park frontage.

90. To increase the width of beach for the combined purpose of protection of the westerly half of the park frontage and increasing the area of the bathing beach, the construction of a groin near the center of the park frontage should be the next step in the improvement. The proposed groin should be constructed at a time when there is an abundance of sand between its location and the existing groin at the east end of the park. Otherwise construction of the proposed groin, which will temporarily cut off the predominant littoral drift from the west, would leave the easterly portion of the beach in a depleted condition for some time. The proposed groin would have a total length of 154 feet. The inner end for a length of 37 feet would have a top elevation of 8 feet above low-water datum and slope to a height of 2 feet above low-water datum at the outer end. A groin of this profile can be expected to build a beach of sufficient height to provide increased beach area and protect the westerly end of the park from erosion. Because of its lower elevation toward the outer end it will eventually allow sand to pass over and nourish the beach to the east. The general design of the proposed groin is shown on plate 9.

91. *Lake Shore Park.*—According to information furnished by the Ashtabula Township Park Commission, the shore and bluff at the west end of the park has receded 60 feet in the past 10 years. However, only about 60 feet of park frontage west of the inner end of the concrete wall is involved. A highway in the park was endangered by slumping of the bluffs, and slag from the nearby Electro Metallurgical Co. plant is being dumped from the top of the bluff to protect the road and shore frontage in this section. Approximately 1,200 feet of the park frontage adjacent to and easterly of this section is protected by a concrete wall with a top height of about 5 feet above low-water datum. The adjoining 300 feet of shore line to the east of the concrete wall is well protected by an existing sand and gravel beach. The easterly

820 feet of the park frontage, where the unprotected bluff is approximately 15 feet high, is eroding.

92. Revetment of the toe of the bluff from elevation 10 feet above low-water datum down to the underlying shale at approximately 2 feet below low-water datum is considered the most suitable plan to provide permanent protection for the easterly 820 feet of the park frontage. A filter blanket of well graded gravel or crushed stone should be placed between the heavy facing blocks and the bluff to prevent leaching of the fine silt and clay through large openings between facing blocks on the lakeward face of the revetment. The stone or concrete blocks on the lakeward face should have a weight range of 1 to 4 tons with at least 50 percent over 2 tons. The surface material should be excavated and the foundation of the revetment should be placed on the underlying shale to prevent undermining of the toe of the structure. A typical cross section of the proposed revetment is shown as plan A for Lake Shore Park on plate 10.

93. An alternative plan of protection and development of beach area for the same approximately 820 feet of frontage is shown as plan B on plate 10. This plan would provide protection to the low bluffs by artificially building a sand beach along the frontage between the existing sea wall and the east limit of the park. The area is sheltered by the Ashtabula Harbor breakwaters and the projecting structures of the Cleveland Electric Illuminating Co. There is no evidence of strong littoral currents which would be likely to remove sand from this area rapidly enough to justify the cost of groins to reduce the rate of loss. Cost of replenishment of sand which is lost would probably be less than the carrying charges for groins.

94. As shown in alternative plan B on plate 10, the proposed beach fill beginning at the base of the bluff should have a horizontal berm at least 10 feet wide at an elevation of 8 feet above low-water datum. It would then have a slope of about 1 on 10 to water level, and 1 on 20 below water level to the natural bottom. Maintenance of the beach would require artificial replenishment of any material lost as there is no natural drift of sand in the area. Because of the protected location of the beach area, the loss of sand should be small.

95. *Plans of improvement for private property.*—The characteristics of the shore line vary considerably throughout the study area. One characteristic which has a decided influence on the choice of the type of improvement is the amount of sand and gravel in the bluffs of a particular area or in unprotected bluffs to the west or updrift side of the area. On the basis of the type of material in the bluffs the study area can be divided into four general areas: (1) From Fairport Harbor to Perry Township Park the bluffs are composed almost entirely of boulder clay; (2) from Perry Township Park to the Perry-Madison Township line the boulder clay bluffs have an upper stratum of sand from 4 to 6 feet thick; (3) between the Perry-Madison Township line and Madison Township Park, the upper stratum of the bluffs is sand varying in thickness from 35 feet just east of the township line to approximately 14 feet near Madison Township Park; (4) between Madison Township Park and Ashtabula Harbor, the bluffs are boulder clay with an upper stratum of sand from 1 to 3 feet thick. Between Geneva Township Park and Ashtabula Harbor, the amount of sand in the bluffs gradually diminishes.

96. *Fairport Harbor to Perry Township Park.*—Since there is very little beach-building material in the bluffs and any natural supply of sand from the west is cut off by the Fairport Harbor structures, the protection of long stretches of shore line by groins designed to trap littoral drift, is impractical. Toe protection at the base of the bluff by use of a sea wall and slope revetment is the most positive means of shore protection in this area. General design features for such a structure are shown as plan C on plate 10. The top height of the cellular steel sheet pile sea wall is 8 feet above low-water datum and the slope revetment is carried up to an elevation approximately 12.5 feet above low-water datum. Foundations for this type of protection must be placed below the depth of scour that is anticipated on the lakeward face. Wave action on the face of the proposed sea wall can be expected to remove any existing beach and may cause scour to a depth of 4 to 6 feet below low-water datum. Earth pressure on the landward side must be considered in the design of the sea wall. The estimated cost of gravity-type structures is no greater than the cost of a cantilever type structure with adequate anchorage.

97. As an alternative to plan C, bluff revetment similar to that shown on plate 10 as plan A for Lake Shore Park or a rough-faced riprap sea wall, shown as plan F, may be considered. For the worst exposures where high waves will reach the revetment, its top elevation should be about 12 feet above low-water datum. In its simplest form, revetment consists of a continuous belt of heavy rip-rap or stone pavement laid on a stable slope and covering the zone of destructive wave action. A bedding or filter course of crushed stone should be used, its size varying from about one-fourth inch up to a little larger than the largest openings to be left between the heavy cover stone. The rock composing the protective belt should have a weight range of 1 to 4 tons with not more than 50 percent less than 2 tons, if placed on a slope of 1 on 1½. The bluff behind this armored zone need not be sloped or drained unless it is obviously in such a fluid state that horizontal thrust from its movement would displace the stone revetment. Progressive recession of the top of the bluff is to be expected until the slope of the bluff approximates that of the natural angle of repose of the material composing it. Use of these types of protection will probably result in the loss of beach in front of the belt of revetment or riprap. This will in turn result in an intensification of the wave attack at the toe of the belt of stone protection with consequent settlement of stone. The stone lost or displaced by such settlement should be replaced without delay to prevent breaching of the protective belt. The cost of this maintenance, while initially relatively high, may be expected to decrease as the beach approaches a new state of equilibrium after the protection has been placed. Stone revetment or dumped riprap are adapted to the needs of this shore line where little beach material is available, where esthetic considerations are not important, and where a beach in front is not needed. Toward the easterly end of this section of shore line, the plan of improvement described in the following paragraph may be used.

98. *Perry Township Park to Perry-Madison Township line.*—In this section of shore line there is sufficient beach-building material in the bluffs to allow an individual property owner or group of adjacent property owners to control erosion by constructing high groins to hold the coarse material derived from erosion of the bluffs and

accumulate a beach area at the toe of the bluffs. This plan, shown as plan E on plate 10, can be used only in cases where further limited erosion of the bluffs would not endanger improvements near the top of the bluffs. Plan E, groins, constructed for the purpose of holding the eroded material, should be approximately 100 feet in length, constructed to a height of 8 feet above low-water datum at the inner end, and have a top slope approximately paralleling the existing beach and bottom slope. The outer end of the groins would, in most cases, be at an elevation of about 2 feet above low-water datum. The inner end of the groins should be well tied into the face of the bluff at the time of construction and contact should be maintained with the face of the bluff by landward extension of the groins if necessary. Groins of this length should be spaced approximately 100 feet apart. Wherever no further erosion of the top of the bluff can be permitted other than that necessary to obtain a stable slope by grading or natural slumping after the toe is protected, plan C or F which provide a sea wall or revetment for protection of the zone of wave attack may be used. Where there are existing beaches they may be stabilized and improved by low short groins as described for plan D in the following paragraph.

99. *Perry-Madison Township line to Madison Township Park.*—The bluffs in this section of the shore line contain a high percentage of sand. Relatively wide sand beaches which have resulted from erosion of the bluffs extend along the entire frontage. The natural sand beach has encouraged the recreational development of the area and residents have constructed groins and sea walls to prevent further erosion of the bluffs. The natural supply of sand has gradually been decreased and the present problem is to maintain existing beaches for recreational use and shore protection. The most practical general plan for the entire area is the use of low groins to slow down the rate of movement of the littoral drift and still allow a uniform distribution of sand over the beach frontage. During periods of high water, wave action will extend to a height of approximately 10 feet above low-water datum. With the quantity of sand available, it is not practical to build beaches to this elevation. Therefore, a beach at lower elevation backed by slope revetment at the base of the bluff is a more suitable plan. Existing groins with a top elevation of approximately 5 feet above low-water datum have been effective during normal lake stages. A plan of improvement using groins of this height and slope revetment is shown as plan D on plate 10. Groins of 60-foot length should be spaced from 100 feet to 150 feet apart. The drainage system indicated on the drawing may be unnecessary in stretches of shore line where the bluffs are lower than indicated by the particular profile used for illustrating plan D.

100. *Madison Township Park to Ashtabula Harbor.*—The characteristics of the bluffs in this section are similar to the bluffs in the section between Perry Township Park and the Perry-Madison Township line. The use of high groins, as shown in plan E to control erosion of the bluffs where some further erosion to furnish beach-building material can be permitted, sea walls as in plan C or the revetment of plan F where less recession can be allowed, or plan D where there are existing beaches are alternative plans of improvement. The plans are described in preceding paragraphs and shown in plate 10. Although the bluffs between Geneva Township Park and Ashtabula

Harbor contain fewer sand deposits than the bluffs farther west, there is considerable littoral drift as shown by the accumulation of sand at the Red Brook jetties, at structure No. 220 and the west breakwater at Ashtabula Harbor. The final choice of plan must be made by an individual property owner depending upon the existing condition of the shore and whether or not a beach is particularly desired. It must be recognized that wherever high groins are used for protection of a particular section of shore line the adjoining section in the down-drift direction will be deprived of its former supply of sand from littoral drift and increased erosion can be expected. For this reason, cooperative action by a group of property owners to extend any proposed protection far enough to tie in to existing protection on the down-drift side should be considered. Otherwise the last groin on the down-drift side of an improved section must be designed to be stable under conditions of anticipated erosion alongside the groin and at its inner end.

