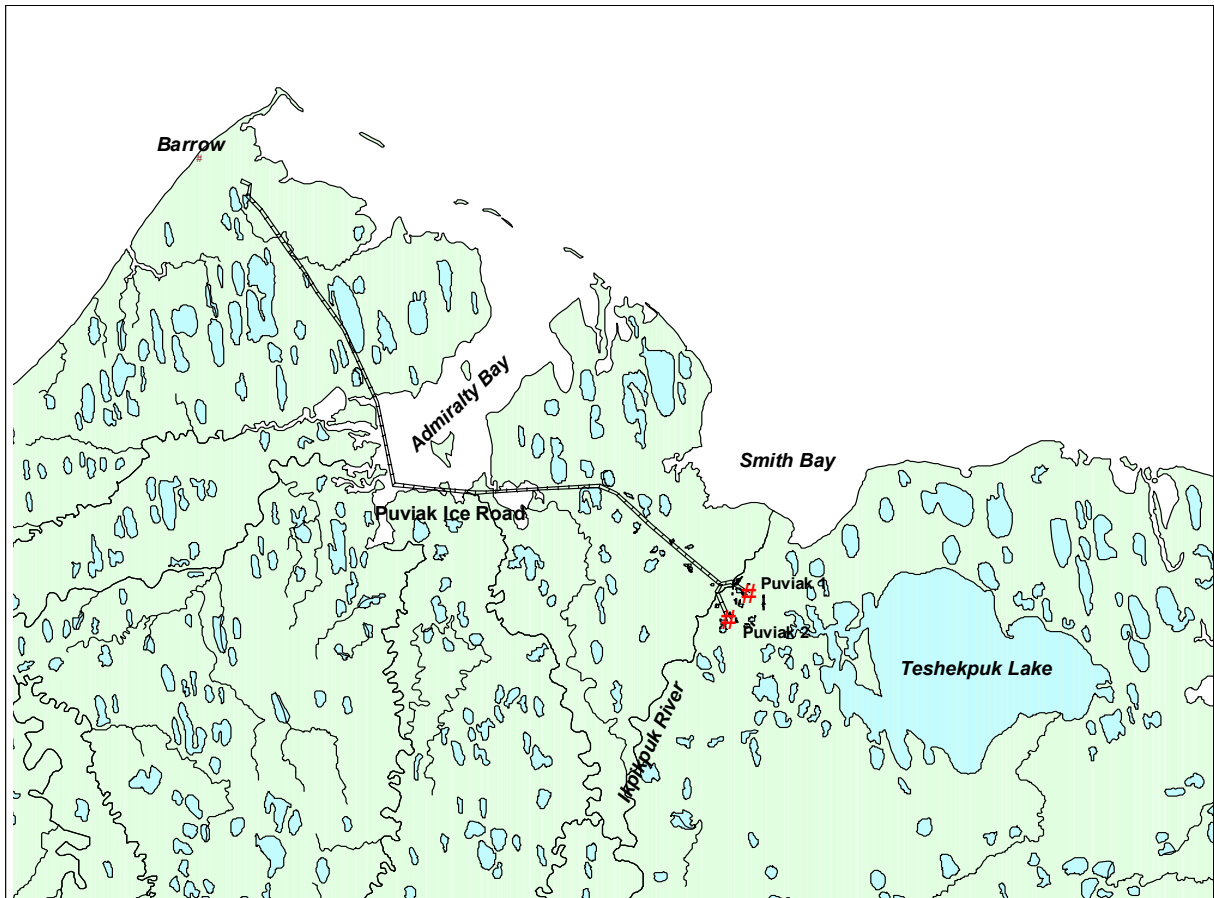


FISH SURVEY OF LAKES IN ASSOCIATION WITH THE PUVIAQ EXPLORATION PROSPECT: 2001-2002

Final Data Report

January 2003



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EXECUTIVE SUMMARY

ConocoPhillips Alaska Inc. has been preparing to explore for oil in an area named Puviaq, which lies between the Ikpikuk River and Teshekpuk Lake. Exploration includes crossing rivers and lakes with ice roads, construction of ice pads, and withdrawal of water from lakes to support both industrial and domestic needs. For agency review of exploration permits, information is required on the biological sensitivity of lakes in the region. The study was designed to provide physical and biological information on these lakes to understand their use by various fish species.

The objectives of the study are to document fish presence and habitat use in lakes that may be used as water sources to support the Puviaq Exploration. The area surveyed during 2001-2002 lies along a potential ice road from Barrow to Puviaq and the immediate area around the proposed drill sites.

Specific tasks of the survey were to:

- 1) inventory fish species in the various lakes within the project study areas;
- 2) obtain information on relative abundance of species in different water bodies sampled, especially from lakes that may be proposed for water withdrawal during exploration;
- 3) obtain basic descriptive population data for the species captured,
- 4) measure lake depths at sufficient locations to estimate lake volumes; and
- 5) measure water chemistry parameters to assess suitability of water for potential uses.

Additional information on water availability along the western portion of the potential ice road near Barrow and from Teshekpuk Lake are included as attachments to this report.

The biological survey, conducted between July 18 and August 3, 2002, consisted of sampling with gill nets and minnow traps combined with physical measurements. Lakes were sampled with short-duration gill net sets (typically 4 to 6 hours) using a multimesh gill net. Since the objective of the gill netting is to document presence/absence, the nets were pulled after fish were detected. Minnow traps were used to identify smaller fish species that may not be detected by gill nets. At lakes where bottom contours allowed, a 20 ft seine was pulled through vegetation beds along the lakeshore to detect small fishes.

