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# RESTORATION & WATER QUALITY MANAGEMENT

## INTERIM REPORT

FOR

ANOKA COUNTY

ON

HIGHLAND LAKE, KORDIAK PARK, COLUMBIA HEIGHTS, MINNESOTA

DECEMBER 14, 1987

by: Virgil Muller
Muller Engineering

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December 29, 1987

Dave Torkildson
Director of Parks & Recreation
Anoka County
550 Bunker Hills Blvd.
Anoka, MN 55303

Dear Dave:

Enclosed please find an encouraging report prepared by myself and Bob Laing of Clean-Flo Laboratories. This report is part of our contract to give the County Board an update on the progress of our aeration system on Highland Lake.

As you can see by the report, the muck removal process has been progressing very nicely. I only wish that we had the opportunity to keep the aerator running all winter long. We would like to stock the lake with fathead minnows and crappies in the spring. This would certainly further the improvement of water quality in the lake.

You may want to copy this report and give it to your County Board members to show the progress that is occurring at Highland Lake. I hope this report is satisfactory. If you have any questions, please do not hesitate to call me.

Sincerely,

Virgil Muller

VM:rd

Enclosure

# INTERIM REPORT ON THE HIGHLAND LAKE RESTORATION PROJECT FOR ANOKA COUNTY

December 15, 1987

## ABSTRACT

Highland Lake, located in Kordiak Park, Columbia Heights, Anoka County, Minnesota is in its early stages of a complete lake restoration program, as sponsored and specified by the Anoka County Parks and Recreation Department. So far, muck has been reduced, resulting in an average 4-inch per month decrease in muck since the program began on July 23, 1987.

The summer flood had a harmful effect on water quality, from which the lake did not quickly recover. Nevertheless, carbon dioxide, hydrogen sulfide, ammonia, nitrite, and nitrate were all reduced to zero level (too low to measure) by October 12, 1987, while both available phosphorus and total phosphorus were reduced significantly.

The pH factor has been improved for fish, but no fish are in the lake now. Insects have not yet been able to establish themselves.

Results of testing indicate a strong need for winter aeration as well as spring, summer, and fall aeration, and the need for stocking the lake with algae-feeding fathead minnows and pan fish. The lake would make an excellent crappie fishing lake. Other needs indicated are the continued additions of Clean-Flo Lake Cleanser and Clean-Flo Living Organisms (C-FLO), as specified in the Anoka County bid specifications.

# BACKGROUND

Highland Lake, also known as Kordiak Lake, was a shallow, eutrophic 15-acre municipal storm water holding basin used only for aesthetic purposes as a focal point of Kordiak Park. The lake underwent fish kills periodically, and was filled with aquatic plants (primarily cattails and water lilies), and a heavy algal bloom.

The lake was 10 to 17 feet deep in the 1930's. On June 3, 1987, the deepest spot found in the lake was two feet deep. This was after a drought which lowered many lakes in the area as much as four feet. A flood occurred on July 16th, which raised the lake above the outlet weir. By July 21, the water was at the level of the weir, and the lake was four inches deeper than it was on June 3rd. It is estimated that organic sediment mixed with inorganic silt from the watershed is from six to twenty feet deep throughout the lake.

On July 21, 1987, Clean-Flo Laboratories, Inc. of Hopkins, Minnesota had completed the installation of a continuous laminar flow inversion/oxygenation system comprised of six ½ hp oilless air compressors setting in a block building on shore, with 6000 feet of high-density rubber air line, impregnated with a muskrat repellent, connected from the compressors underground to the lake, and from there to 12 microporous ceramic air diffusers which are dispersed on the bottom of the lake (Figure 1). On July 23, 1987, the power switch was actuated by David Torkildson, Director of Parks and Recreation for Anoka County, and the lake began it recovery from a long period of pollutant influx.

The lake had been tested on October 23, 1973, and again on June 2, 1987 and July 21, 1987 before the inversion system was turned on. Tests were repeated on August 26, September 21, and October 12, 1987 after the system was turned on. This testing will be repeated in December and February, and then monthly from April through October of each year, and December and February of each year over a three-year period. Testing consists of water chemistry, aquatic plants, physical parameters such as depth, temperature, and water transparency, and sediment analysis. Benchmark stakes have been placed around the shoreline to monitor the recession of muck from the shoreline from year to year.