VIII. ECONOMIC ANALYSIS

101. *Authority for Federal aid.*—Public Law 727, Seventy-ninth Congress, second session, states "* * * That, with the purpose of preventing damage to public property and promoting and encouraging the healthful recreation of the people, it is hereby declared to be the policy of the United States to assist in the construction, but not the maintenance of works for the improvement and protection against erosion by waves and currents of the shores of the United States that are owned by the States, municipalities, or other political subdivisions: *Provided,* That the Federal contribution toward the construction of protective works shall not in any case exceed one-third of the total cost * * *." Since the law does not provide for Federal contribution toward the protection or improvement of privately owned property, an economic analysis to determine the justification of Federal participation is required only where protection and improvement of public property is involved. However, if the improvement considered most satisfactory for public property cannot be accomplished without also including the adjoining private property the latter must also be included in the economic analysis.

102. The publicly owned lake front properties in the study area are Painesville Township Park, Perry Township Park, North Perry Village Park, Tuttle Park, Madison Township Park, the Madison sewage disposal plant, Geneva Township Park, Saybrook Township Park, Walnut Beach Park, and Lake Shore Park. Improvements are considered necessary only at Perry Township Park, Geneva Township Park, and Lake Shore Park. The other publicly owned areas have been improved by local interests or need no improvements. Maintenance of existing structures will provide all the protection needed at this time.

103. *First costs.*—The total first costs for the considered plans of improvement for publicly owned parks have been estimated and are given in table 8. These costs include the direct costs for plant, labor, materials, engineering services for design, preparation of plans and specifications, supervision, inspection, and overhead. It is assumed that the costs would be the same whether the projects were under-

taken by the Corps of Engineers or the cooperating agency. Detailed estimates are given in appendix 5.

TABLE 8.—*Summary of estimated total first costs*

Improvement:	*Total first costs*
Perry Township Park	$45, 000
Geneva Township Park	19, 900
Lake Shore Park:	
Plan A	76, 000
Plan B	30, 000

104. *Allocation of costs.*—The Federal policy for the expenditure of Federal funds to construct short protection structures and other related works for the improvement and protection of shores owned by States, municipalities, and other political subdivisions, is set forth in Public Law 727, Seventy-ninth Congress, second session, approved August 13, 1946. The Federal share of the cost of a project is the percentage of the total interest represented by the Federal interest plus not to exceed one-third of the total cost of construction of works for the improvement and protection of shores owned by States, municipalities, or other political subdivisions, excluding costs of necessary lands, easements, and rights-of-way. The non-Federal share of the cost is determined as the percentage of the total interest represented by the non-Federal interests, less that portion of the cost to be contributed by the Federal Government under the provisions of Public Law 727, Seventy-ninth Congress, second session.

105. There is no Federal interest in the considered improvements since no federally owned land is involved. However, all the parks where improvements have been considered are publicly owned and all the benefits derived from their improvement are public benefits. The full one-third contribution toward the protection and improvement of these parks is considered possible under the provisions of the law as outlined above and because of the public benefits involved the maximum contribution is considered justified. Any necessary alterations to utilities are considered the responsibility of the owners. The allocation of costs to Federal and non-Federal interests in accordance with the above principle is shown in table 9.

TABLE 9.—*Allocation of costs*

Item	Perry Township Park	Geneva Township Park	Lake Shore Park, plan A	Lake Shore Park, plan B
Federal	$15, 000	$6, 600	$25, 300	$10, 000
Non-Federal	30, 000	13, 300	50, 700	20, 000
Total	45, 000	19, 900	76, 000	30, 000

106. *Annual costs.*—The annual carrying charges for the proposed plans of improvement for public areas are based on interest rates of 3 percent for Federal costs and 3½ percent for non-Federal costs, and amortization over a period of 50 years. Interest during construction has not been included since the construction period is not likely to extend into more than one season for any of the considered improvements.

TABLE 10.—*Estimated annual costs*

Item	Perry Township Park	Geneva Township Park	Lake Shore Park, plan A	Lake Shore Park, plan B
Interest:				
Federal	$450	$200	$760	$300
Non-Federal	1,050	470	1,780	700
Amortization:				
Federal	130	60	230	90
Non-Federal	230	100	390	150
Maintenance:				
Federal				
Non-Federal	250	70	290	700
Total annual costs	2,110	900	3,450	1,940

107. *Estimates of benefits.*—The principal benefits that will result from the proposed improvements consist of direct damages prevented and recreational benefits. The publicly owned upland property will continue to be used for park purposes and its earning power will not be materially increased if protected from erosion. The recreational benefits which have been evaluated take cognizance of the increased beach areas and are a measure of the value of the earning power of such additional areas to be provided.

108. *Average annual direct damages prevented.*—The obvious direct damages prevented are actual losses of property and repairs or replacement to park facilities attributable to erosion.

(*a*) *Perry Township Park.*—Based on available records of surveys the rate of recession of the bluffs at Perry Township Park is approximately 4 feet annually. The estimated direct damages from loss of land is $160 annually. Replacement of guard fences at the top of the high bluff and repairs to the stairway providing access to the beach area down the steep face of the bluff are items of maintenance made necessary by continuous erosion of the bluff and are estimated at $50 annually. Within the next 50 years if the present rate of erosion continues the existing bathhouse, refreshment stands, and shelters must be moved or they will be destroyed. Damages to structures estimated at $100 annually could be prevented by adequate shore-line protection.

(*b*) *Geneva Township Park.*—The westerly third of the park frontage has a history of continual erosion at a rate of approximately 2.5 feet annually during the past 25 years. Over a frontage of approximately 300 feet where erosion is occurring damages from actual loss of land are estimated at $100 annually. Attempts have been made to grade and landscape the bluff along the park frontage. Along the unprotected westerly third active erosion maintains a vertical bluff which is a hazard to users of the park about which park officials are quite concerned.

(*c*) *Lake Shore Park.*—The rate of erosion at Lake Shore Park is approximately 3.5 feet annually. The estimated direct damage from loss of property is $370 annually. No existing structures are threatened by continued erosion of the portion of the park frontage which is unprotected at the present time.

109. The items mentioned do not represent the full extent of the damages from erosion of the park properties. The land itself is a natural resource which is totally lost if destroyed by erosion. If it

were to be replaced by fill brought in from outside sources the cost of replacement would far exceed its value as estimated in the preceding paragraph. A strip of property bordering an eroding shore line cannot be used for normal development and what would otherwise be the most desirable and valuable portion of a parcel of lake-front property is unfit for improvement. A portion of it is sacrificed annually because of lack of protection. The value of the upland portion of a parcel of shore-front property is also reduced by the constant threat of erosion. As its depth measured normal to the shore line decreases, its total value decreases at an accelerating rate disproportionate to the actual loss of area. Thus a parcel of property originally having a depth of 100 feet instead of losing one-half its value becomes practically worthless by the time erosion reduces its depth to 50 feet. While it is difficult to evaluate the above-mentioned benefits from protection of shore-front property, it is considered that the increased security in the development of protected property and the enhancement of value of the upland property has a value even greater than the actual damages prevented which have been evaluated.

110. *Average annual benefits and benefits-costs ratio.*—Recreational benefits have been evaluated by what is considered a reasonable estimate of the increased use of beaches assuming a value of $0.25 per person for the number of persons likely to be accommodated by the proposed increased beach areas. A further explanation of the methods used in computing direct damages and recreational benefits is given in appendix 5. The total annual benefits are summarized in table 11.

TABLE 11.—*Total estimated annual benefits*

Improvement	Direct damages prevented	Recreational benefits	Total annual benefits
Perry Township Park	$310	$3,800	$4,110
Geneva Township Park	100	3,800	3,900
Lake Shore Park:			
Plan A	370		370
Plan B	370	4,500	4,870

The estimated annual benefits, annual costs and the benefits-costs ratio for the considered improvement of publicly owned areas are given in table 12.

TABLE 12.—*Benefits-costs ratio*

Project	Annual benefits	Annual costs	Benefits-costs ratio
Perry Township Park	$4,110	$2,110	1.95:1
Geneva Township Park	3,900	900	4.33:1
Lake Shore Park:			
Plan A	370	3,450	.11:1
Plan B	4,870	1,940	2.51:1

111. The considered plans of improvement will protect public property and will provide facilities for the encouragement of healthful recreation of the people in the study area. It is recognized that the favorable benefits-costs ratios shown above are due largely to recreational benefits which have been evaluated. It is further recognized that the monetary value of these benefits cannot be accurately deter-

mined because of the intangible health benefits involved. An attempt has been made to arrive at a reasonable value of recreational benefits based on the anticipated increase in patronage and a conservative value per person. In addition to the direct damages evaluated there are substantial benefits derived from protection of shore front property which are discussed in paragraph 109.