Water chemistry measurements included surface measures of water temperature, specific conductance, dissolved oxygen, pH, and turbidity. A water sample was sent to Northern Test Labs for laboratory determination of chloride, sodium, calcium, magnesium, hardness (as CaCO₃) and total dissolved solids (TDS).

Bathymetric data were collected to allow estimating lake volume. Location and depth were recorded with an integrated GPS/depth sounder. Lake volume was estimated by contour mapping of depth

intervals. The surface area of each contour was obtained, then the volume was estimated using the formula for truncated cones. For the two lakes surveyed in 2001, volumes were estimated by applying the formula for the volume of a cone to the surface area and maximum depth of each lake. This method of volume estimation is a conservative measure of lake volume, consistently underestimating the true volume of a lake.

The amount allowed for winter water withdrawal when sensitive fish species are present is currently set at 15% of the volume of the lake deeper than 7 feet. When resistant fish species (i.e. ninespine stickleback and Alaska blackfish) are present, the current allocation is 30% of the volume deeper than 5 feet. There is no withdrawal limit if fish are not present.

The area potentially available for ice aggregate was estimated by calculating the area of the lake shallower than 4 feet, assuming that the ice would grow to at least 4 feet prior to the need for aggregate. If the ice is shallower than 4 feet at the time of ice removal, then the area available will be less.

A total of 26 lakes were evaluated as water sources in 2001-2002 for the Puviaq Exploration Prospect in NPR-A. Twenty of the 26 evaluated lakes were sampled for fish in 2002. Broad whitefish, least cisco, arctic grayling and lake trout were captured by gill net in the Puviaq area lakes, which was consistent with earlier reports from the region. Ninespine stickleback were also caught in minnow traps.

When sensitive fish are present, the amount of water available during winter is limited to 15% of the volume under 7 feet of ice. The water withdrawal criteria are relaxed when only resistant fish species are present because of the greater tolerance to lower dissolved oxygen and higher concentrations of dissolved solids. In this case, up to 30% of the water volume under 5 feet of ice is allowed for winter withdrawal. For lakes that do not contain fish, there is currently no limit to the amount taken. For practical reasons, the volume available is limited to the volume of unfrozen water under the ice at the time of withdrawal. In most cases, the withdrawal occurs when the ice is 4 feet thick or greater. In order to provide some estimate of water likely to be available, the volume of water under 4 feet of ice was calculated.

Based on the above lake evaluation, 19 lakes were confirmed to contain fish. Three additional lakes were not sampled because they were connected to streams or other fish-bearing lakes, and are assumed to support fish. Four additional lakes where fish were not caught were large, deep lakes capable of supporting fish and are listed as potential fish-bearing lakes. Only lake appeared to be marginal fish habitat and ninespine stickleback were observed in this lake.

The area covered by water less than 4 feet deep, and therefore likely to be suitable for removing ice aggregate, was estimated for each lake. A map of the potential ice aggregate area for each lake is included in the individual lake summaries. On average, about 20% of the lake surface was less than 4 feet deep, although the range was considerable, from 3% to over 50%.

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INTRODUCTION

ConocoPhillips Alaska Inc. has been preparing to explore for oil in an area named Puviaq, which lies between the Ikpikpuk River and Teshekpuk Lake. Exploration includes crossing rivers and lakes with ice roads, construction of ice pads, and withdrawal of water from lakes to support both industrial and domestic needs.

For agency review of exploration permits, information is required on the biological sensitivity of lakes in the region. The study was designed to provide physical and biological information on these lakes to understand their use by various fish species. In addition, results of the survey can be used, in concert with previous surveys within the area, to direct any future investigations that may be needed.

The objectives of the study are to document fish presence and habitat use in lakes that may be used as water sources to support the Puviaq Exploration. The area surveyed during 2001-2002 lies along a potential ice road from Barrow to Puviaq and the immediate area around the proposed drill sites (Figure 1).

The specific tasks of the survey were to:

- 1) inventory fish species in the various lakes within the project study areas (sampling areas identified in Figure 1);
- 2) obtain information on relative abundance of species in different water bodies sampled, especially from lakes that may be proposed for water withdrawal during exploration;
- 3) obtain basic descriptive population data for the species captured,
- 4) measure lake depths at sufficient locations to estimate lake volumes; and
- 5) measure water chemistry parameters to assess suitability of water for potential uses.

Additional information on water availability along the western portion of the potential ice road near Barrow and from Teshekpuk Lake are included as attachments to this report.

METHODS

The biological survey, conducted between July 18 and August 3, 2002, consisted of sampling with gill nets and minnow traps combined with physical measurements. Lakes were sampled with short-duration gill net sets (typically 4 to 6 hours) using a multimesh gill net (120 feet long, six panels of variable mesh, mesh size ranging from 1 to 3.5 inches stretched mesh). These nets have been previously used to collect inventory-level data from lakes throughout the Colville Delta and nearby areas. The sets were kept to a short duration to minimize the chance for entangling waterfowl and to

minimize fish mortality. Since the objective of the gill netting is to document presence/absence, the nets were pulled after fish were detected. Fish captured were measured and released if not severely injured. Duration of each set was recorded to allow calculation of catch rates.

In 2002, minnow traps were used to identify smaller fish species that may not be detected by gill nets. Minnow traps baited with preserved salmon eggs were set in pairs at the edge of surveyed lakes. The traps were set and retrieved in concert with the gill net sampling. At lakes where bottom contours allowed, a 20 ft seine was pulled through vegetation beds along the lakeshore to detect small fishes. Where this method was employed, three hauls were made at each lake.