3000 pounds of a buffered alum phosphate precipitant was added on July 30th, and again on August 13, and on August 27.

60 pounds of cellulose-feeding microorganisms were added to the lake on August 4, August 18, September 1, and September 15. 120 pounds were added on September 22 and 120 pounds on September 29.

## RESULTS

### Water Quality

Water quality improved from July 23 to October 12, the time the lake was last tested, Table 1. The lake shifted from a carbon dioxide limited lake before treatment to a nitrogen limited lake within thirty days of initiation of the program. By October 12th, all forms of available nitrogen were too low to measure. On July 21st, the plants were phosphorus limited.

Total phosphorus, that tied up in the algae, decreased from 0.33 mg/l on the surface and 0.32 mg/l at the bottom on July 21st to 0.23 mg/l on the surface and 0.27 mg/l on the bottom by October 12th, a 30 percent reduction and 16 percent reduction, respectively.

pH was at an excessively high level for fish on June 2nd and July 21st. By October, it was stabilized at the excellent level of 7.0 to 7.1.

Iron, a micronutrient for aquatic plants, was reduced from 0.6 mg/l on July 21st to 0.2 mg/l by October 12th, a 67 percent reduction.

In June, the lake was carbon dioxide limited, with carbon dioxide reading zero, and all the alkalinity in the carbonate form, which does not provide carbon dioxide for plant growth. After the flood, some bicarbonate was present in the water, and by October, all the alkalinity was in the bicarbonate phase.

In accord with the specification requirements by Anoka County the system has proven capable of maintaining a minimum bottom dissolved oxygen concentration of 5 mg/l, and the resultant aerobic environment at the sediment-water interface to maintain and promote benthic organisms and the biodegradation of organic sediment. Furthermore, the system reduced and held bottom ammonia below the specified requirement of 0.1 mg/l, and hydrogen sulfide below 0.05 mg/l.

## Sediment

Sediment was analyzed on February 11, 1987, June 4, 1987 and again July 21, 1987 after the flood. Sediment samples were taken at sites A, B, and C and D, shown in Figure 2.

Sediment samples were found to have the following analysis, Table 2, using Standard Methods for the Examination of Water and Wastewater, 14th Edition, 1975.

Table 2. Sediment analysis for Highland Lake.

| Measurement | Site A | Site B | Site C | Site D |
|---|---|---|---|---|
| % Water, by weight | | | | |
| February 11, 1987 | 84 | 83 | 52 | |
| June 4, 1987 | 67 | 48 | 50 | 64 |
| July 21, 1987 | 70 | 75 | 53 | 75 |
| % Volatile, by weight* | | | | |
| February 11, 1987 | 27 | 15 | 22 | |
| June 4, 1987 | 63 | 51 | 31 | 62 |
| July 21, 1987 | 17 | 23 | 10 | 22 |
| % Ash weight** | | | | |
| February 11, 1987 | 73 | 85 | 78 | |
| June 4, 1987 | 37 | 49 | 69 | 38 |
| July 21, 1987 | 83 | 77 | 90 | 78 |

* Volatile weight is an approximate measure of organic matter in the sediment, with the water extracted.

** Ash weight is an approximation of the inorganic silt in the sediment, the water extracted.

The sediment is a loose deposit of organic matter containing a high water content, and silty clay. The flood apparently brought in a large deposit of inorganic silt. The muck will be analyzed once a year to see what changes are taking place.

Water depth was monitored on June 3, July 21 after the flood, and on September 2, 1987, using a Lowrance Model AX15A, Figure 3. The water level dropped about a foot between June 3rd and July 15th. Before the flood on June 3, the deepest place in the lake was two feet at a location 350 feet from the west shore on transect 3, Figure 4. This was about a foot deep by July 15th. Immediately after the flood, water depth increased to about a foot above the outlet weir, or about 28 inches total. By July 21, the water was at the level of the weir, and the lake was 4 inches deeper than it was on June 3.