112. *Estimates of cost for protection of private property.*—Three different plans of improvement have been designed to meet the various requirements of private property owners within the study area. Since it is beyond the scope of this report to prepare cost estimates for protection of specific stretches of privately owned shore line, general cost estimates of the three types of protection have been prepared. Plan C consists of a cellular steel sheet pile sea wall and grading, drainage, and revetment of the bluffs. Plan D provides low groins to build or maintain relatively narrow beaches, revetment of the toe of slope, and drainage of the bluffs. Plan E is a system of short high groins designed to build and hold a protecting beach as further controlled erosion of the bluffs in the immediate area furnishes suitable beach building material. Plan F is a stone revetment to armor the toe of the slope in the zone of destructive wave action. The plans of protection and the areas suitable for the use of each are discussed in paragraphs 95–100. The cost of protecting 100 linear feet of shore line has been estimated in each case. Since mobilization and demobilization costs are independent of the lengths of shore line improved, some savings will be realized where long stretches are improved under one contract. Detailed estimates of first costs for the considered plans of improvement based on November 1949 cost levels are given in appendix 5. A summary of estimated first costs is given in table 13

TABLE 13.—*Summary of estimated first costs (private property)*

Plan of improvement	Length of shore line protected	Total first cost [1]	Cost per linear foot of shore line protected [1]
	Feet		
Plan C. Sea wall and slope treatment	100	$23,500	$235
Plan D. Low groins and slope treatment	100	12,500	125
Plan E. High, short groins	100	8,400	84
Plan F. Stone revetment	100	9,500	95

[1] Exclusive of planning, inspection, and supervision.

Maintenance costs of plan F are likely to be high during the first few years after the revetment is placed but would decrease as the beach and revetment approach a state of equilibrium. Annual maintenance should be very low during the early life of plan C but would increase with age as the concrete cap and slope revetment may need repair and replacement.

113. *Coordination with other agencies.*—During the progress of the study, frequent conferences have been held between representatives of the Corps of Engineers and the cooperating agency. The views and suggestions of representatives of the cooperating agency expressed orally and in writing have been given careful consideration in the preparation of this report. The attention of the cooperating agency has been called to the fact that Federal participation in the work

would require approval by the Chief of Engineers of detailed plans and specifications and arrangements for the prosecution of the project prior to commencement. Attention has also been called to the fact that Federal participation would be contingent upon the State of Ohio or the appropriate local authority agreeing to be responsible for:

(*a*) Maintenance and repair during the useful life of the project as may be required to serve the intended purpose.

(*b*) Provision of all necessary lands, easements, and rights-of-way.

(*c*) Claims for damages either before, during, or after prosecution of the work.

114. Members of local park boards have been interviewed by representatives of the Corps of Engineers and their views on desired improvements and the ability and willingness of local interests to assume the required financial responsibilities have been obtained. The local interests' share of the cost of considered improvements is of such amount that bond issues requiring a referendum in each township involved would be required. The sentiment of the majority of the townspeople on the question of shore protection and improvement of bathing beaches is, therefore, indeterminable at this time. However, the amounts of the local contribution required for the considered plans of improvement are considered to be well within the means of the local communities particularly if the present practice of offering State aid in the amount of two-thirds of the non-Federal share of the cost is continued.

115. The use of beaches at Perry Township Park and Geneva Township Park is not considered to endanger the health of bathers because of pollution under existing conditions. There is serious pollution of the water at Lake Shore Park in Ashtabula. The city of Ashtabula has no sewage-treatment facilities and raw sewage and industrial wastes are discharged from a main trunk sewer into the harbor near the shoreward end of the United States east breakwater. A recently enacted State law making it unlawful for municipalities to discharge untreated sewage into the lake in Ohio waters should eventually lead to improving this condition but the location of a bathing beach immediately downdrift of a commercial harbor is undesirable.

IX. DISCUSSION

116. *General plans of improvement.*—The protection and improvement of the shore line between Fairport Harbor and Ashtabula Harbor presents a variety of problems because of the variation of shore-line characteristics. The steep bluffs in the westerly portion of the study area between Fairport Harbor and Perry Township Park are approximately 45 feet high and are composed principally of boulder clay. Approximately 29 percent of the material in the bluffs is coarser than fine sand retained on a No. 200 sieve. In the vicinity of Perry Township Park a stratum composed entirely of sand begins to appear in the bluffs.

117. The direction of the predominant littoral drift throughout the study area is from west to east. No beach building material enters the study area from the west as it is entirely cut off by the structures at Fairport Harbor. The narrow beaches exposed at the base of the bluffs during low water periods are composed of the coarse material derived from erosion of the adjacent bluffs. At Painesville Township

Park and at the sewer outlet of the Industrial Rayon Corp. wider beaches have been formed by the accumulation of littoral drift on the west side of existing structures.

118. Since the amount of littoral drift and the quantity of suitable beach building material in the bluffs is limited, the most practical and economical type of improvement for private property in this particular area is toe protection for the base of the bluffs either by means of a sea wall and slope revetment or stone revetment alone. The bluffs should be graded to a stable slope and drainage added wherever water seepage contributes to slumping of the bluffs. General design features are shown as plans C and F on plate 10. The estimated first cost of protection per linear foot of shore line is $235 for plan C and $95 for plan F exclusive of planning, inspection, and supervision.

119. Between Perry Township Park and the Perry-Madison Township line and in the easterly section of the study area between Madison Township Park and Ashtabula Harbor the bluffs contain thicker strata of sand. In these areas relatively short groins, well tied in to the base of the bluffs, and designed to prevent loss of beach material derived from further controlled erosion of the bluffs, can be used to stabilize sections of privately owned shore line where some further recession of the bluffs can be tolerated without endangering structures near the top of the existing bluff. The general design of a typical groin for this purpose is shown as plan E on plate 10. With a spacing of 100 feet between groins, the estimated cost of protection per linear foot of shore line is $84. Where no further loss of bluff can be tolerated, other than recession of the top necessary to stabilize the slope, sand fill can be placed between the groins or the sea wall and slope revetment plans C and F described in the preceding paragraph can be used. Where there are existing beaches plan D may also be used.

120. In the central portion of the study area between the Perry-Madison Township line and Madison Township Park, there is a high percentage of sand in the bluffs and relatively wide sand beaches are almost continuous. In this section, the construction of low groins to maintain beaches of sufficient height and width to protect the shore line during normal lake levels is the most practical type of improvement for privately owned property. This general plan will allow distribution of the available sand over the maximum possible length of shore line. Revetment of the toe of the bluffs to an elevation of 10 feet above low water datum should be added as protection against erosion during storms concurrent with high lake levels. This plan of improvement is shown as plan D on plate 10. The estimated cost per linear foot of shore line protected is $125.

121. It is beyond the scope of this report to prepare a detailed plan of improvement for individual pieces of privately owned property. The typical plans described as suitable for use in each locality are considered to be the best over-all plans of improvement. However, a sea wall and slope revetment similar to plan C could be used anywhere in the study area if protection is the only consideration. The typical structures shown in the plans are designed for an anticipated life of 50 years. Other materials may be used in construction if found more economical under local conditions. The effectiveness of the

proposed structures depends upon their height, length, and profile. The choice of material affects only the durability.

122. *Perry Township Park.*—It has been determined that the only publicly owned sections of shore line requiring further improvement at this time are Perry Township Park, Geneva Township Park, and Lake Shore Park at Ashtabula. The most practical and economical plan of improvement for Perry Township Park is the construction of four groins to control erosion of the bluffs and stabilize the park frontage by creating and maintaining a beach. The beach material would be supplied by the bluff itself as erosion continues at a gradually decreasing rate until a beach of sufficient width and height to protect the toe of the bluff is accumulated. Immediate protection from wave action at the toe of the bluff could be obtained by adding sand artificially after construction of the groins. Because further recession of the bluff will not seriously endanger existing structures at the park and funds available for erosion control by local interests are rather limited, creation of a beach by further controlled erosion of the bluff is considered a more practical solution than artificially adding sand fill to build the beach immediately. The estimated first cost of the four groins in the proposed plan of improvement is $45,000. The estimated annual cost of the improvement is $2,110. The estimated annual benefits are $4,110, giving a benefits-costs ratio of 1.95:1.

123. *Geneva Township Park.*—The plan of improvement proposed for Geneva Township Park is the landward extension of an existing steel sheet pile groin located near the easterly limit of the park followed by construction of a new groin near the middle of the park frontage. There is sufficient sand in the immediate area and supplied by littoral drift to maintain an adequate beach if stabilized by groins as proposed. The estimated first cost of the proposed improvements is $19,900. Estimated annual costs are $900. The estimated annual benefits are $3,900, giving a benefits-costs ratio of 4.33.

124. *Lake Shore Park.*—Two plans of improvement have been considered for Lake Shore Park at Ashtabula. Plan A, designed only for the purpose of preventing further erosion, provides for the construction of approximately 820 feet of revetment at the toe of the low bluffs in the easterly section of the park frontage. The proposed revetment consists of heavy stone facing backed with a filter blanket of finer material. The estimated first cost of the improvement is $76,000. Total estimated annual costs are $3,450. Estimated annual benefits are $370, giving a benefits-costs ratio of 0.11:1.

125. Because existing beaches in the vicinity are inadequate to serve the needs of the tributary area, the cooperating agency and local interests have requested a plan of improvement which would provide a bathing beach in this same section of the park frontage. As there is no natural supply of sand to the area, artificial filling of the desired beach area would be required. The proposed location and general design of the beach is shown on plate 10. The total estimated cost of the considered plan is $30,000. Estimated annual costs are $1,940. The estimated annual benefits, assuming that existing pollution is abated to remove hazards to the health of bathers so that recreational benefits can be realized are $4,870, giving a benefits-costs ratio of 2.51:1.

126. *Responsibilities of local interests.*—Federal participation in the cost of the proposed improvements would be contingent upon the

State of Ohio or the appropriate local authority agreeing to be responsible for—

(*a*) Maintenance and repair during the useful life of the project, as may be required to serve the intended purpose.

(*b*) Provision of all necessary lands, easements, and rights-of-way.

(*c*) Claims for damages either before, during, or after prosecution of the work.

(*d*) Maintaining public ownership and administration of the respective beaches for public use only.

(*e*) Control or abatement of any possible pollution in the beach areas or adjacent areas to the extent necessary to safeguard the health of bathers.

X. CONCLUSIONS

127. It is concluded that the only publicly owned sections of shore line in the study area where additional protection or improvement is needed at this time are Perry Township Park, Geneva Township Park, and Lake Shore Park.