Water chemistry parameters were measured to assess habitat conditions and provide information on the suitability of the water for domestic and industrial uses. Water chemistry measurements included surface measures of water temperature, specific conductance, dissolved oxygen, pH, and turbidity. Temperature, specific conductance and dissolved oxygen were *in situ* surface measurements taken just below the surface along the edge of each lake with a YSI Model 85 meter. A sample was returned to the field office to measure pH and turbidity. PH was measured with an Oaktron Acorn Series pH5 meter. Turbidity was measured with a LaMotte Model 2020 turbidity meter. A water sample was sent to Northern Test Labs for laboratory determination of chloride, sodium, calcium, magnesium, hardness (as CaCO₃) and total dissolved solids (TDS).

Bathymetric data were collected to allow estimating lake volume. In 2002, location and depth were recorded on a Lowrance Model LCX-15MT integrated GPS/depth sounder. Location and depth were recorded every 1-2 seconds. The study design was to record at least six to eight depth transects on each lake. Lake volume was estimated by contour mapping of depth intervals. Contour maps were prepared by plotting the position and depth data obtained by GPS on GIS basemaps using ArcView 3.2 and plotting the contours in 1 or 2 ft intervals on maps of the surveyed lakes. One foot intervals were plotted for lakes where the maximum depth was 10 ft or less, two foot intervals were used on deeper lakes. The surface area of each contour was obtained, then the volume was estimated using the formula for truncated cones:

$$V = h/3*(A1+A2+(A1*A2) (1/2))$$

Where h = vertical depth of the stratum, A1 = area of the upper surface, and A2 = area of the lower surface of the stratum whose volume is to be determined. The volumes of individual strata are summed to obtain the volume of the desired depth intervals.

For the two lakes surveyed in 2001, volumes were estimated by applying the formula for the volume of a cone to the surface area and maximum depth of each lake. The surface area was obtained from a GIS base map using USGS 1:63,360 scale quadrangle sheets. The volume estimation is a conservative measure of lake volume, consistently underestimating the true volume of a lake.

The amount allowed for winter water withdrawal when sensitive fish species are present is currently set at 15% of the volume of the lake deeper than 7 feet. When resistant fish species (i.e. ninespine stickleback and Alaska blackfish) are present, the current allocation is 30% of the volume deeper

than 5 feet. There is no withdrawal limit if fish are not present.

The area potentially available for ice aggregate was estimated by calculating the area of the lake shallower than 4 feet, assuming that the ice would grow to at least 4 feet prior to the need for aggregate. If the ice is shallower than 4 feet at the time of ice removal, then the area available will be less.

Lake Summaries

This report uses lake numbering based a researcher/year code. The lake number contains several pieces of information, including the code of the sampler and the year of sampling.

Sampler Code:

MC = McElderry and Craig (1981); sampling in 1979

B = Bendock sampling from 1997-1986

L = Lobdell; water chemistry sampling in 1991-1999

M = Moulton; fish sampling in 1995-2002

N = Netsch et al. (1977) NPRA sampling in 1977

First Two Numerals:

Year of Initial Sampling

(if Moulton sampled a lake previously sampled by McElderry and Craig, then the McElderry and Craig lake number is used)

Last Two Numerals:

Numbers from 1 to 99 used to identify the individual lake sampled within a given year

Information contained for each surveyed lake (if measured) includes:

1. A diagram of the lake,
2. Other names utilized for the same lake,
3. Lake location, in latitude/longitude,
4. The USGS quadrangle sheet and the township and range in which the lake is situated
5. Habitat classification,
6. Surface area in acres, obtained from USGS digital maps,
7. Maximum depth in feet,
8. Presence or absence of an outlet,
9. pH,
10. Calculated lake volume and volume of water permitted for winter withdrawal,
11. Water chemistry measurements,
12. Catch record, including gear used, date sampled, species caught and size range,
13. Where appropriate data exist, the length frequency of dominant species is plotted,
14. The depth distribution based on bathymetric transects that were recorded.

Five different lake types are defined, based primarily on the potential for access by fish. Definitions for the lake types are as follows:

Perched (Frequent Flooding) = Perched lake near a floodplain, but above the water surface elevation of the active channel, with an obvious high water channel. These lakes are likely subject to annual flooding.

Perched (Infrequent Flooding) = Perched lake near a floodplain, but above the water surface elevation of the active channel, with no obvious high water channel. These lakes are likely subject to flooding on an infrequent basis (every five years or more).

Drainage = Drainage Lake, a lake that is part of a defined drainage system, i.e. there is an active connection to a creek.

Oxbow = Oxbow lake, formed from abandoned river channels.

Tundra = Tundra Lake, a thaw lake not within or connected to a river drainage, little potential for fish access on a regular basis.

RESULTS AND DISCUSSION

A total of 26 lakes were evaluated as water sources in 2001-2002 for the Puviaq Exploration Prospect in NPR-A (Table 1).

Biological Observations

Twenty of the 26 evaluated lakes were sampled for fish in 2002 (Table 2). Broad whitefish, least cisco, arctic grayling and lake trout were captured by gill net in the Puviaq area lakes, which was consistent with earlier reports from the region (Netsch et al. 1977, Bendock and Burr 1984, 1985). Ninespine stickleback were also caught in minnow traps (Table 2). Length information is presented for each fish-bearing lake in the Lake Summaries.

Water Chemistry Measurements

Water chemistry parameters measured in the studied lakes are presented Table 3. Mean water temperatures during the summer 2002 survey ranged as follows:

2002 (Jul 18 to Aug 3, 2002): 15.0°C (range: 10.3 to 18.9°C).

