# 1998 BATHYMETRIC SURVEY IN THE VICINITY OF THE IDNR-PROPOSED ARTIFICIAL REEF FOR RECREATIONAL FISHING OFF THE CHICAGO LAKESHORE

## Report to Accompany Bathymetric Map

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## EXECUTIVE SUMMARY

The bathymetry of Lake Michigan in the vicinity of the IDNR-proposed site for an artificial reef for recreational fishing off the Chicago lakeshore was surveyed in May 1998 by the Illinois State Geological Survey. The resulting bathymetric map which covers 318 acres (128 hectares) indicates a generally low-relief lake bottom sloping toward increasing depths from west-northwest to east-southeast. The design depth for the proposed reef is 25 ft (7.6 m) Low Water Datum (LWD). The 25 foot Low Water Datum (LWD) contour has a sinusoidal trend around some swales and ridges in the northwestern quadrant of the map area, but also has an elongate reach of near-linear trends in a northeast-southwest direction across much of the central map area. Bottom grab samples indicate a bottom of clay, sandy silt, sand, and mixed sand and gravel. Zebra mussels were present in nearly all bottom samples. Comparison of this 1998 bathymetric data and data from 1964 indicates that over this 34-year interval nearly all of the map area has experienced erosion. Erosion has generally been in the range of 1 to 3 ft (0.3 to 0.9 m), but more severe erosion has occurred in the northeastern part of the survey area on the flanks of South Park Shoal.

## INTRODUCTION

### Background

In November 1996, the Illinois Department of Natural Resources (IDNR) convened a Blue Ribbon Committee for Artificial Reef Construction in Lake Michigan. The mandate of this committee was to work toward the construction of an artificial reef off the Chicago lakeshore for the purpose of providing a habitat for smallmouth bass and to serve as a recreational fishing site. This reef project is modeled after a project built in Lake Erie off Loraine, Ohio that was monitored by the Ohio Sea Grant College Program in 1992-1993 (Kelch and Reutter, 1995). The site selected for the Chicago reef is located about 1 mile (1.6 km) lakeward of 59th Street Harbor on Chicago's southside lakeshore (Figures 1 and 2). Following the Lake Erie design, the reef will be built at a depth of 25 ft (7.6 m) LWD and will consist of a rubble-mound structure rising as much as 10 ft (3 m) above the lake bottom. The preliminary plan for the Chicago reef is a structure 500 ft (152 m) long and 20 to 40 ft (6.1 to 12.2 m) wide.

### Purpose and Scope

Prior to this study, the most recent bathymetric survey at the proposed reef site was done by the U. S. Lake Survey in 1964 at a scale of 1:15,000 (U. S. Lake Survey, 1964). Because of potential lake-bottom changes since that time, and because of the need for more detailed mapping of the proposed site, the DNR Office of Water Resources requested that the Illinois State Geological Survey (ISGS) conduct a detailed bathymetric survey of the proposed reef site. Besides aiding in reef design and construction, this mapping was intended to serve as a baseline survey to evaluate post-construction lake-bottom changes. This report summarizes the collection of survey data, the data processing, and discusses overall lake-bottom characteristics depicted on the resulting bathymetric map.

### Funding

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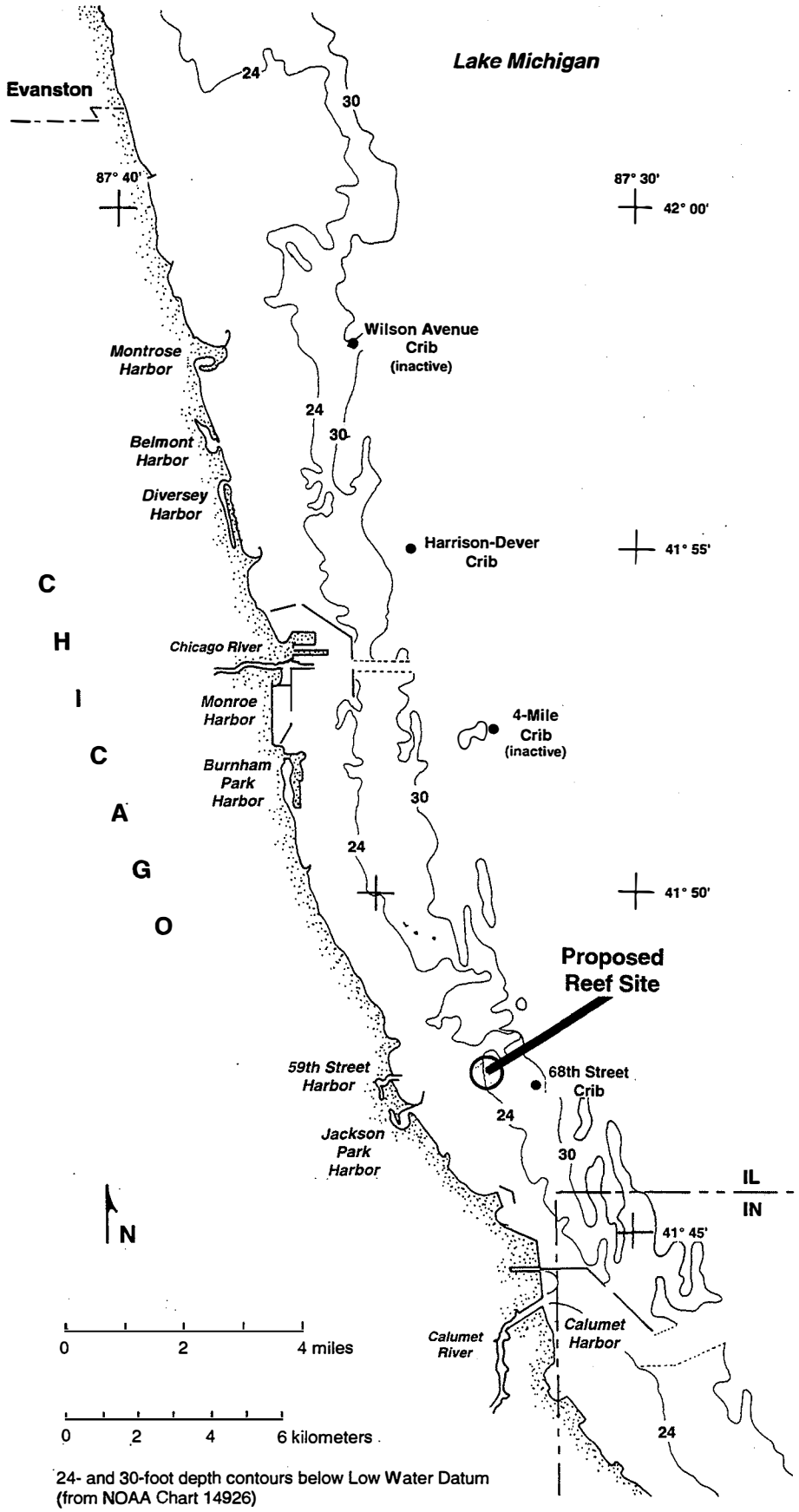