128. *Perry Township Park.*—The plan of improvement considered best suited to the needs and resources of the local park authorities at Perry Township Park is the construction of four groins at the locations shown on plate 9. While this plan will not immediately provide a wide beach or stop erosion of the bluff, the rate of erosion will be gradually decreased as a beach for protection and recreational use is built up. The estimated total first cost of the proposed improvement is $45,000. Annual costs are estimated at $2,110 and annual benefits at $4,110, giving a benefits-cost ratio of 1.95:1. It is therefore considered advisable to adopt a project for the improvement of Perry Township Park. Since all the benefits derived from the proposed project are public benefits, the full one-third Federal participation in the first cost of the project provided by law is considered justified.

129. *Geneva Township Park.*—The plan of improvement considered suitable for the further improvement of Geneva Township Park is the landward extension of the existing groin near the easterly limit of the park followed by the construction of a new groin near the middle of the park frontage at the location shown on plate 9. Closure of the gap at the inner end of the easterly groin will prevent excessive loss of sand from the park frontage due to the predominant easterly littoral drift. Construction of a groin near the middle of the park frontage will create a wider beach in the westerly portion of the park for protection of the bluffs and for recreational use. The estimated first cost of the proposed plan of improvement is $19,900. Annual costs are estimated at $900 and annual benefits at $3,900, giving a benefits-costs ratio of 4.38:1. All the benefits accruing from the proposed improvements are public benefits. It is considered advisable to adopt the proposed plan of improvement and the full one-third Federal participation in the first cost of the improvement is considered justified because of the public benefits to be obtained.

130. *Lake Shore Park.*—Either of the two plans considered for the protection of Lake Shore Park at Ashtabula are suitable for protection of the shore line. The revetment plan which provides only protection against loss of property from erosion is not economically justified. The considered alternative plan would be economically justified if recreational benefits from use of the proposed beach could be realized.

Because of pollution the development of a bathing beach is not considered advisable at this time. The location of a bathing beach close to and downdrift from a commercial harbor even in cases where municipal sewage is properly treated is considered inadvisable because of contamination from lake front industrial installations and from visiting commercial vessels which cannot be entirely controlled. An equivalent beach area for public use could be provided in this instance by public acquisition of additional frontage adjacent to Walnut Beach Park west of the inner end of the west breakwater. Natural accumulation has created a wide beach in that area and accretion will probably continue. It is considered inadvisable to adopt a Federal project for the protection and improvement of Lake Shore Park at this time because the cost of the revetment plan is in excess of anticipated benefits and the development of a beach is inadvisable because of pollution likely to endanger the health of bathers.

131. *Private property.*—General plans for three types of improvement considered suitable for the protection and improvement of stretches of privately owned property having various shoreline characteristics have been prepared and are shown on plate 10. The adoption of the plan best suited to each locality and for the purpose intended as discussed in paragraphs 95–100 is considered advisable. No Federal participation in the cost of protection of private property is permitted under existing laws.

XI. RECOMMENDATIONS

132. It is recommended that—

(*a*) The State of Ohio or the appropriate local authority adopt the plan of improvement for Perry Township Park, consisting of the construction of 4 groins, as described in paragraphs 87–88 and shown on plate 9 and adopt the plan of improvement for Geneva Township Park consisting of the landward extension of an existing groin and the construction of a new groin as described in paragraphs 89–90 and shown on plate 9.

(*b*) Projects be adopted by the United States authorizing Federal participation in amounts equal to one-third the first cost at an estimated Federal cost of $15,000 for Perry Township Park and $6,600 for Geneva Township Park.

(*c*) The Federal participation in the proposed plans of improvement shall be contingent upon—

1. Approval by the Chief of Engineers of the detailed plans and specifications and arrangements for the prosecution of the project, prior to commencement of work.

2. Agreement by the State of Ohio or the appropriate local authority that it will be responsible for such maintenance and repair as may be necessary during the useful life of the work to serve the intended purpose.

3. Provision by the State of Ohio or the appropriate local authority of all lands, easements, and rights-of-way and release of the Federal Government from all claims for damages either before, during, or after prosecution of the work.

4. Rigid control and abatement of any possible pollution in the beach areas or adjacent areas to the extent necessary to safeguard the health of bathers.

5. Assurances on the part of the State of Ohio or the appropriate local authority that public ownership and administration of the respective beaches for public use will be maintained.

133. It is recommended that if local interests desire to improve Lake Shore Park at Ashtabula, they adopt either plan A for protection alone, or plan B for providing both protection and a bathing beach as described in paragraphs 92 and 93, and shown on plate 10. No Federal participation in either plan is recommended at this time for the reason that the cost of protection alone is not economically justified and development of a bathing beach at Lake Shore Park is not advisable for the reasons stated in paragraph 130.

134. It is also recommended that owners of private property adopt one of the proposed plans of improvement best suited to the physical characteristics and the desired utilization of their shore-front property. Continuous sections of shoreline should be protected wherever the cost of protection can be justified by the reduction in direct damages and by the intangible benefits due to increased security and enjoyment in the use of lake-front property.

EDWARD M. WRIGHT,
Major, Corps of Engineers,
Acting District Engineer.

[First endorsement]

OFFICE OF THE DIVISION ENGINEER,
GREAT LAKES DIVISION,
CORPS OF ENGINEERS,
Chicago 15, Ill., August 28, 1950.

To: The Chief of Engineers, United States Army, Washington 25, D. C.

I concur in the conclusions and recommendations of the district engineer.

JOHN R. HARDIN,
Colonel, Corps of Engineers,
Division Engineer.

APPENDIX 5

ESTIMATE OF BENEFITS AND COSTS

ESTIMATE OF BENEFITS

1. *General.*—The principal benefits that would be derived from the considered improvements at Perry Township Park, Geneva Township Park, and Lake Shore Park are direct damages prevented and recreational benefits. The direct damages from erosion consist of loss of land along the park frontages. The recession of the bluffs at Perry Township Park and at Lake Shore Park has been appreciable within recent years. At Geneva Township Park the principal damage has been the loss of beach area toward the west side of the park with very minor recession of the bluff. The direct damages and recreational benefits are evaluated in the following paragraphs.

2. *Direct damages prevented.*—At Geneva Township Park local officials estimate that the rate of erosion of the westerly third of the

park is approximately 2.5 feet annually. Over a frontage of approximately 300 feet this amounts to an annual loss of 750 square feet of park area. Property values in this resort community are relatively high and it is estimated that the value of the property lost annually is at least $100. At Perry Township Park comparison of surveys made in 1946 by the State of Ohio and the 1948 survey made for this report and land records showing the location of the shore line in 1903 indicate that the average rate of recession of the bluffs is approximately 4 feet annually. Along the 850 feet of park frontage the average annual loss amounts to 3,400 square feet of park area. In this locality the value of lake-front property is relatively low because of lack of access roads and utilities.

To evaluate the direct damages due to loss of land a unit value of $0.05 per square foot has been assumed. At the present rate of erosion, the annual damages amount to $170. The proposed plan of improvement will not immediately eliminate this loss but it is assumed that within a period of 5 years the beach and bluff will become stabiized and no further damage will occur. Assuming a 50-year life for the considered improvements and a uniform reduction in damages during the first 5 years, the average annual reduction in damages is approximately $160. If the present rate of erosion continues, within a period of 50 years the existing bathhouse, refreshment stands and shelters would be destroyed or would have to be moved back. The average annual damage is estimated at $100. At the present time the average cost of replacement of guard fences at the top of the high bluff and repairs to the stairway which provides access to the beach area down the face of eroding bluff is estimated at $50 annually. The total reduction in obvious direct damages amounts to $310 annually.

3. The rate of erosion in the easterly 820 feet of the Lake Shore Park frontage is reported by park officials as approximately 4.5 feet annually. Because of its accessibility and location in a more highly developed area a unit value of $0.10 per square foot has been assumed. The average annual damages from loss of park property is estimated at approximately $370. Both of the considered plans of improvement would provide immediate protection.

4. *Recreational benefits.*—At the three parks for which improvements have been considered, some bathing beach area is now available. No records of attendance are kept but park officials have stated that existing beaches are overcrowded on peak days. They are of the opinion that beaches extending across the entire available park frontages would be used to capacity on these days. There are 30 such peak days in an average year considering Saturdays, Sundays, and holidays between June 1 and Labor Day. Allowing 6 days for bad weather leaves 24 days of peak attendance. Existing beach areas are considered adequate to provide for patronage on other days.

5. In order to arrive at a reasonable value of the recreational benefit to an individual for use of a bathing beach, it has been assumed that it would be at least equal to the charges made for the use of privately owned beaches. Very few privately owned beaches in the study area are open to the public and the only bathing beaches available for public use without charge are at the various township and village parks. In other localities on Lake Erie the usual charge for parking and use of beaches varies from $0.50 to $2 per car. Assuming an average fee of

$1 per car and an average of four persons per car, this amounts to $0.25 per person.

6. The total recreational benefits, assuming that the additional beach areas provided by the considered plans of improvement and shown on plates 9 and 10, are used to capacity on 24 peak days, are summarized in table 1. In computing the capacity of the increased beach area, an allowance of 75 square feet of area per person has been made for the additional beach area provided by the improvement between the existing and proposed shore lines at an elevation of 2 feet above low-water datum.

TABLE 1.—*Estimated annual recreational benefits*

Beach	Increased capacity, number of people	Increased annual patronage	Estimated annual recreational benefits
Perry Township Park	670	[1] 15,275	$3,800
Geneva Township Park	670	[1] 15,275	3,800
Lake Shore Park [2]	750	18,000	4,500

[1] Average for 50-year period assuming full capacity available 5 years after construction and uniformly increasing capacity during first 5 years.
[2] For alternative plan B which provides beach area.

7. *Total benefits.*—The total annual benefits which would be derived from considered improvements at the three parks are tabulated in table 2.

TABLE 2.—*Total estimated annual benefits*

Improvement	Direct damages prevented	Recreational benefits	Total annual benefits
Perry Township Park	$310	$3,800	$4,110
Geneva Township Park	100	3,800	3,900
Lake Shore Park [1]	370		370
Do.[2]	370	4,500	4,870

[1] Revetment plan A.
[2] Beach plan B.