From July 21st to September 2nd, the water depth increased at the 350' mark from 2.33 feet to 3.0 feet deep.

## Aquatic Plants

Aquatic plant density and percent occurrence were tested on June 2, July 21, and again on September 2, 1987. Results are shown in Table 3. No plants were found on September 2nd.

Table 3. Aquatic macrophyte recovery at seven pseudo-randomly selected test sites in Highland Lake.

| Aquatic Plant | % Recovery | June 2, 1987 Average Density | Recovery Index |
|---|---|---|---|
| Elodea canadensis (Canadian waterweed) | 57.1 | 1.6 | 0.9 |
| Potamogeton filaformis (fineleaf pondweed) | 42.9 | 1.1 | 0.5 |
| Pondweed (unspeciated) | 28.6 | 0.3 | 0.1 |
| Nuphar Variegatum (Yellow waterlily) | 14.2 | 0.7 | 0.1 |
| Mean Average Recovery Index | | | 0.4 |

| Aquatic Plant | % Recovery | July 21, 1987 Average Density | Recovery Index |
|---|---|---|---|
| Elodea canadensis (Canadian waterweed) | 57.1 | 1.4 | 0.8 |
| Potamogeton filaformis (fineleaf pondweed) | 28.6 | 0.6 | 0.2 |
| Pondweed (unspeciated) | 14.2 | 0.1 | 0.02 |
| Nuphar Variegatum | 14.2 | 0.4 | 0.1 |
| Mean Average Recovery Index | | | 0.3 |

# CONCLUSIONS

While the restoration program for Highland Lake is still in its early stages, organic sediment has been reduced and the nutrients have decreased.

Water quality has improved considerably, but still has a way to go before algae is under control. Since turning the inversion system off for the winter will cause a release of phosphorus and nitrogen from the bottom sediment as the lake bottom becomes anaerobic, the system should be kept operating throughout the year, including winter.

Continued use of the buffered alum will continue to reduce phosphorus in the water. Phosphorus tied up in phytoplankton and aquatic macrophytes cannot be reduced unless they are released to the water column. Introduction of minnows to the lake can help this process. As the minnows feed on the algae, they excrete a portion of the nutrients into the water column. Also some of the nutrients can be passed up the faunal food web to larger fish.

Therefore, water quality can be further improved by stocking the lake with fathead minnows and crappie. This will result in a decline in algae, followed by an increase in water transparency, and an improvement in water quality. As stated above, nutrients presently bound up in the algae will become food for the fatheads, which in turn will become food for the crappies.

This will have the additional benefit of providing an exciting fishing lake for local residents.

While zooplankton was not measured, the shift from carbonate alkalinity to bicarbonate alkalinity tends to indicate a large increase in the zooplankton community. This should be followed by a clearing of the water next year, especially if fathead minnows are added, both to feed on algae, and to be a food source for a crappie population.

Muck was to be tested at the end of each year of the restoration process. But to assure that the Microorganisms were living and feeding on bottom sediment, interim tests were made. It was also important to know the effect of the flood on the sediment constituents. This test showed that a large deposit of inorganic silt occurs after heavy rains, and that some years from now, some limited dredging may be necessary at the inlet.

Otherwise, it is significant that eight inches of sediment has been removed from the lake in only the first two months of the restoration program. This leads us to believe that the goal of six inches muck removal per year will be easily met, and has already been exceeded for the first year.

Aquatic macrophytes were shaded out by the algal growth, and declined during the summer. However, it appears that the lilies also declined. This can be the result of the limited muck removal in combination with the continuous oxygenation of the sediment, which may render the phosphate and nitrogen unavailable for emergent plant growth.

Likewise, the decline in submergent vegetation could be at least partially attributed to the decline of nutrients in the water column. While some nutrients are absorbed from the sediment, it has been established that submergent macrophytes take in considerable amounts of nutrients from the water column. And certainly, all the carbon dioxide inspired by submergent plants comes from the water column. Carbon dioxide was held at zero throughout the summer, and is probably the prime cause of the decline of macrophytes.