Figure 1: Map of the Chicago lakeshore showing location of the DNR-proposed fishing reef.

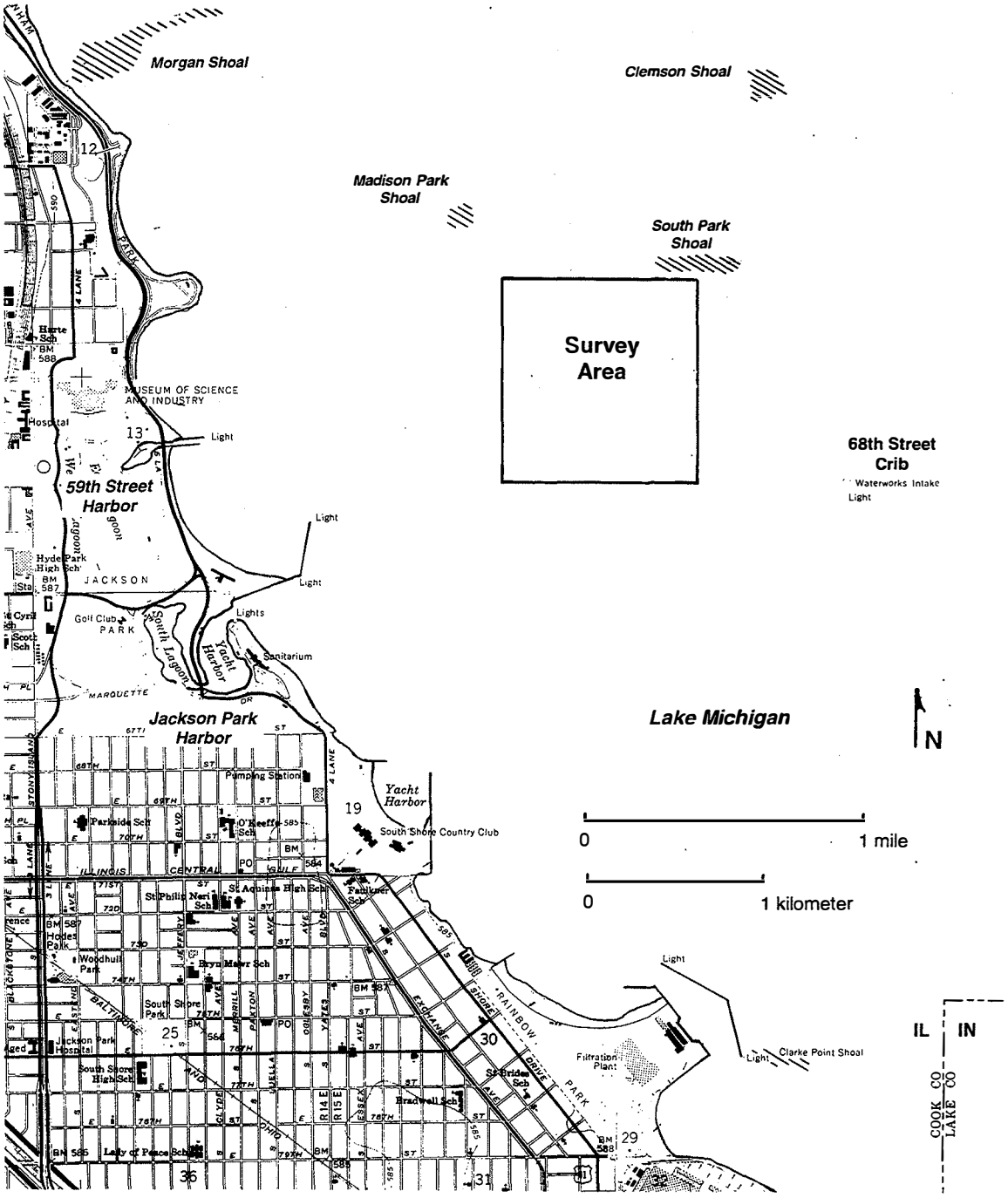


Figure 2: Map of the Chicago south-side lakeshore near Jackson Park showing location of the survey area. Base map from USGS Jackson Park Quadrangle (7.5 minute; Photorevised 1973).