8. *Direct costs.*—The estimated direct costs of the various plans of improvement based on November 1949 cost levels are shown in detail in table 3. The cost of an access road has been included wherever a temporary construction road must be built to provide means of moving construction equipment from the top of the high bluffs to the beach area.

TABLE 3.—*Estimated direct costs*

PERRY TOWNSHIP PARK

Item	Quantity	Unit	Unit cost	Subitem cost	Item cost
Access road		Lump sum			$550
Groin No. 1:					
Excavation	60	Cubic yards	$2.40	$144	
Steel sheet piling	55,500	Pounds	.11	6,105	
Gravel fill	105	Cubic yards	6.60	693	
Concrete cap	14	do	28.50	399	
					7,340
Groin No. 2:					
Excavation	40	do	2.40	96	
Steel sheet piling	44,000	Pounds	.11	4,840	
Gravel fill	60	Cubic yards	6.60	396	
Concrete cap	14	do	28.50	399	
					5,730
Groin No. 3:					
Excavation	40	do	2.40	96	
Steel sheet piling	66,800	Pounds	.11	7,348	
Gravel fill	130	Cubic yards	6.60	858	
Concrete cap	14	do	28.50	399	
					8,700
Groin No. 4:					
Excavation	40	do	2.40	96	
Steel sheet piling	66,800	Pounds	.11	7,348	
Gravel fill	130	Cubic yards	6.60	858	
Concrete cap	14	do	28.50	399	
					8,700
Contingencies					2,980
Total direct costs, Perry Township Park.					34,000

GENEVA TOWNSHIP PARK

New groin:					
Steel sheet piling	83,100	Pounds	$0.12	$9,972	
Gravel fill	96	Cubic yards	6.20	595	
Concrete cap	20	do	20.50	410	
					$11,000
Extension of groin No. 171: Steel sheet piling	13,200	Pounds	.175	2,310	2,310
Contingencies					1,290
Total direct costs, Geneva Township Park					14,600

LAKE SHORE PARK

Plan A. Revetment:					
Excavation	4,450	Cubic yards	$0.75	$3,338	
Gravel	870	do	3.50	3,045	
Derrick stone	3,200	Tons	14.30	45,760	
					$52,100
Contingencies					5,900
Total direct costs, plan A					58,000
Plan B. Artificially filled sand beach:					
Sand fill [1]	11,000	Cubic yards	1.95	21,450	
					21,450
Contingencies					4,550
Total direct costs, plan B					26,000

PRIVATE PROPERTY

Plan C. 100 feet of cellular sea wall and bluff treatment:					
Access road		Lump sum		$525	
Steel sheet piling	114,020	Pounds	$0.11	12,542	
Gravel fill, cells	470	Cubic yards	6.40	3,008	
Gravel filter	110	do	6.15	676	
Excavation and grading	610	do	.95	580	
Trench excavation	35	do	8.50	298	
Tile pipe drains	220	Linear feet	2.75	605	

[1] Cost of sand fill is based on use of sand from publicly owned area in vicinity of west breakwater at Ashtabula Harbor.

TABLE 3.—*Estimated direct costs*—Continued

PRIVATE PROPERTY—Continued

Item	Quantity	Unit	Unit cost	Subitem cost	Item cost
Plan C. 100 feet of cellular sea wall and bluff treatment—Continued					
Gravel fill, trenches	30	Cubic yards	$6.40	$192	
Concrete cap	30	do	31.00	930	
Derrick stone	140	Tons	14.50	2,030	
Seeding	0.17	Acre	600.00	100	
					$21,490
Contingencies					2,010
Total direct costs, plan C					23,500
Plan D. Low groin and 100 feet of slope revetment:					
Access road		Lump sum		525	
Excavation and grading	750	Cubic yards	1.00	750	
Steel sheet piling	29,200	Pounds	.13	3,796	
Gravel fill, cells	16	Cubic yards	8.30	133	
Concrete caps	6	do	20.50	123	
Gravel filter	120	do	6.15	738	
Derrick stone	250	Tons	14.50	3,625	
Trench excavation	150	Cubic yards	1.70	255	
Tile pipe	350	Linear feet	2.60	910	
Gravel fill, drains	30	Cubic yards	6.10	183	
Trench backfill	120	do	1.35	162	
Seeding	0.17	Acre	600.00	100	
					11,300
Contingencies					1,200
Total direct costs, plan D					12,500
Plan E. Protection of 100 feet of shore line by 100-foot groin:					
Access road		Lump sum		525	
Excavation	30	Cubic yards	3.30	99	
Steel sheet piling	53,430	Pounds	.12	6,412	
Gravel fill	60	Cubic yards	6.30	378	
Concrete cap	9	do	23.00	207	
					7,620
Contingencies					780
Total direct costs, plan E					8,400
Plan F. Protection of 100 feet of shore line by stone revetment:					
Access road		Lump sum		525	
Crushed stone filter	300	Cubic yards	6.75	2,025	
Cover stone	450	Tons	12.00	5,400	
					7,950
Contingencies					1,550
Total direct costs, plan F					9,500

9. *Total costs.*—A summary of the estimated total first costs of the considered improvements of public areas is given in table 4. Estimates of costs are based on the assumption that the costs will be the same whether done by the Corps of Engineers or the cooperating agency. Total costs include design studies, plans and specifications, supervision, inspection, and overhead.

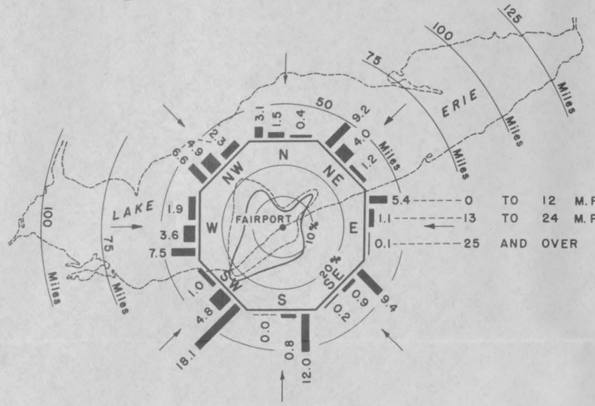
TABLE 4.—*Summary of estimated total first costs*

Item	Perry Township Park	Geneva Township Park	Lake Shore Park plan A	Lake Shore Park plan B
Direct costs	$34,000	$14,600	$58,000	$26,000
Design studies, plans and specifications, supervision, inspection and overhead	11,000	5,300	18,000	4,000
Total first costs	45,000	19,900	76,000	30,000

O

LEGEND

Indicates wind duration in percent of time
Indicates wind movement in percent of total

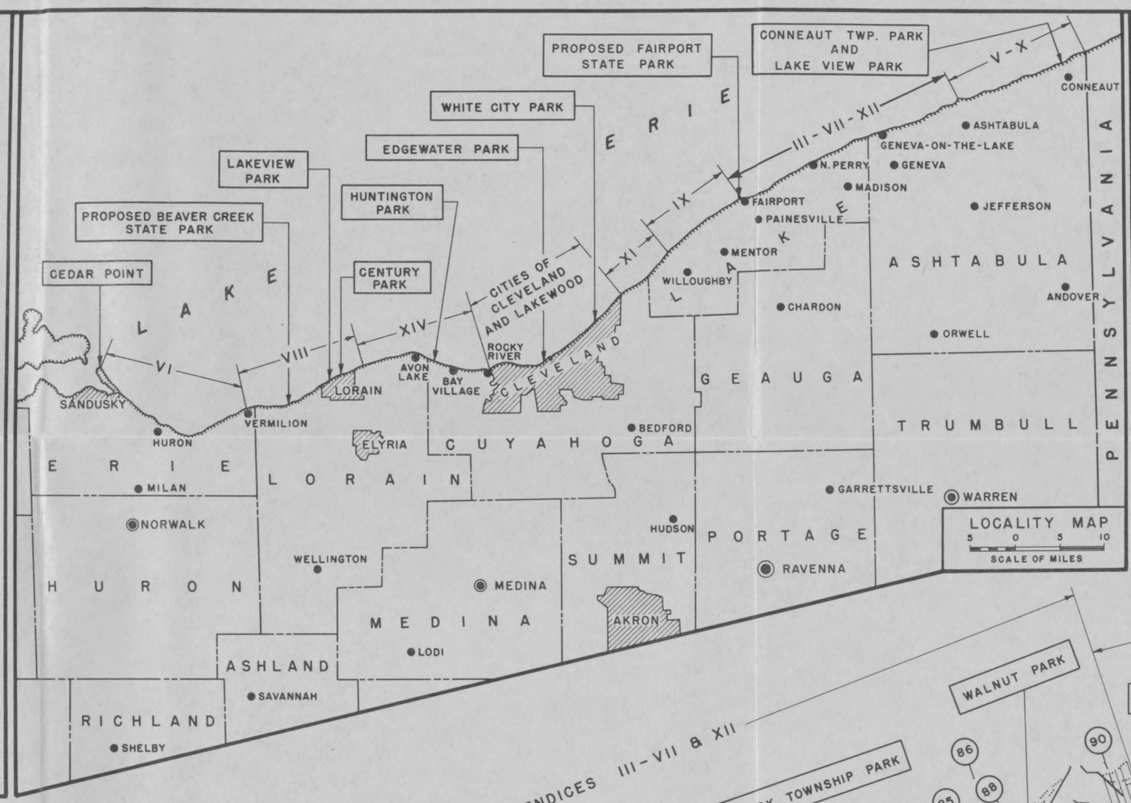


WIND DIAGRAM FOR FAIRPORT, OHIO

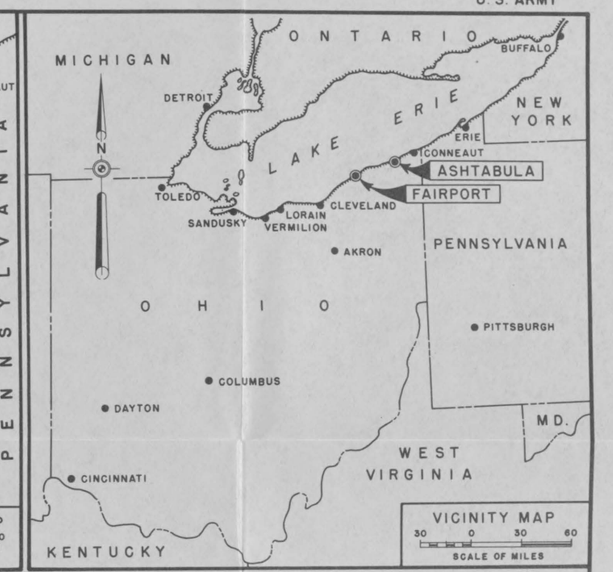
NOTES

Figures at end of bars indicate average yearly percentage of occurrence of wind in the direction and intensity shown for the period of Feb. 1, 1932 to Jan. 31, 1942.