Results of the restoration program are positive, and indicate that the lake will continue to improve as the program is continued over the next three years.

# HIGHLAND LAKE

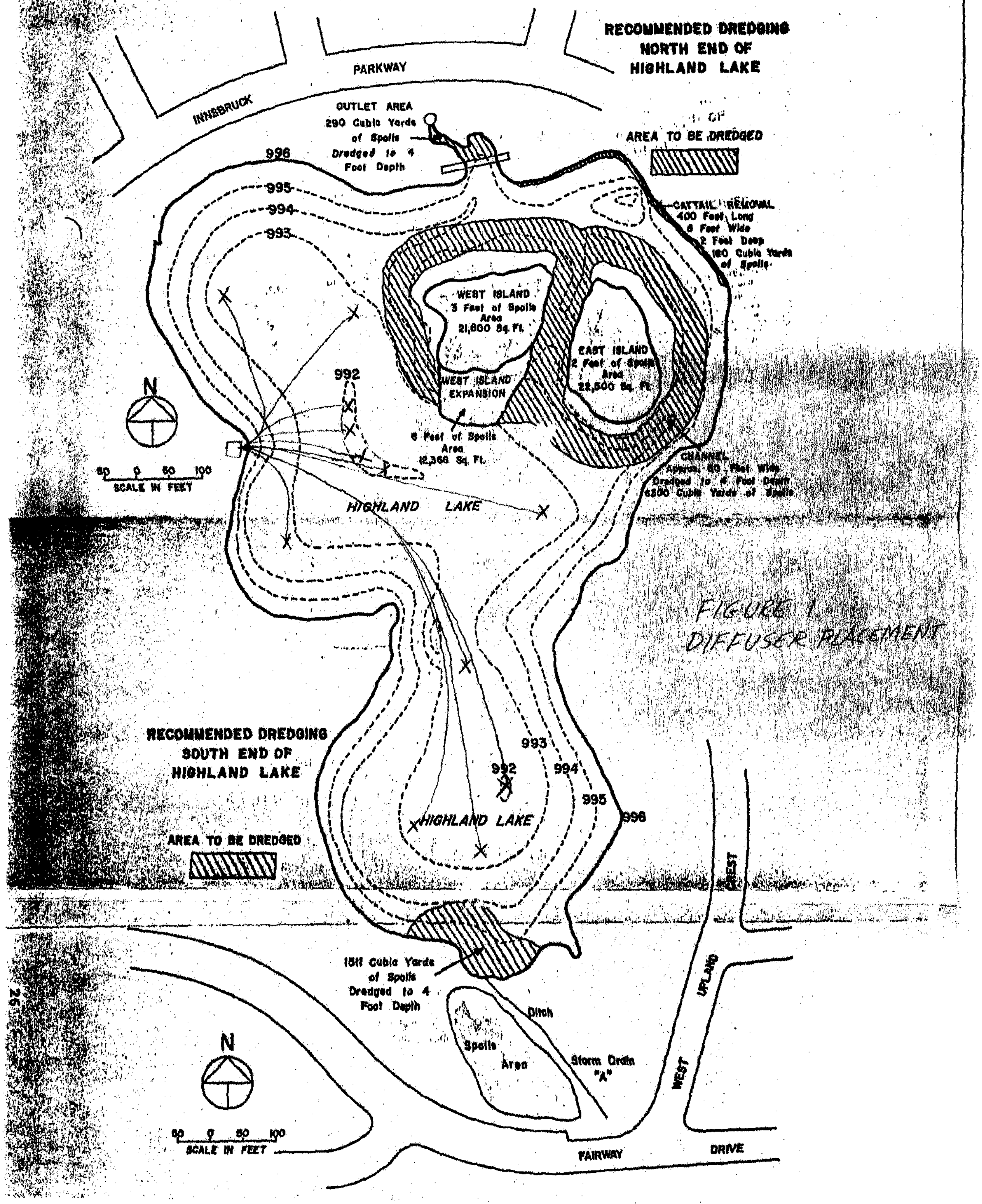