## DATA COLLECTION

### Survey Area

Bathymetric mapping was done across a nearly square area of approximately 318 acres (128 hectares) extending 3838 ft (1170 m) north-south and 3608 ft (1100 meters) east-west. The center of this area is located approximately 1.5 miles (2.4 km) east of the lakeshore at 59th Street Harbor and 1 mile (1.6 km) west-northwest of the 68th Street Crib which is the water intake for the City of Chicago South Shore Filtration Plant. A total of 40 east-west bathymetric profiles were measured across the area with a 30 m (98.4 ft) line spacing (Figure 3).

### Survey Vessel and Personnel

(Note: Company names are shown in capital letters for informational purposes)

All survey work was done using the ISGS's 17-foot BOSTON WHALER work boat (*R/V Abigail*) powered by a 100-hp EVINRUDE outboard motor. For this survey, the boat was fitted with an over-the-side fathometer transducer, antennas for GPS navigation, and a winch for lowering and raising a bottom sampler. The bathymetric data collection involved a three-person crew consisting of boat operator, fathometer annotator, and GPS data collector.

### Survey Equipment (Hardware and Software)

(Note: Company names are shown in capital letters for informational purposes)

A continuous analog paper record of the lake bottom was collected using a ROSS Model 803 Portable Survey Fathometer that utilized a 100-kHz transducer. A TRIMBLE Pro XL and a STARLINK radiobeacon receiver were used for GPS data collection. The GPS receiver's antenna was positioned about 4 ft (1.3 m) above water level and about 1 ft (0.3 m) aft of (behind) the bracket holding the fathometer transducer.

Real-time, differentially-corrected GPS (DGPS) positions were digitally stored on a TRIMBLE data logger (Asset Surveyor). The nominal accuracy of this positioning is within 3 ft (1 m) . DGPS positions were simultaneously transmitted to a WALKABOUT COMPUTERS Hammerhead Pentium computer by means of GeoLink software (GEORESEARCH). The DGPS positions were displayed on the Hammerhead computer using GeoLink PowerMap version 5.3. The simultaneous display of DGPS positions on base maps provided navigational assistance for the boat operator to steer along each of the profile lines.

Arc/Info and ArcView software (ESRI) were employed to prepare maps used for navigation. Specific maps used were the USGS Digital Raster Graphs of the Jackson Park 7.5-minute topographic map (U. S. Geological Survey, 1972) and the NOAA digital bathymetric map of Lake Michigan (NOAA, 1996) . End points for the survey lines were computed and drawn on the base maps, then downloaded onto the TRIMBLE Asset Surveyor for navigation.