Dissolved oxygen was high, averaging 96.0% saturation. The observed frequency of specific conductance and pH values from surveyed lakes are graphed in Figure 8.

Evaluation of Fish Concerns

Information from fish sampling and depth measurements was used to evaluate each lake regarding its potential to support fish. Obviously, if fish were captured during gill net sampling, the lake was classified as fish-bearing. Gill net sets were relatively short, however, so absence of catch does not necessarily mean a lake does not support fish. Lakes also were assessed for their proximity to fish-bearing streams and their depth. Lakes deeper than 7 feet are likely to retain unfrozen water during winter, thus have potential to overwinter fish. Deep lakes that are near fish-bearing streams and are likely to have a connection with the stream at some point during the year are classified as potential fish-bearing lakes, with additional sampling needed if further clarification of the designation is desired. Results of the evaluation are included in Table 4.

Lakes in which fish were verified as present are divided into those lakes containing species sensitive to habitat changes likely to be associated with water withdrawal and those containing species more resistant to such changes. Species sensitive to impacts of water withdrawal (such as reduced dissolved oxygen and increased dissolved solids) include broad whitefish, least cisco and arctic grayling, while the more resistant species are Alaska blackfish and ninespine stickleback. Alaska blackfish are particularly resistant to low dissolved oxygen, being able to breathe atmospheric oxygen (Armstrong 1994). Residents of the Yukon Delta have reported observing Alaska blackfish oriented along cracks in the ice during winter to use oxygen in ponds that have gone anoxic. Ninespine stickleback can also withstand low dissolved oxygen (Lewis et al. 1972), although not the same extent as Alaska blackfish. Ninespine stickleback, however, can withstand higher levels of dissolved solids, and often frequent brackish nearshore waters during summer.

When sensitive fish are present, the amount of water available during winter is limited to 15% of the volume under 7 feet of ice. The water withdrawal criteria are relaxed when only resistant fish species are present because of the greater tolerance to lower dissolved oxygen and higher concentrations of dissolved solids. In this case, up to 30% of the water volume under 5 feet of ice is allowed for winter withdrawal. For lakes that do not contain fish, there is currently no limit to the amount taken. For practical reasons, the volume available is limited to the volume of unfrozen water under the ice at the time of withdrawal. In most cases, the withdrawal occurs when the ice is 4 feet thick or greater. In order to provide some estimate of water likely to be available, the volume of water under 4 feet of ice is provided.

Based on the above lake evaluation, 19 lakes were confirmed to contain fish. Three additional lakes (M0218, M0223 and M0227) were not sampled because they were connected to streams or other fish-bearing lakes, and are assumed to support fish. Four additional lakes where fish were not caught (M0183, M0184, M0214, M0225) were large, deep lakes capable of supporting fish and are listed as potential fish-bearing lakes. Only lake, M0208, appeared to be marginal fish habitat and ninespine stickleback were observed in this lake.

The area covered by water less than 4 feet deep, and therefore likely to be suitable for removing ice aggregate, was estimated for each lake (Table 5). A map of the potential ice aggregate area for each lake is included in the individual lake summaries. On average, about 20% of the lake surface was

less than 4 feet deep, although the range was considerable, from 3% to over 50%.

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Table 1. Summary of lakes sampled near the Puviaq prospect in 2001-2002.

Lake Name	Latitude (NAD27)	Longitude	Town	Range	Section	Surface Area (acres)	Maximum Depth (feet)	Calculated Volume (mill. gals)
M0183	70.66340	154.38674	15N	10W	11/14	154.5	12.0	201.43
M0184	70.65389	154.40628	15N	10W	14/15	34.6	8.5	96.97
M0205	70.71619	154.46110	16N	10W	28	66.3	18.8	212.99
M0206	70.71742	154.44535	16N	10W	22/27/28	63.5	19.5	168.77
M0207	70.69921	154.46877	16N	10W	33	26.1	14.5	81.84
M0208	70.71438	154.40377	16N	10W	26	14.8	6.5	21.00
M0209	70.70470	154.44010	16N	10W	27/34	159.3	10.0	236.79
M0210	70.68952	154.45541	15/16N	10W	3/4/33/34	43.4	11.4	64.57
M0211	70.68345	154.43421	15N	10W	3	87.0	11.0	203.66
M0212	70.66885	154.47374	15N	10W	9	43.6	21.3	112.36
M0213	70.66184	154.45214	15N	10W	10/15	38.2	18.4	71.24
M0214	70.65837	154.50146	15N	10W	16/17	162.0	18.1	184.84
M0215	70.64890	154.50451	15N	10W	16/17/20/21	219.1	23.2	415.91
M0216	70.68594	154.34159	15/16N	10W	1/36	100.4	12.3	191.73
M0217	70.98999	156.07586	19N	16W	15/16/21/22	614.4	6.9	1146.16
M0218	70.85979	154.99490	17/18N	12W	3/34	717.2	7.5	872.73
M0219	70.83651	154.91172	17N	12W	12	129.6	9.8	245.75
M0220	70.77225	154.72461	16N	11W	4	51.6	13.3	106.92
M0221	70.79351	154.87590	17N	11W	30/31	452.1	17.6	586.36
M0222	70.73958	154.64887	16N	11W	14	82.9	17.5	98.89
M0223	70.73466	154.64712	16N	11W	14	171.2	23.5	183.55
M0224	70.68161	154.52934	15N	10W	5	99.5	20.8	156.24
M0225	70.71254	154.55209	16N	10W	30	65.7	22.2	120.25
M0226	70.76575	154.64938	16N	11W	2	217.8	14.3	309.11
M0227	70.75505	154.76386	16N	11W	8	237.4	16.5	433.58
M0228	70.76083	154.79281	16N	11W	5/7/8	274.5	16.7	331.25

Table 2. Catches of fish from lakes sampled near the Puviaq prospect in 2002.