FIGURE 1
DIFFUSER PLACEMENT

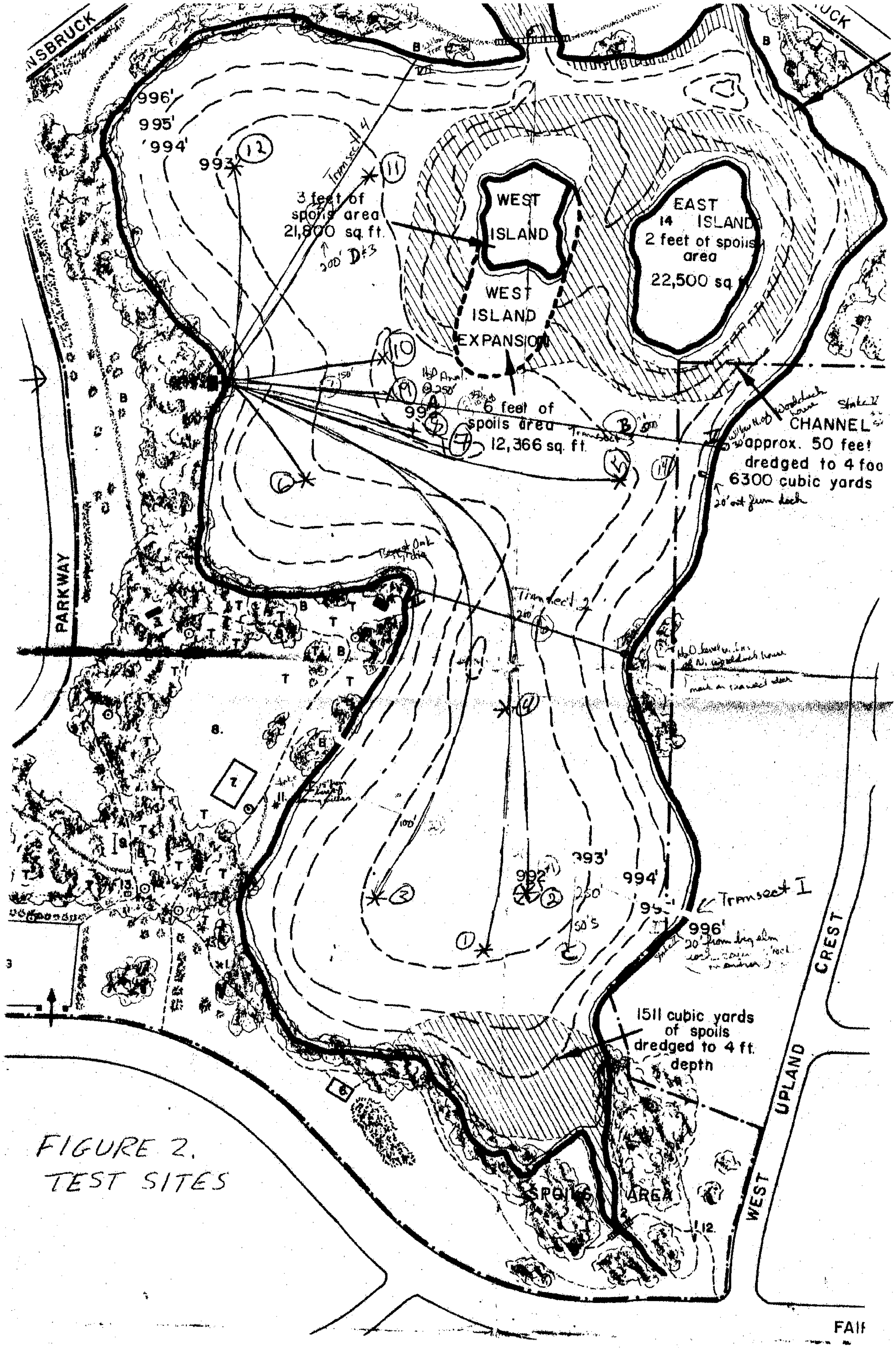
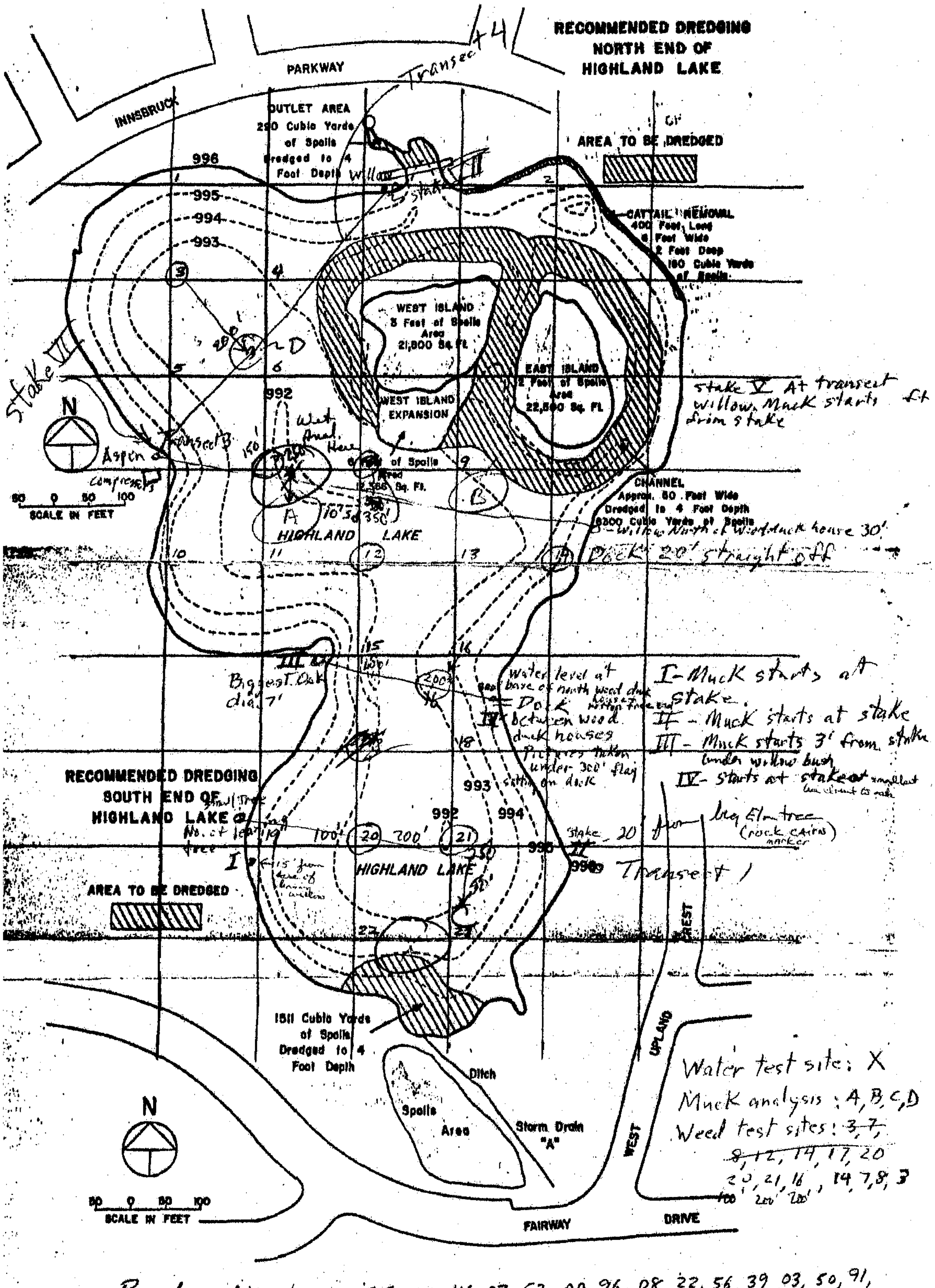