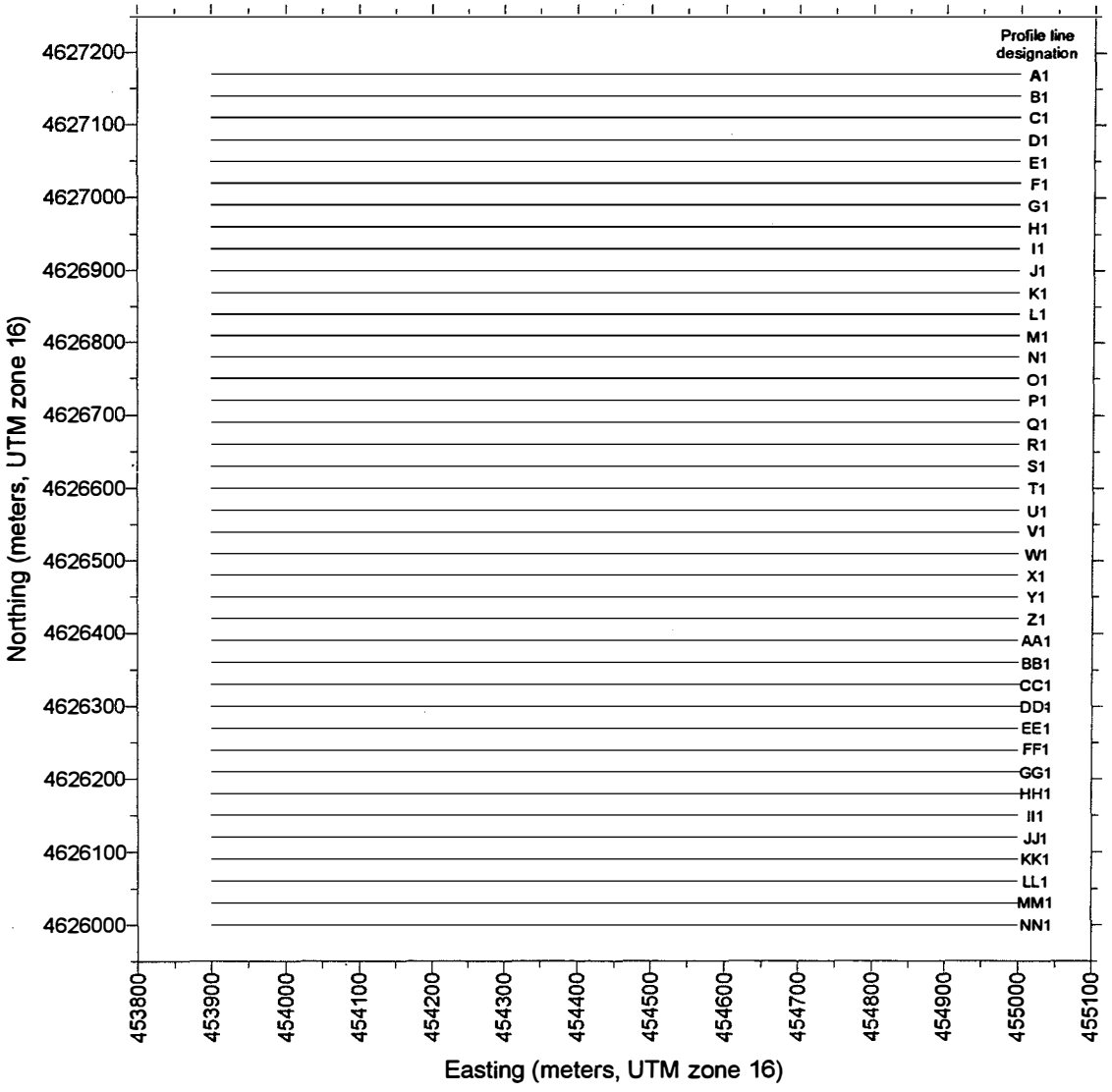


Figure 3: Scheme of 40 east-west profile lines used in the bathymetric survey, profile line designations, and local Universal Transverse Mercator (UTM) grid. See Figure 2 for location of survey area.

## Schedule

Hydrographic survey data were collected on Wednesday, May 6 and Monday, May 11, 1998. Bottom samples were collected on Tuesday, May 12, 1998. Table 1 summarizes the dates and times of data collection and corresponding wave conditions.

Table 1. Summary of field schedule and wave conditions.

| Date / Time (CDT) | Data Collection | Wave Conditions |
|---|---|---|
| May 06, 1998 / 0920 - 1423 | Bathymetry along Profile Lines A1 through Q1 (Lines A1 and C1 redone on May 11 to improve line configuration) (Total of 17 profile lines run) | Calm |
| May 11, 1998 / 1035 - 1712 | Bathymetry along Profile Lines R1 through NN1 plus resurvey of Lines A1 and C1 (Total of 25 profile lines run) | 2-2.5 ft waves from northeast |
| May 12, 1998 / 0920 - 1400 | Bottom sediment samples (Total of 14 samples collected) | 1-2 ft waves from southeast |

## Survey Procedures

Each day of collecting bathymetric data began with a calibration check of the fathometer system. A steel grate was lowered to measured depths below water level to verify that the fathometer trace was recording correct depth to within 0.1 ft (0.03 m).

Waypoints for the beginning and end of each of the 40 lines were pre-entered into the TRIMBLE Asset Surveyor datalogger. As the survey boat proceeded along each profile line, the DGPS data collector recorded and called out marks at 50 m (164 ft) intervals at which time the fathometer annotator made a corresponding mark and annotation on the fathometer record. Start and end times of each line were also recorded.

During part of the bathymetric survey, the Hammerhead Pentium did not display profile line positions, and thus the boat operator steered according to the boat magnetic compass and made course corrections using DGPS data. This resulted in some boat deviation from the designated profile lines. In the northern part of the survey area, two profile lines (A1 and C1) deviated substantially and required repeat data collection (Table 1). For profile lines AA1 through NN1, the Hammerhead Pentium screen display was operational and allowed for more precise navigation.

Positions of the bottom sediment samples were recorded by using an average of multiple DGPS positions for the survey vessel at the time of sampling. The precise position of the samples is not known because of drift of the boat relative to the location where the bottom sampler hit the lake bottom.

## Bottom Sampling

In order to provide data on bottom materials, grab samples were collected at a total of 14 sites using a PONAR grab sampler suspended from an onboard winch. In the field, samples were bagged and labeled for later description. Figure 4 shows the sample locations. Table 2 provides the sample descriptions.

Although some sediment or shells were collected at every site, some sites required more than one attempt, and only three sites resulted in samples with more than a few ounces of material. The typical sparsity of sampled material is attributed to a combination of the descent angle of the sampler, mechanical limitations of the sampler in terms of catching and holding a sample and, possibly, localized hard-bottom conditions which prevented sampler penetration.