Lake Name	Sample Date	Gill Nets		Minnow Traps		Seine and Observation	
		Set Duration (hours)	Fish Species ¹	Set Duration (hours)	Fish Species ²	Number of Hauls	Fish Species ²
M0205	Jul 18 02	1.3	LSCS	2.2	None	0	NSSB observed
M0206	Jul 18 02	2.2	LSCS	3.0	None	0	NSSB observed
M0207	Jul 18 02	1.4	LSCS	2.3	None	0	
M0208	Jul 19 02	0.0	None	0.0		0	NSSB observed
M0209	Jul 19 02	10.0	None	6.7	None	0	NSSB observed
M0210	Jul 19 02	8.3	BDWF	4.4	None	0	NSSB observed
M0211	Jul 20 02	1.5	BDWF, LSCS	3.2	NSSB	0	
M0212	Jul 20 02	3.8	BDWF, LSCS	2.8	None	0	
M0213	Jul 20 02	0.9	BDWF, LSCS	1.5	None	0	
M0214	Jul 20 02	11.0	None	4.2	None	0	
M0215	Jul 21 02	5.7	LKTR, LSCS	4.0	None	0	NSSB observed
M0216	Jul 21 02	0.5	LSCS	2.2	None	0	
M0217	Jul 29 02	3.7	LSCS, GRAY	0.0		0	
M0218	Jul 30 02	(not sampled, connected to river)		0.0		0	
M0219	Jul 30 02	2.8	LSCS	0.0		0	
M0220	Jul 31 02	2.1	None	0.0		0	NSSB observed
M0221	Jul 31 02	5.2	BDWF, LSCS	0.0		0	
M0222	Aug 01 02	2.5	BDWF, LSCS	0.0		0	
M0223	Aug 01 02	(not sampled, connected to M0222)		0.0		0	
M0224	Aug 02 02	2.2	BDWF, LSCS	0.0		0	
M0225	Aug 02 02	1.4	None	0.0		0	
M0226	Aug 02 02	2.7	LSCS	0.0		0	
M0227	Aug 03 02	(not sampled, connected to drainag		0.0		0	
M0228	Aug 03 02	3.2	LSCS	0.0		0	

¹ BDWF = broad whitefish, LSCS = least cisco, GRAY = arctic grayling, LKTR = lake trout

² NSSB = ninespine stickleback

Table 3. Water chemistry parameters measured in conjunction with lake sampling in the Puviaq area, 2001-2002.

Lake	Date	Water Temp (oC)	Dissolved Oxygen		Specific Conductance (microS/cm)	pH	Turbidity (NTU)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)
			(mg/l)	(%)									
M0183	Nov 17 01	1.7	13.2	91	229	6.8	0.3	37.8	5.9	12.6	25.4	119	140
M0184	Nov 17 01	1.0	12.8	90	292	7.3	0.5	48.7	6.4	6.6	14.0	148	160
M0205	Jul 18 02	14.4	10.0	100	105	7.8	0.6	16.8	2.5	1.3	2.3	52.3	80
M0206	Jul 18 02	16.5	9.7	101	98	7.9	1.3	12.2	2.4	2.9	5.8	40.2	80
M0207	Jul 18 02	16.3			78	7.9	1.1	8.0	1.5	1.4	2.7	25.9	30
M0208	Jul 19 02	17.3	8.8	92	210	7.5	0.8	10.6	3.3	22.1	47.2	39.9	130
M0209	Jul 19 02	17.8	9.1	96	71	7.6	0.6	7.6	1.8	2.8	7.1	26.4	30
M0210	Jul 19 02	18.9			61	7.5	0.7	10.8	1.9	1.0	1.9	34.8	50
M0211	Jul 20 02	16.0	8.6	88	72	7.6	0.9	9.0	1.6	1.5	3.1	29.2	30
M0212	Jul 20 02	16.8			147	8.0	0.7	20.3	3.5	2.9	6.1	65.2	90
M0213	Jul 20 02	17.8	9.1	95	150	8.1	0.8	20.3	3.4	3.2	6.7	64.8	110
M0214	Jul 20 02	18.0	9.5	100	170	8.2	0.6	24.4	3.8	3.0	6.1	76.4	80
M0215	Jul 21 02	16.2	9.1	96	230	8.1	0.2	32.5	3.5	5.2	12.6	95.4	140
M0216	Jul 21 02	17.6	8.6	89	198	8.0	1.1	15.0	3.7	13.9	29.7	52.7	80
M0217	Jul 29 02	10.6	11.1	99	150	7.5	6.0	4.8	3.0	13.9	36.6	24.5	
M0218	Jul 30 02	10.3	10.6	94	249	7.9	5.8	21.6	5.5	16.8	34.1	75.4	
M0219	Jul 30 02	12.0	10.6	99	304	7.9	2.0	23.5	6.0	24.1	49.6	83.6	
M0220	Jul 31 02	11.3	10.8	99	317	8.0	1.1	38.5	7.0	32.6	75.0	124.9	
M0221	Jul 31 02	12.2	10.8	98	263	8.0	1.3	27.4	5.1	16.1	32.2	89.5	
M0222	Aug 01 02	14.0			149	8.0	2.1	22.4	3.6	2.4	4.4	70.9	
M0223	Aug 02 02	13.1			151	8.0	1.7	22.8	3.6	2.5	4.6	71.5	
M0224	Aug 02 02	13.2			185	8.0	1.0	28.0	4.6	3.3	6.1	88.8	110
M0225	Aug 02 02	14.3			255	8.2	0.5	39.2	6.6	4.4	8.4	125.1	130
M0226	Aug 02 02	15.1			191	7.9	0.3	23.4	4.3	7.6	18.5	76.2	100
M0227	Aug 03 02	14.5			301	8.3	1.2	43.1	7.3	9.2	23.7	137.4	160
M0228	Aug 03 02	15.5			303	8.3	2.3	44.9	6.6	9.5	23.2	139.3	150