FIGURE 2.
TEST SITES

Figure 4

# HIGHLAND LAKE




Random Numbers: 25, 93, 46, 07, 52, 00, 96, 08, 22, 56, 39, 03, 50, 91,
20, 60, 72, 25, 93, 02, 17, 29, 12, 78, 47, 03, 31, 58,

Table 1. Water quality before and after initiation of the lake restoration pro[g]
samples.

| Measurement | 10/12/87 | 9/21/87 | 8/26/87 |
|---|---|---|---|
| | North basin | North basin | North basin |
| Air Temperature, °F | 60 | 65 | 60 |
| Water Temperature, °F | 43.5 | 61 | 66 |
| Water Transparency, inches | 12 | 10 | 9 |
| Dissolved oxygen, surface | 13 | 12 | 12 |
| Dissolved oxygen, bottom | 13 | 12 | 11 |
| Carbon dioxide surface | 0 | 0 | 0 |
| Carbon dioxide bottom | 0 | 0 | 0 |
| Ammonia (as N) surface | 0 | 0 | 0.1 |
| Ammonia (as N) bottom | 0 | 0 | 0.2 |
| Nitrite (N) surface | 0 | 0 | 0 |
| Nitrite (N) bottom | 0 | 0 | 0 |
| Nitrate (N) surface | TLTM* | 0.02 | 0.02 |
| Nitrate (N) bottom | TLTM | 0.02 | 0.02 |
| Hydrogen sulfide surface | 0 | 0 | 0 |
| Hydrogen sulfide bottom | 0 | 0 | 0 |
| pH, surface units | 7.0 | 9.0 | 9.1 |
| pH, bottom units | 7.1 | 7.2 | 7.8 |
| Available phosphorus surface | 0 | 0.01 | 0 |
| Available phosphorus bottom | 0.01 | 0.01 | 0.03 |
| Total phosphorus surface | 0.23 | 0.37 | 0.43 |
| Total phosphorus bottom | 0.27 | 0.3 | 0.8 |
| Iron | 0.2 | 0.3 | 0.35 |
| Manganese | 0 | 0 | 0 |
| Calcium hardness (as CaCO3) | 50 | 40 | 50 |
| Magnesium hardness (as CaCO3) | 30 | 20 | 10 |
| Total Hardness (as CaCO3) | 80 | 60 | 60 |
| Bicarbonate alkalinity (as CaCO3) | 70 | 20 | 20 |
| Carbonate alkalinity | 0 | 40 | 40 |
| Hydroxide alkalinity | 0 | 0 | 0 |
| Total alkalinity (as CaCO3) | 70 | 60 | 60 |

*TLTM: Too low to measure.

gram. Unless stated otherwise, measurements are in mg/l, and are surface

| 7/21/87 | 6/2/87 | 2/11/87 | 10/23/73 | |
|---|---|---|---|---|
| North basin | North basin | North basin | North basin | South basin |
| 75 | 77 | 50 | 59 | 59 |
| 76 | 74 | 34.7 | | |
| 6 | 12 | | | |
| 8 | 13 | | | |
| 5 | 13 | 13.2 | 11.27 | 18.27 |
| 0 | 0 | | | |
| 2 | 0 | 10 | | |
| 0.2 | 0.1 | | | |
| 0.25 | 0.35 | <0.1 | | |
| 0 | 0 | | | |
| 0 | 0 | 0.1 | | |
| 0.04 | 0.03 | | | |
| 0.04 | 0.03 | 4.0 | 0.16 | 0.12 |
| 0 | 0 | | | |
| 0 | 0 | <0.05 | | |
| 9.1 | 9.1 | 6.4 | | |
| 7.6 | 9.1 | | | |
| 0 | 0.01 | | | |
| 0 | 0.04 | 0.05 | ).02 | 0.03 |
| 0.33 | 0.06 | | | |
| 0.32 | 0.1 | 0.20 | 0.16 | 0.12 |
| 0.6 | 0.45 | | | |
| 0 | 0 | | | |
| 50 | 50 | 85.6 | | |
| 10 | 10 | 51.4 | | |
| 60 | 60 | 137.0 | | |
| 30 | 0 | 154 | | |
| 20 | 40 | 0 | | |
| 0 | 0 | 0 | | |
| 50 | 40 | 154 | | |