Table 2. Bottom sample descriptions.

| Sample No. | Description<br>Colors referenced to MUNSELL Rock Color Chart<br>Pebble measurements are along long axis |
|---|---|
| 1 | Olive gray mud with pebbles up to 3 cm diameter. Abundant live zebra mussels. |
| 2 | Gravel. Pebbles up to 4 cm diameter. Live zebra mussels. |
| 3 | Brownish gray medium sand with pebbles up to 3 cm diameter. |
| 4 | Olive gray, soft mud with pebbles up to 3 cm diameter. |
| 5 | Brownish gray medium to coarse sand. Live zebra mussels as well as shell fragments. |
| 6 | No sediment recovered. Live zebra mussels. |
| 7 | Olive gray mud with pebbles up to 3 cm diameter. Abundant live zebra mussels. |
| 8 | No sediment recovered. Abundant live zebra mussels. |
| 9 | Gravel. Pebbles up to 3.5 cm diameter. Live zebra mussels. |
| 10 | Olive gray mud with pebbles up to 5 cm diameter. Abundant live zebra mussels (most abundant concentration of any of the 14 samples recovered). |
| 11 | Stiff, olive gray clay with pebbles up to 1 cm diameter. |
| 12 | Olive gray silty sand with pea gravel. Live zebra mussels. |
| 13 | Brownish gray mixed sand and gravel. Pebbles up to 3 cm diameter. Live zebra mussels as well as shell fragments. |
| 14 | Brownish gray medium sand with pebbles up to 1 cm diameter. Live zebra mussels as well as shell fragments. |

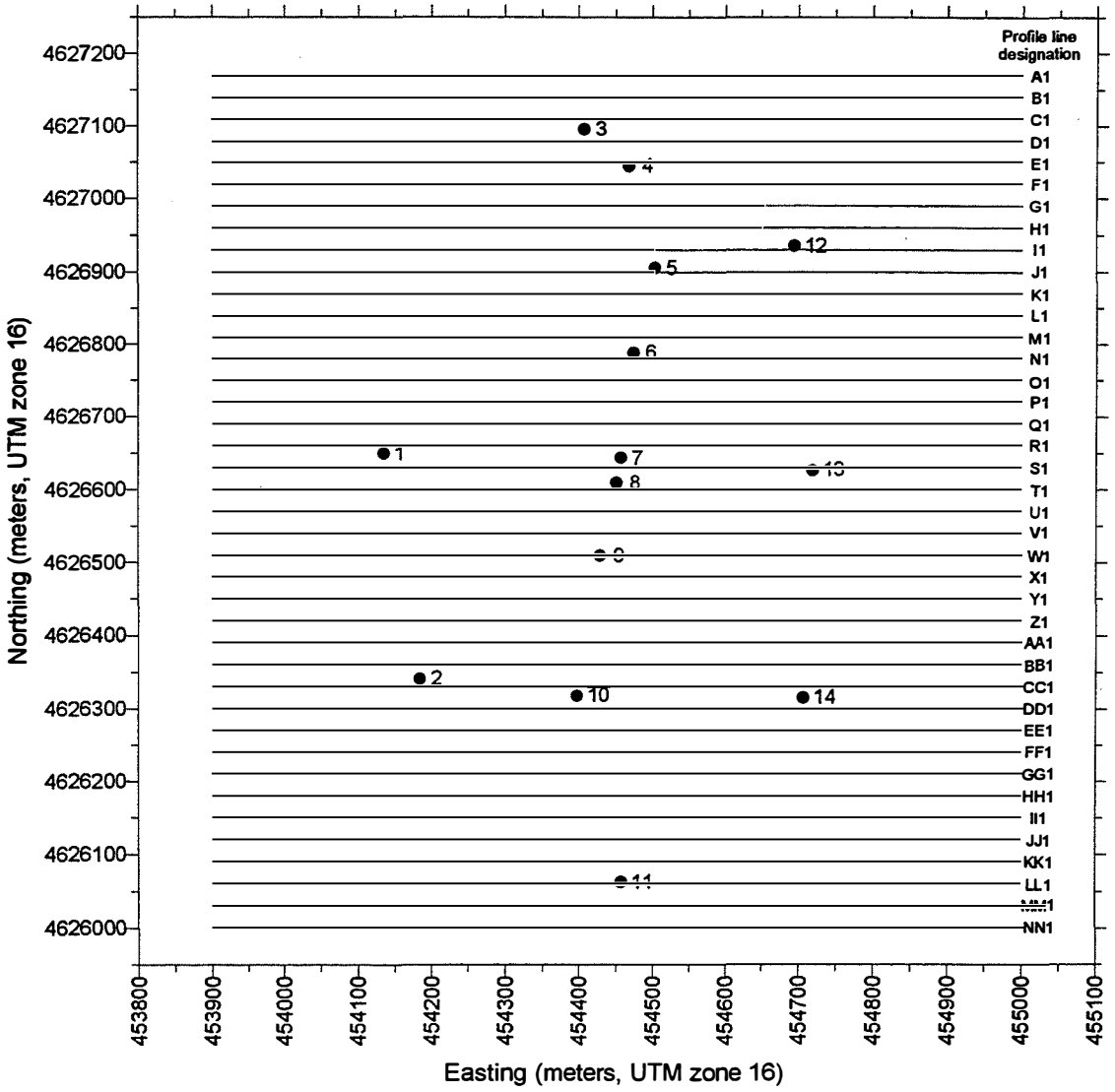


Figure 4. Location of bottom sediment samples within the survey area. This scheme was designed to provide coverage along the approximate 25 ft (7.6 m) LWD contour (Samples 3 through 11) with supplemental samples in adjacent shallower and deeper water (Samples 1, 2, and 12 through 14). See Figure 2 for location of survey area.