Table 4. Estimated water volumes available for winter withdrawal from surveyed lakes near the Puviaq prospect in 2001-2002

(available water based on 15% of winter volume deeper than 7 ft when sensitive species are present, 30% of winter volume deeper than 5 ft when only resistant fish are likely to be present).

Lake	Surface Area (acres)	Max. Depth (feet)	Calculated Volume (mil. gals)	Sensitive Fish Species Present ¹	Resistant Fish Species Present ²	15% of 7 ft Winter Volume (mil. gals)	30% of 5 ft Winter Volume (mil. gals)	4 ft Winter Volume (mil. gals)	Available Water (mil. gals)
M0183	155	12.0	201.43	not sampled	not sampled	2.19			2.19
M0184	35	8.5	96.97	not sampled	not sampled	0.08			0.08
M0205	66	18.8	212.99	LSCS	NSSB	9.02			9.02
M0206	63	19.5	168.77	LSCS	NSSB	6.29			6.29
M0207	26	14.5	81.84	LSCS	not detected	3.13			3.13
M0208	15	6.5	21.00	not sampled	NSSB	0.00	0.31		0.31
M0209	159	10.0	236.79	none caught	NSSB	1.44	12.21		12.21
M0210	43	11.4	64.57	BDWF	NSSB	0.40			0.40
M0211	87	11.0	203.66	BDWF, LSCS	NSSB	5.16			5.16
M0212	44	21.3	112.36	BDWF, LSCS	not detected	4.10			4.10
M0213	38	18.4	71.24	BDWF, LSCS	not detected	2.20			2.20
M0214	162	18.1	184.84	none caught	not detected	3.96	15.97	90.48	no limit
M0215	219	23.2	415.91	LKTR, LSCS	not detected	15.01			15.01
M0216	100	12.3	191.73	LSCS	not detected	4.37			4.37
M0217	1146	6.9	1146.16	LSCS, GRAY	not detected	0.00			0.00
M0218	873	7.5	872.73	not sampled	not detected	0.00			0.00
M0219	246	9.8	245.75	LSCS	not detected	2.20			2.20
M0220	107	13.3	106.92	none caught	NSSB	2.71	11.34		11.34
M0221	586	17.6	586.36	BDWF, LSCS	not detected	13.07			13.07
M0222	99	17.5	98.89	BDWF, LSCS	not detected	2.62			2.62
M0223	184	23.5	183.55	not sampled	not detected	3.79			3.79
M0224	156	20.8	156.24	BDWF, LSCS	not detected	6.64			6.64
M0225	120	22.2	120.25	none caught	not detected	6.98			6.98
M0226	309	14.3	309.11	LSCS	not detected	10.33			10.33
M0227	434	16.5	433.58	not sampled	not detected	24.82			24.82
M0228	331	16.7	331.25	LSCS	not detected	6.78			6.78

¹ BDWF = broad whitefish, LSCS = least cisco, LKTR = lake trout

² NSSB = ninespine stickleback

³ No = lake does not represent fish habitat, Yes = fish present during survey, Y? = fish not caught but lake has potential to be fish habitat.

Table 5. Estimated area available for removing ice aggregate, based on the area covered by water shallower than 4 feet, Puviaq prospect in 2002.

Lake	Surface Area (acres)	Max. Depth (feet)	Acres covered by Water shallower 4 feet
M0205	66.3	18.8	6.3
M0206	63.5	19.5	12.1
M0207	26.1	14.5	2.4
M0208	14.8	6.5	4.6
M0209	159.3	10.0	80.0
M0210	43.4	11.4	20.2
M0211	87.0	11.0	12.9
M0212	43.6	21.3	9.9
M0213	38.2	18.4	17.9
M0214	162.0	18.1	32.2
M0215	219.1	23.2	98.9
M0216	100.4	12.3	35.1
M0217	1146.2	6.9	41.0
M0218	872.7	7.5	278.0
M0219	245.8	9.8	33.2
M0220	106.9	13.3	16.7
M0221	586.4	17.6	19.7
M0222	98.9	17.5	12.9
M0223	183.5	23.5	30.6
M0224	156.2	20.8	8.0
M0225	120.2	22.2	4.5
M0226	309.1	14.3	17.3
M0227	433.6	16.5	22.0
M0228	331.2	16.7	23.0