Wind data based on records of the U. S. Coast Guard at Fairport, Ohio.



LOCALITY MAP
5 0 5 10
SCALE OF MILES



VICINITY MAP
30 0 30 60
SCALE OF MILES

APPENDIX V & X

APPENDIX III-VII & XII

NOTE

SEE SHEET NOS. 2, 3 AND 4 FOR PROFILES INDICATED ON THIS PLAN

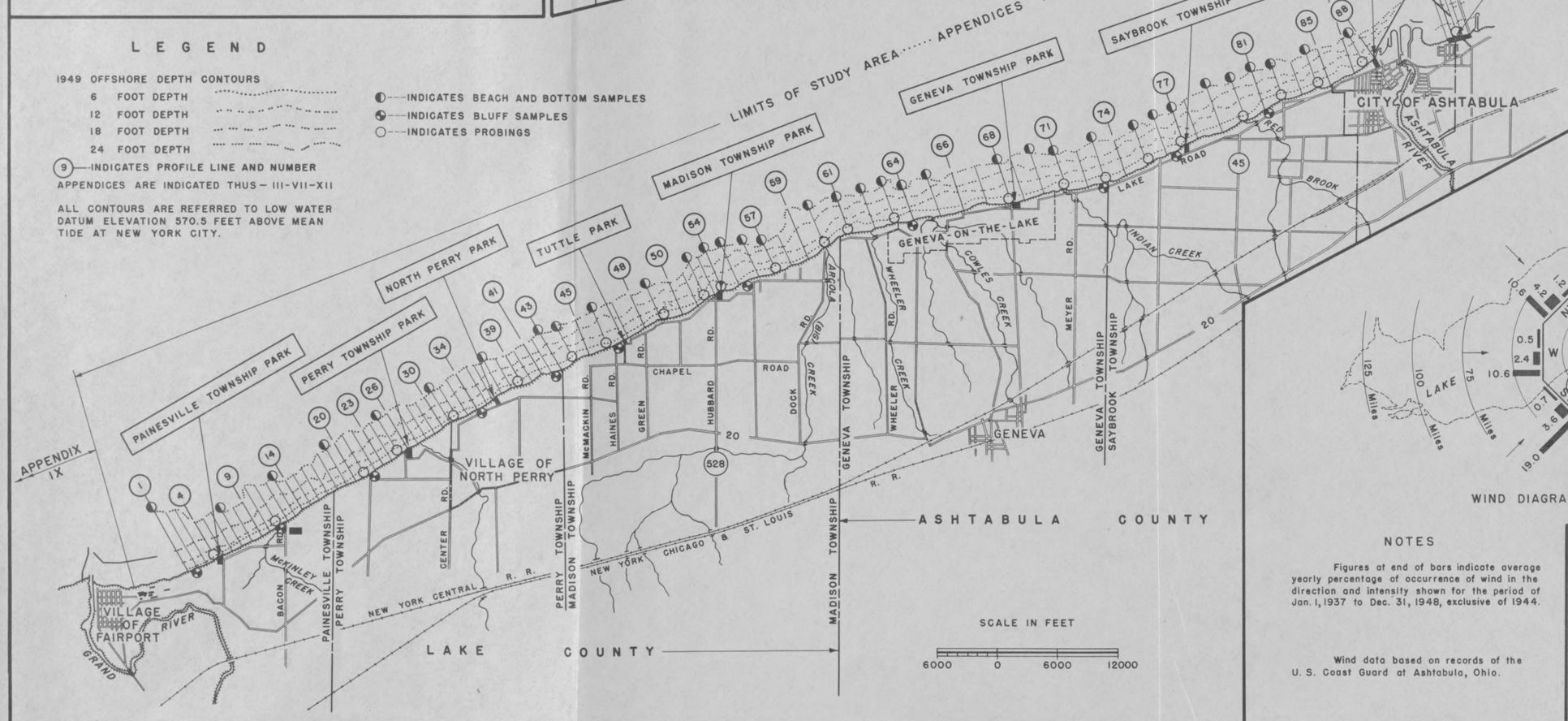
LEGEND

1949 OFFSHORE DEPTH CONTOURS
6 FOOT DEPTH
12 FOOT DEPTH
18 FOOT DEPTH
24 FOOT DEPTH

(9)—INDICATES PROFILE LINE AND NUMBER
APPENDICES ARE INDICATED THUS — III-VII-XII

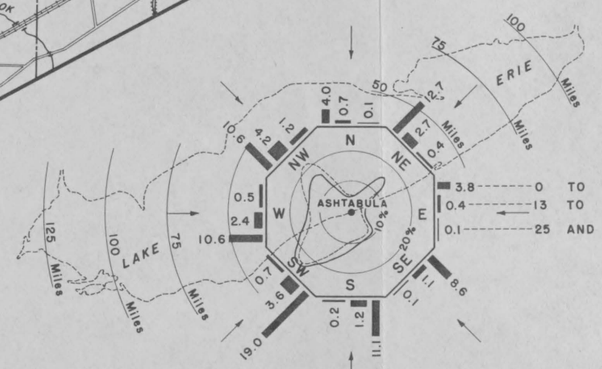
ALL CONTOURS ARE REFERRED TO LOW WATER DATUM ELEVATION 570.5 FEET ABOVE MEAN TIDE AT NEW YORK CITY.

◐---INDICATES BEACH AND BOTTOM SAMPLES
◐---INDICATES BLUFF SAMPLES
○---INDICATES PROBINGS



LEGEND

Indicates wind duration in percent of time
Indicates wind movement in percent of total



WIND DIAGRAM FOR ASHTABULA, OHIO

NOTES

Figures at end of bars indicate average yearly percentage of occurrence of wind in the direction and intensity shown for the period of Jan. 1, 1937 to Dec. 31, 1948, exclusive of 1944.

Wind data based on records of the U. S. Coast Guard at Ashtabula, Ohio.

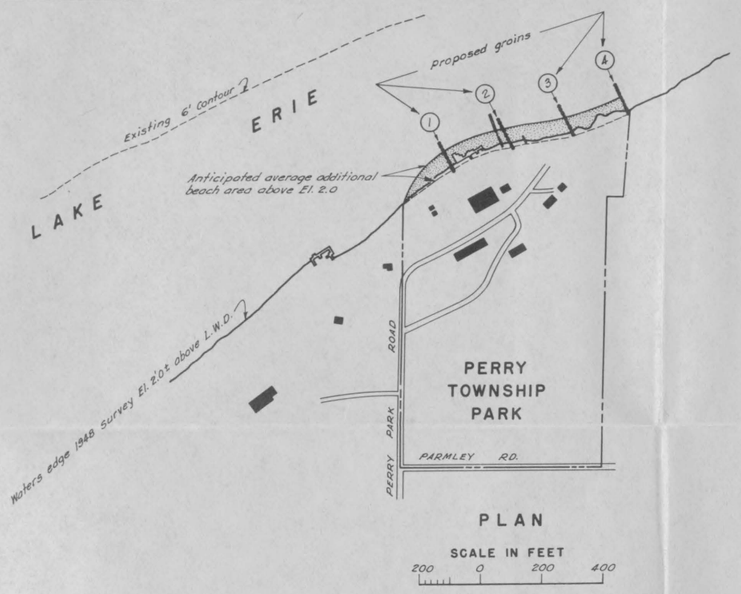
COOPERATIVE BEACH EROSION STUDY IN PAINESVILLE, PERRY, MADISON, GENEVA, SAYBROOK & ASHTABULA TWP'S.
STATE OF OHIO
APPENDICES III-VII-XII-LAKE & ASHTABULA CO'S.
GENERAL PLAN

IN 10 SHEETS — SHEET NO. 1 — SCALE AS SHOWN
BUFFALO, N.Y. DISTRICT — JULY, 14, 1950

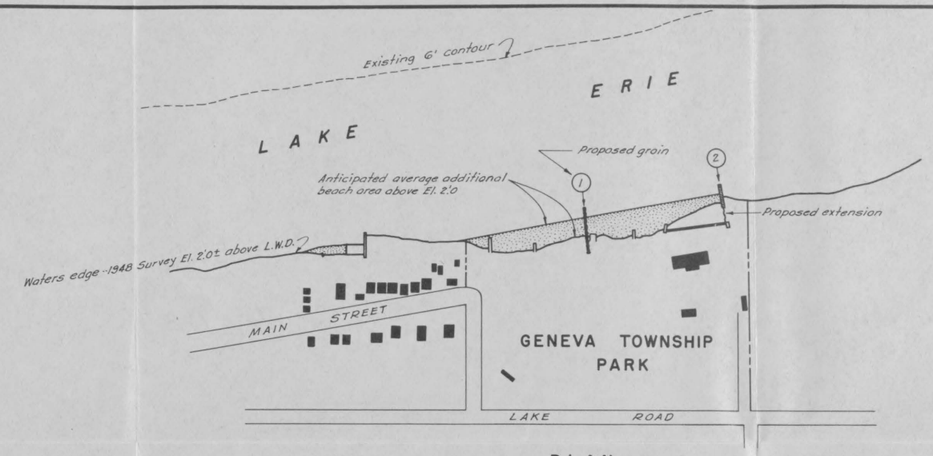
SUBMITTED: Joseph H. Wiemann, CHIEF, PROJECT BRANCH
RECOMMENDED: E. E. Edwards, CHIEF, ENGINEERING DIVISION
APPROVED: Francis W. Farney, COL., CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED JULY, 24, 1950

DRAWN R.D.P. TRACED R.D.P. CHECKED FILE NO.