## DATA PROCESSING

### Adjusting Fathometer Depths to LWD

The fathometer traces recorded lake-bottom depth relative to the lake level at the time of the survey. To adjust all depths to Lakes Michigan-Huron Low Water Datum (LWD), hourly lake-level data were obtained from the NOAA/NOS lake-level gauge at Calumet Harbor, Illinois (Gauge 7044) located about 3.5 miles (5.6 km) southeast of the study area. These data were used to determine the hourly height of lake level above LWD. For each profile line, the fathometer record was read with the nearest hour adjustment necessary to read depths relative to LWD. For the fathometer data collected on May 6, datum adjustments ranged from 3.0 to 3.2 ft (0.91 to 0.97 m); for data collected on May 13, datum adjustments ranged from 3.1 to 3.2 ft (0.94 to 0.97 m). Prior to reading the fathometer traces for May 11, a smooth line was drawn along the trace to average out the effect of 2 to 2.5 ft (0.6 to 0.7 m) waves that persisted through the data collection. No smoothing was necessary for the fathometer traces of May 6.

### Bathymetric Map Production

A vertical scale was used to identify the location of the one-foot LWD intercepts along the fathometer trace. The X and Y coordinates for each of these one-foot intercepts were determined by interpolating the location between the preceding and subsequent DGPS fix marks which were made every 50 m (164 ft) of boat advance. Supplementing the one-foot contour intercepts, one or more decimal depths and associated X-Y coordinates were determined if a marked change in slope or a major lake-bottom high or low occurred between the one-foot intervals. A spreadsheet was used in all data tabulation.

A total of 1332 X-Y-Z coordinates were recorded for the 40 profile lines. Using Arc/Info software, the locations of the data points were plotted at 1:1500 scale. From this plot, a bathymetric map with a one-foot contour interval was hand contoured, drafted on Mylar, and reproduced by blueprint process. The hand contouring assured more realistic portrayal of the lake bottom than can occur with some software-contouring packages.

## BATHYMETRIC MAP EVALUATION

### Lake-Bottom Morphology

The bathymetric map that accompanies this report show that the lake bottom has a morphology dominated by a north-northeast / south-southwest trend. This likely relates to the local flow direction of glacial ice during the last glaciation. However, the bottom is being modified by erosional processes which are discussed in the next section (Comparison with Previous Lake-Bottom Mapping). In addition, all of this mapped area was exposed land from about 10,000 to 5,000 years ago when Lake Michigan water levels were significantly lower than today, and some of the existing lake-bottom morphology may reflect subaerial erosional and depositional processes of that time. This former erosion and deposition may be the most significant contributor to the present morphology, masking or altering the earlier ice-flow influence.

The most prominent lake-bottom feature is a narrow (approx. 500 ft; 150 m wide) ridge that runs along the entire east edge of the map area. The ridge has 30 ft (9.1 m) LWD depth along its eastern side and the ridge crest reaches up to the 25 ft LWD contour. Other than this localized relief along the eastern margin of the survey area, the remaining area of lake bottom is generally a low relief surface, gently sloping toward greater depths from west-northwest to east-southeast.

The target depth for the artificial reef construction is 25 ft (7.6 m) LWD. In the northern half of the mapped area, the 25 ft LWD contour loops around a closed depression having a maximum depth of 26.9 ft (8.2 m) LWD and loops around two knolls having least depths of 23.2 ft (7.1 m) LWD and 21.9 ft (6.7 m) LWD (see accompanying bathymetric map).

A near-linear trend occurs along the 25 ft LWD contour for a distance of about 2000 ft (600 m) in a northeast-southwest direction between UTM coordinates 4626775N / 454465E at the north and 4626230N / 454210E at the south. Along this reach the slope between the 24 and 26 ft (7.3 and 7.9 m) LWD contours ranges from about 1:100 to 1:500 and averages about 1:300. Two additional near-linear trends along the 25 ft LWD contour occur to the west and north of this reach.

**Comparison with Previous Lake-Bottom Mapping**

Prior to this 1998 survey, the most recent detailed bathymetric survey across this area was done by the U.S. Lake Survey in 1964. Figure 5 is a reproduction of a section of the 1964 survey sheet with the location of the 1998 survey area superimposed. A comparison of this historical data with the 1998 data provides a means of computing lake-bottom change caused by erosional or depositional processes.

Figure 6 shows differences between 1964 and 1998 lake-bottom depths to the nearest 0.5 ft (0.15 m). Although a few locations show either no change or accretion of as much as 1 ft (0.3 m), erosion predominates. Most erosion is in the range of 1 to 3 ft (0.3 to 0.9 m). The general low-slope character of the lake bottom results in a high degree of certainty that these depth changes are not the result of differences in sounding location between the 1964 and 1998 data. The most severe erosion is concentrated in the northeast corner of the survey area on the flanks of South Park Shoal. This is an area of considerable relief where differences in sounding location can result in apparent bathymetric changes that are larger than actual changes. Here several point comparisons indicate erosion greater than 4 ft (1.2 m) and as great as 16 ft (4.8 m).

For the majority of the survey area, erosion in the range of 1 to 3 ft (0.3 to 0.9 m) over the 34-year interval results in an average annualized erosion rate of 0.4 to 1.1 inches/yr (0.8 to 2.6 cm/yr).

A cautionary note is necessary regarding these erosional rates. Widespread and severe lake-bottom erosion has been documented elsewhere on the Illinois shore by using a time series of multiple surveys, such as on the northern Illinois shore in the vicinity of Lake Bluff (Chrzastowski and Trask, 1995). However, this 1964-1998 map comparison in the vicinity of the proposed artificial reef relies on a comparison of only two data sets of considerable difference in map scale, each having hand-drawn contours that are subject to considerable interpretation.