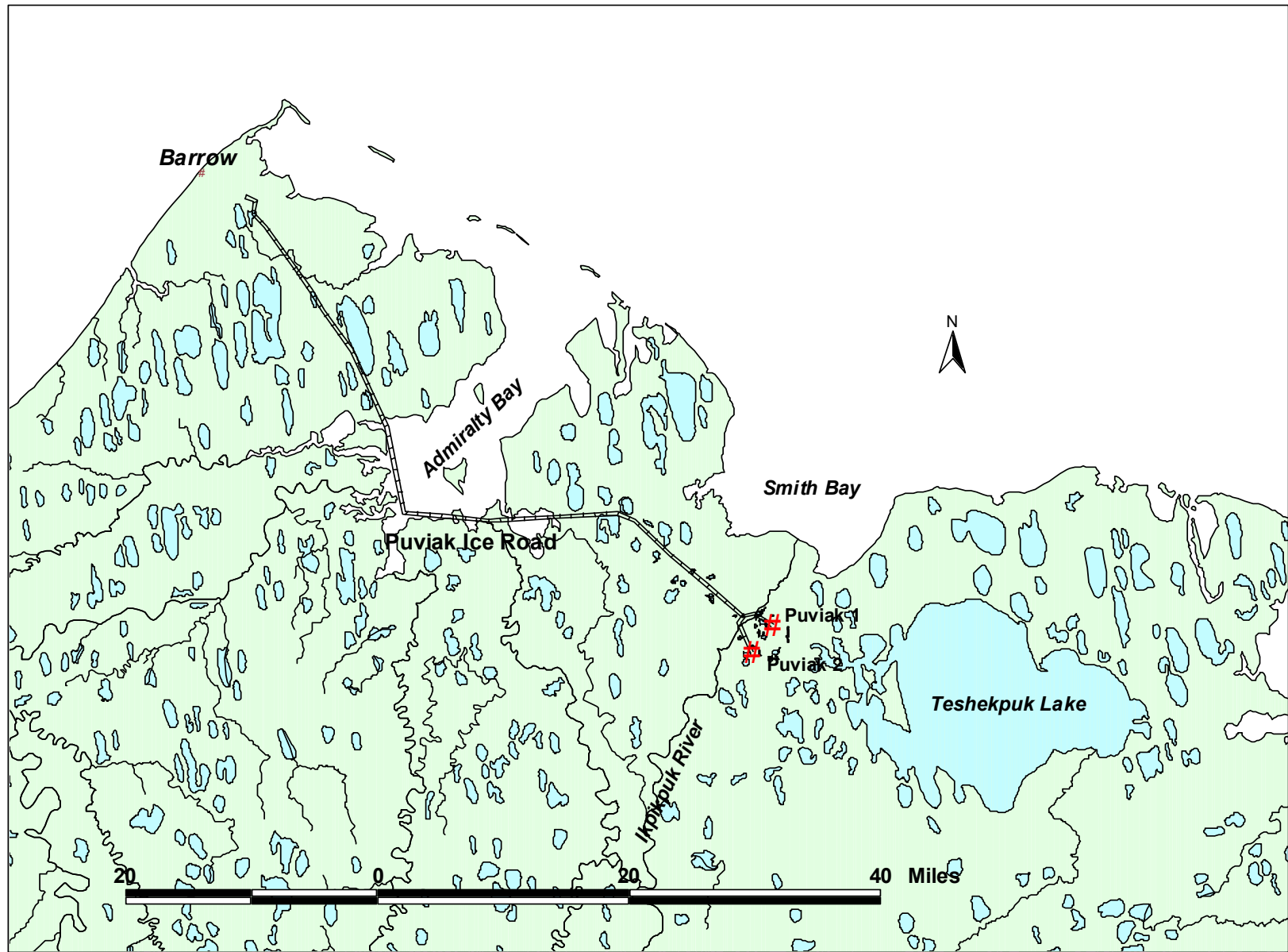


Figure 1. Potential Puviaq ice road linking Barrow with the Puviaq exploration prospects.