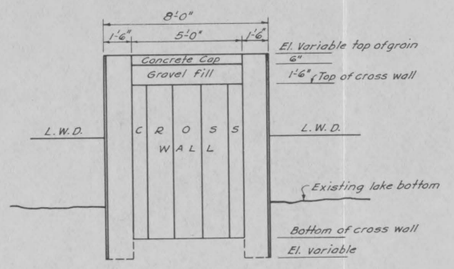
PLAN



PLAN

SCALE IN FEET

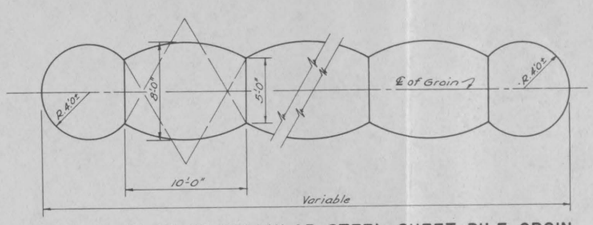
200 0 200 400



TYPICAL CELL SECTION

SCALE IN FEET

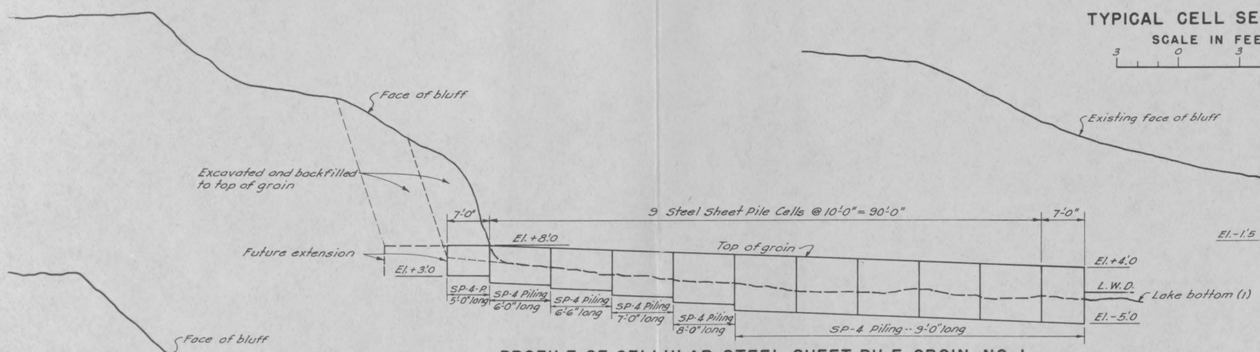
3 0 3 6



TYPICAL PLAN OF CELLULAR STEEL SHEET PILE GROIN

SCALE IN FEET

5 0 5 10

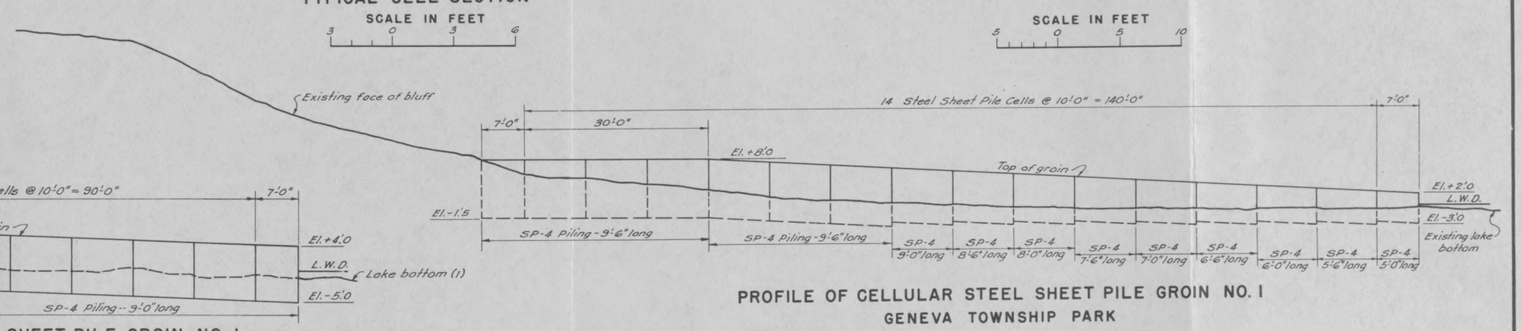


PROFILE OF CELLULAR STEEL SHEET PILE GROIN NO. 1

PERRY TOWNSHIP PARK

SCALE IN FEET

10 0 10 20

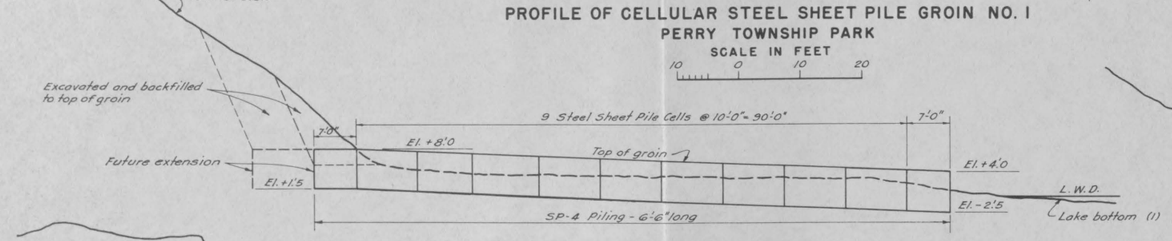


PROFILE OF CELLULAR STEEL SHEET PILE GROIN NO. 1

GENEVA TOWNSHIP PARK

SCALE IN FEET

10 0 10 20

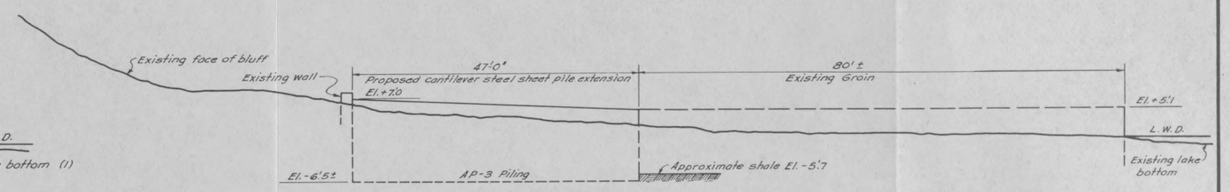


PROFILE OF CELLULAR STEEL SHEET PILE GROIN NO. 2

PERRY TOWNSHIP PARK

SCALE IN FEET

10 0 10 20

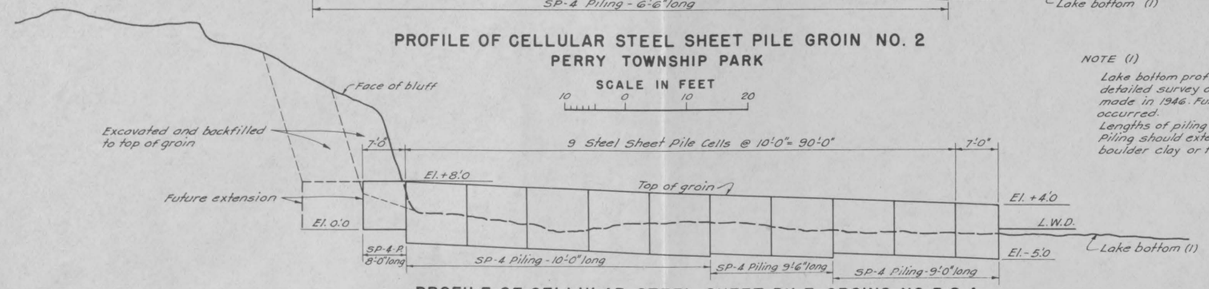


PROFILE OF CANTILEVER STEEL SHEET PILE EXTENSION TO GROIN NO. 2

GENEVA TOWNSHIP PARK

SCALE IN FEET

10 0 10 20



PROFILE OF CELLULAR STEEL SHEET PILE GROINS NO. 3 & 4

PERRY TOWNSHIP PARK

SCALE IN FEET

10 0 10 20

NOTE (1)

Lake bottom profiles are from a detailed survey of the park area made in 1946. Further erosion has occurred.
Lengths of piling are approximate. Piling should extend 3 feet into boulder clay or to rock.

Elevations are in feet and tenths and are referred to Low Water Datum elevation 570.5 feet above mean tide at New York City.

COOPERATIVE BEACH EROSION STUDY IN PAINESVILLE, PERRY, MADISON, GENEVA, SAYBROOK & ASHTABULA TWP'S.

STATE OF OHIO

APPENDICES III-VII-XII-LAKE & ASHTABULA CO'S.