**Bottom Sediments**

The 14 bottom grab samples indicate that the bottom is a patchwork of clay, sandy silt, sand, and mixed sand and gravel (Table 2). The largest pebble collected measures 5 cm on the long axis (Sample 10). At one location (Sample 11) the bottom consisted of clay. This likely represents an exposure of the underlying glacial till that is otherwise covered with a veneer of sand and gravel. All but three samples (Samples 3, 4, and 11) included zebra mussels.

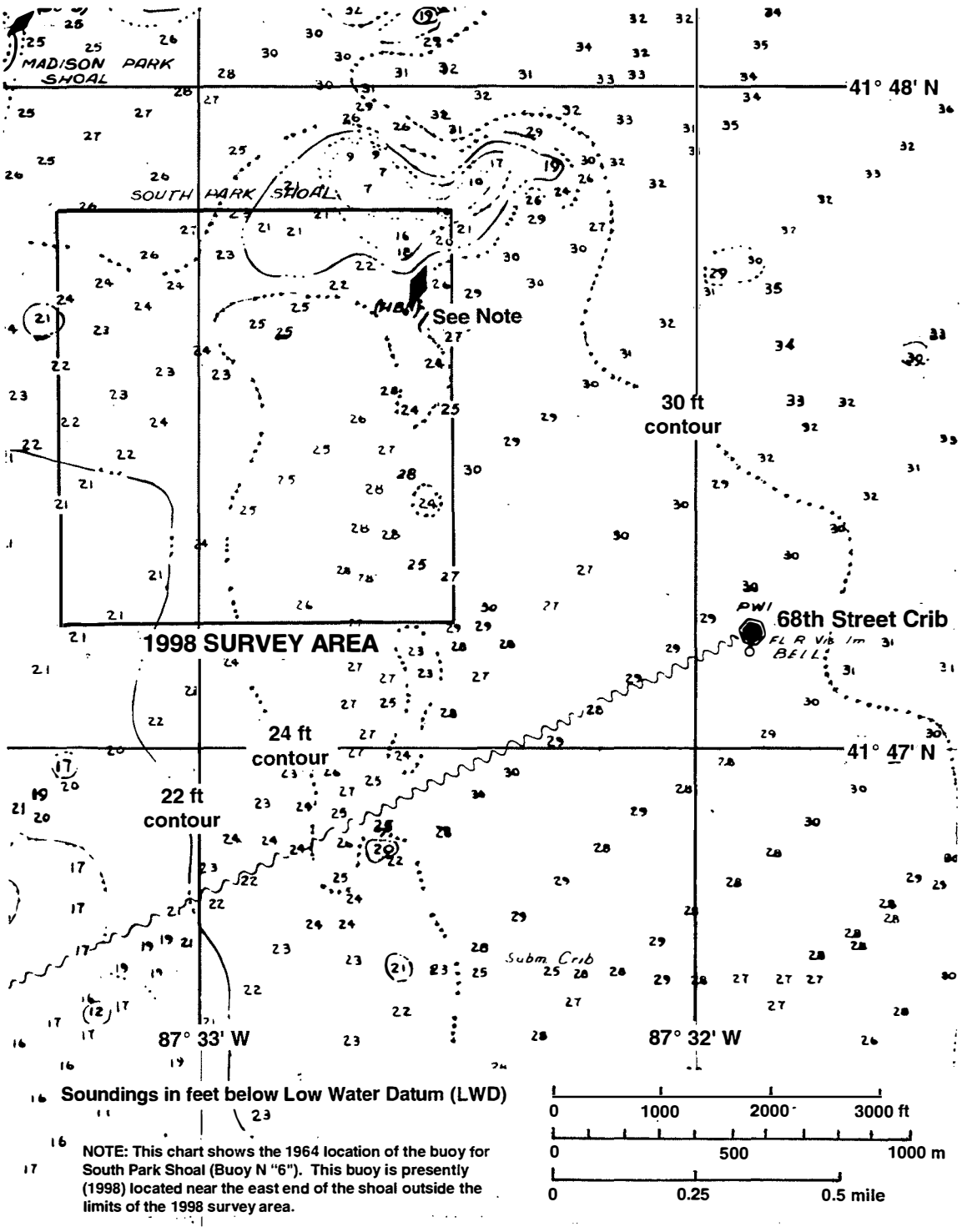


Figure 5: 1964 bathymetry in the area of the proposed artificial reef. The 1964 data were collected by the U.S. Lake Survey. Limits of the 1998 bathymetric survey are shown for reference.