PROPOSED PLANS OF IMPROVEMENTS

IN 10 SHEETS — SHEET NO. 9 — SCALE AS SHOWN

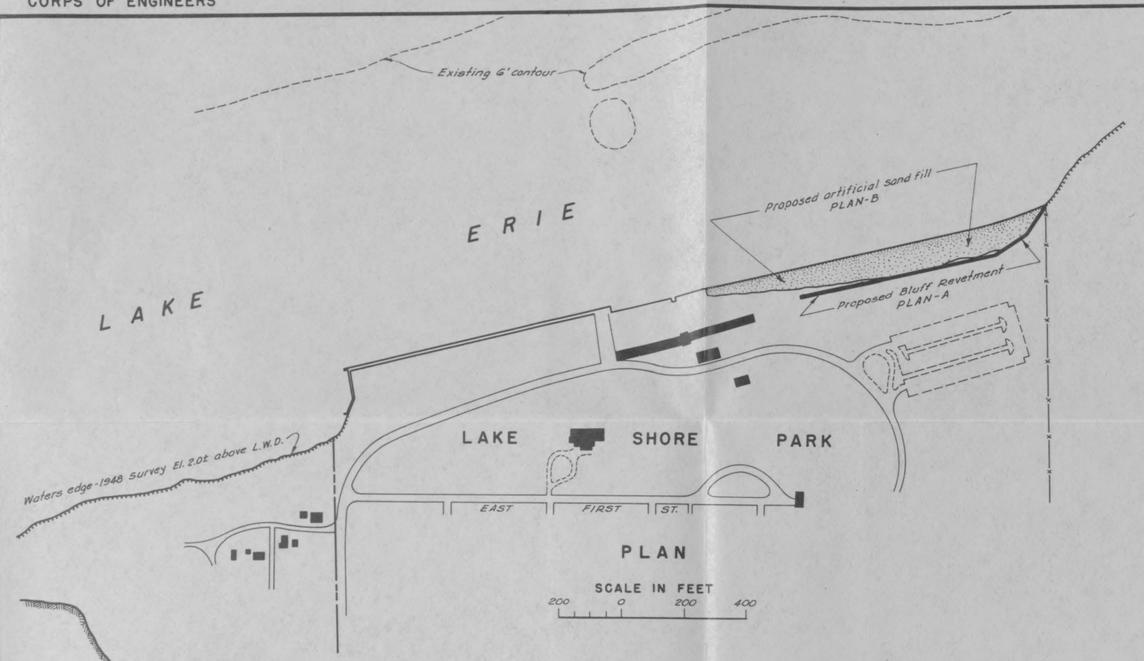
BUFFALO, N.Y. DISTRICT — JULY, 14, 1950

SUBMITTED — RECOMMENDED — APPROVED

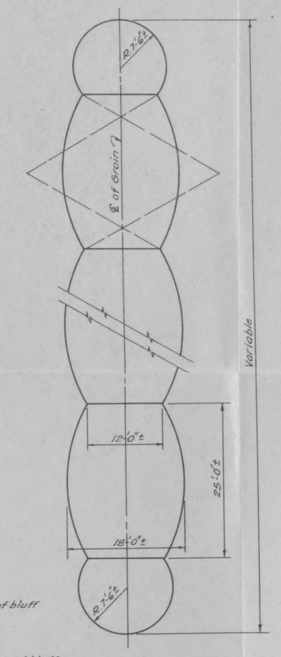
Joseph G. Wenzel, CHIEF, PROJECT BRANCH — S. E. Hunt, CHIEF, ENGINEERING DIVISION — Jerald L. Farmer, COL., CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED JULY, 24, 1950

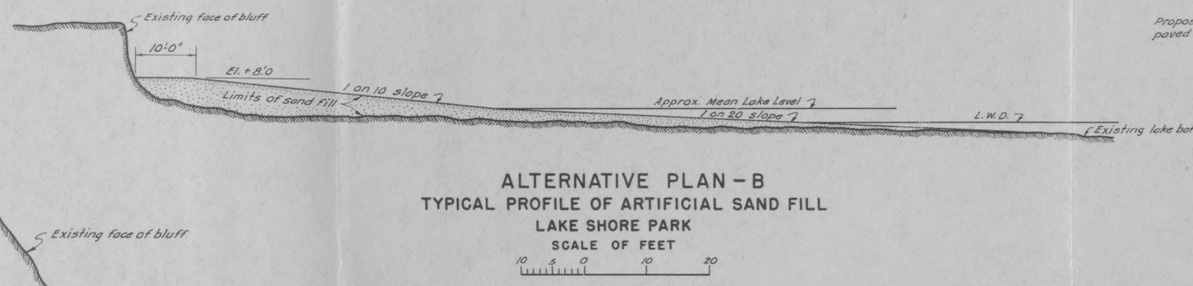
DRAWN R.D.R. TRACED R.D.R. CHECKED GAP FILE NO



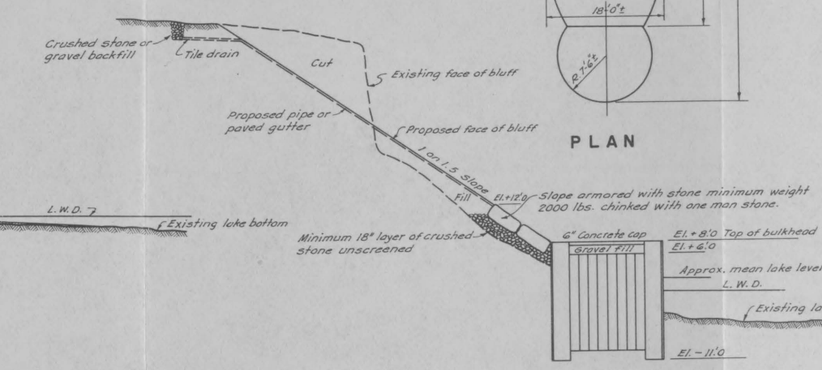
PLAN



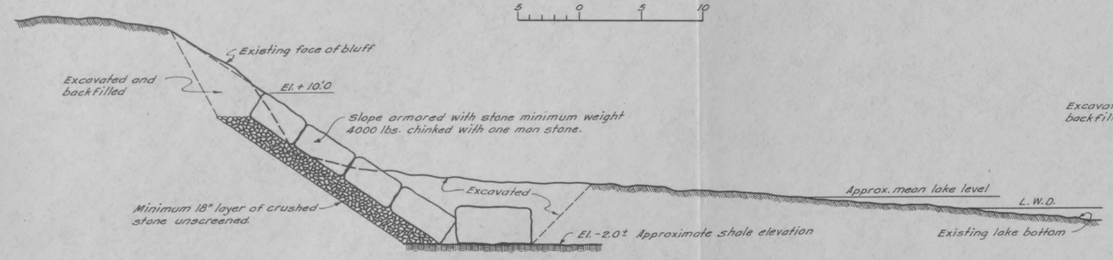
PLAN



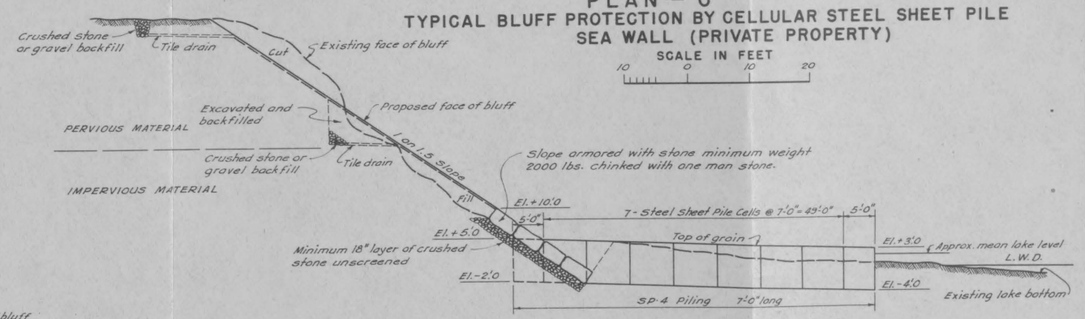
ALTERNATIVE PLAN – B
TYPICAL PROFILE OF ARTIFICIAL SAND FILL
LAKE SHORE PARK



PLAN – C
TYPICAL BLUFF PROTECTION BY CELLULAR STEEL SHEET PILE SEA WALL (PRIVATE PROPERTY)
SCALE IN FEET
10 0 10 20

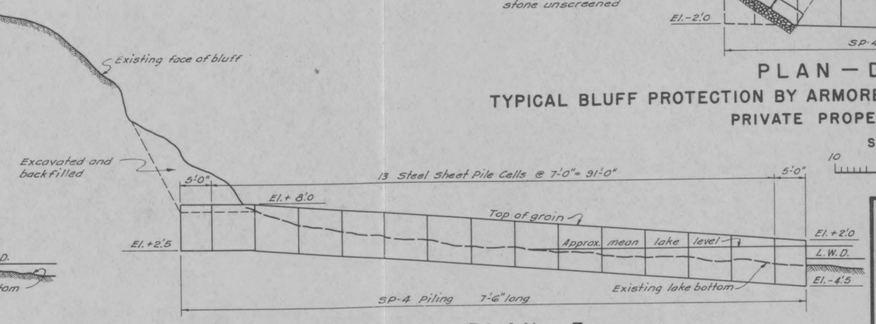


PLAN – F
TYPICAL SECTION OF ROUGH FACED BLUFF REVETMENT
PRIVATE PROPERTY
SCALE OF FEET
5 0 5 10



PLAN – D
TYPICAL BLUFF PROTECTION BY ARMORED SLOPE AND SHORT GROINS
PRIVATE PROPERTY
SCALE IN FEET
10 0 10 20

PLAN – A
TYPICAL SECTION OF BLUFF REVETMENT
LAKE SHORE PARK
SCALE IN FEET
5 0 5 10



PLAN – E
TYPICAL PROFILE OF CELLULAR STEEL SHEET PILE GROIN
PRIVATE PROPERTY
SCALE IN FEET
10 0 10 20

NOTE
Elevations shown are in feet and tenths and are referred to Low Water Datum, elevation 570.5 feet above mean tide at New York City.

COOPERATIVE BEACH EROSION STUDY IN PAINESVILLE, PERRY, MADISON, GENEVA, SAYBROOK & ASHTABULA TWP'S.
STATE OF OHIO
APPENDICES III-VII-XII-LAKE & ASHTABULA CO'S.
PROPOSED PLANS OF IMPROVEMENTS

IN 10 SHEETS	SHEET NO. 10	SCALE AS SHOWN
BUFFALO, N.Y. DISTRICT		JULY, 14, 1950
SUBMITTED	RECOMMENDED	APPROVED
Joseph G. Weinert, CHIEF, PROJECT BRANCH	S. B. Hunt, CHIEF, ENGINEERING DIVISION	Frank H. Conway, COL., CORPS OF ENGINEERS

TO ACCOMPANY REPORT DATED JULY, 24, 1950

DRAWN R.D.R. TRACED R.D.R. CHECKED BH FILE NO