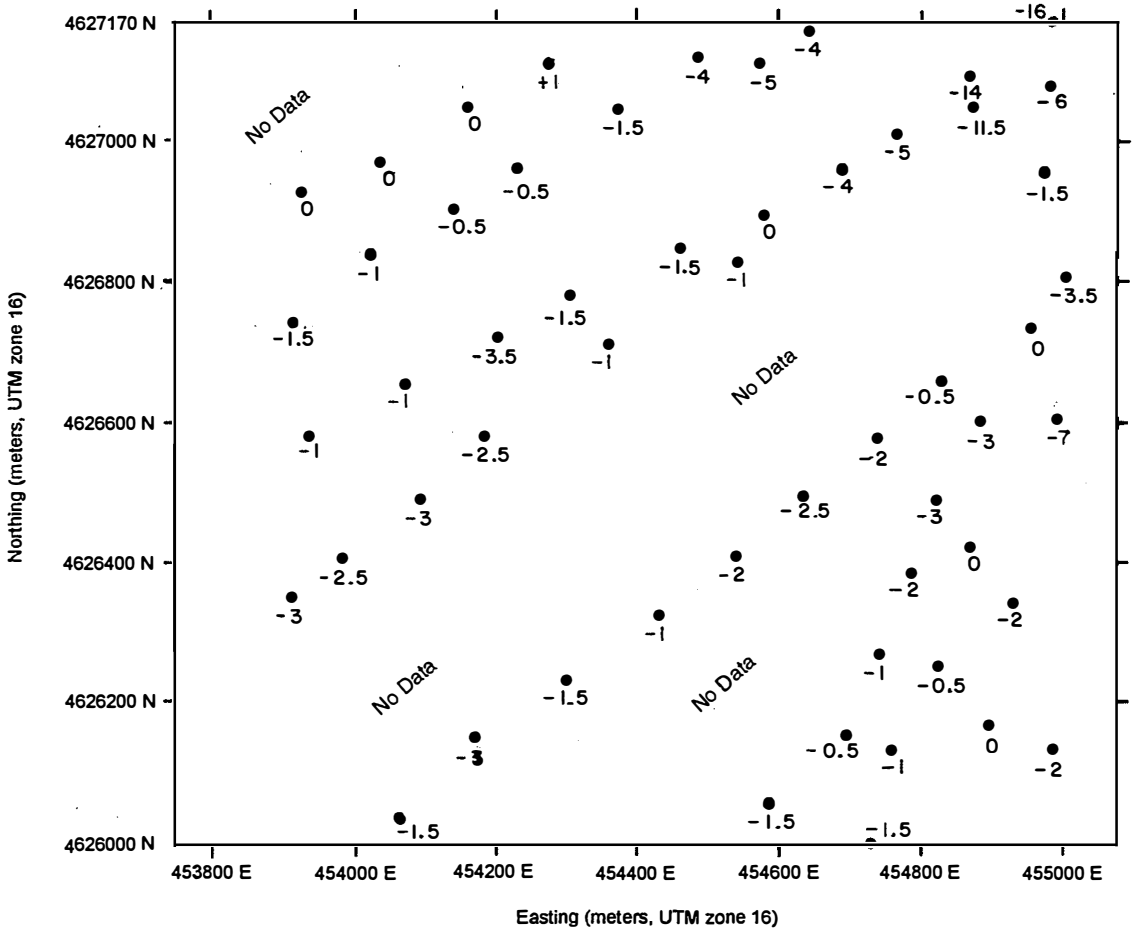


Figure 6: Difference (in feet) between the 1964 and 1998 bathymetric data. Dots show the location of the 1964 soundings. Whole number differences result from a superposition of the 1964 soundings and the 1998 one-foot contours. Half-foot differences result from the 1964 soundings falling between the 1998 contours and therefore being subtracted from the mid-contour value.

## Subbottom Sediments and Depth to Bedrock

Determining the thickness of the subbottom sediments that overlie the local bedrock was beyond the scope of this study. However, a summary of published data is presented here which may be valuable in any lake-bottom coring at the reef site prior to construction.

Regional mapping of depth to bedrock and thickness of overlying unconsolidated sediments in southern Lake Michigan was most recently done by Foster and Folger (1994) based on a compilation of data existing at that time and new data they obtained with a subbottom seismic survey. In the vicinity of the proposed artificial reef, their mapping indicates that the top of the bedrock surface is in the range 525 to 558 ft (160 to 170 m) above mean sea level. This elevation range is 20 to 53 ft (6 to 16 m) below LWD. Their mapping indicates, therefore, that sediments overlying bedrock in this area are as much as 32.8 ft (10 m) thick. These elevations and thicknesses are valuable as first approximations, but the bedrock surface may have considerable local relief, and borings at the reef site will be needed to determine local conditions.

The unconsolidated sediment overlying the bedrock is likely dominated by Wadsworth Till, which is typically a gray clayey till with few pebbles and discontinuous stringers of sand. The underlying bedrock in this area consists of dolomite of Silurian age. In the general vicinity of the proposed artificial reef, this dolomite crops out on the lake bottom at Morgan Shoal (Figure 2), on land near Rainbow Park (Figure 2), and farther inland where it forms a broad knoll known as Stony Island which is located about 3 miles (4.8 km) south of Jackson Park Harbor (Willman, 1971).

## SUMMARY

This bathymetric survey results in a detailed, one-foot contour interval map of the vicinity of the proposed artificial reef. The desired lake-bottom depth for the reef construction is 25 ft (7.6 m) LWD. Three near-linear reaches of the 25 ft (7.6 m) LWD contour occur in the west-central part of the mapped area. Each of these three reaches would be a suitable area for construction of a 500 ft-long (152 m) reef and allow for the possibility of either adding additional length at some future date, or building one or more additional 500 ft-long reefs having a similar orientation.

A comparison of bathymetric data spanning 34 years (1964-1998) indicates that long-term erosion dominates the survey area. Most of the erosion is in the range of 1 to 3 ft (0.3 to 0.9 m), yielding an average annualized erosion rate of 0.4 to 1.1 inches/yr (0.8 to 2.6 cm/yr).

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