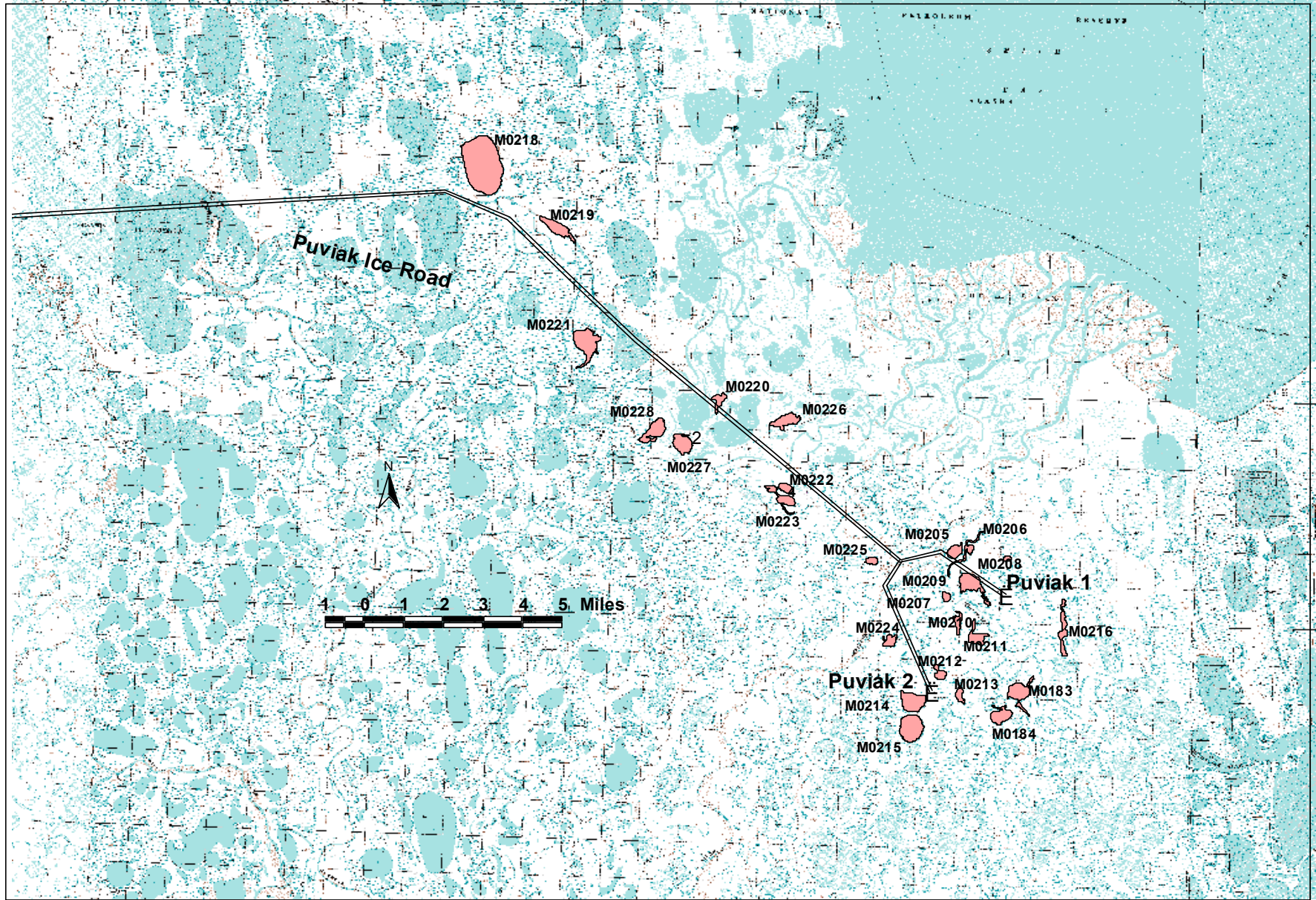


Figure 2. Lakes sampled for fish in the eastern Puvialq region during 2001-2002.

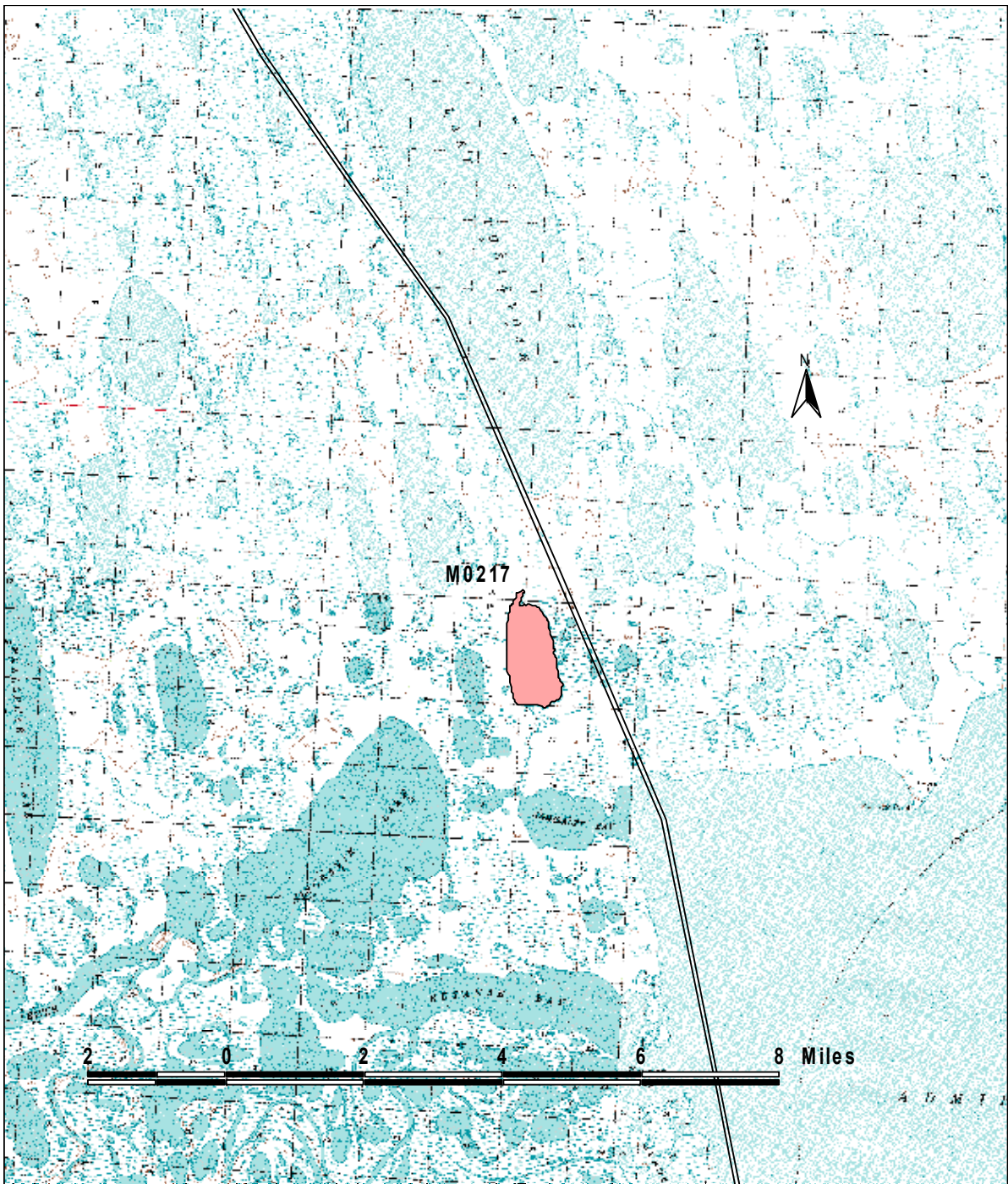


Figure 3. Lake sampled for fish along the western portion of the Puviaq ice road, 2002.

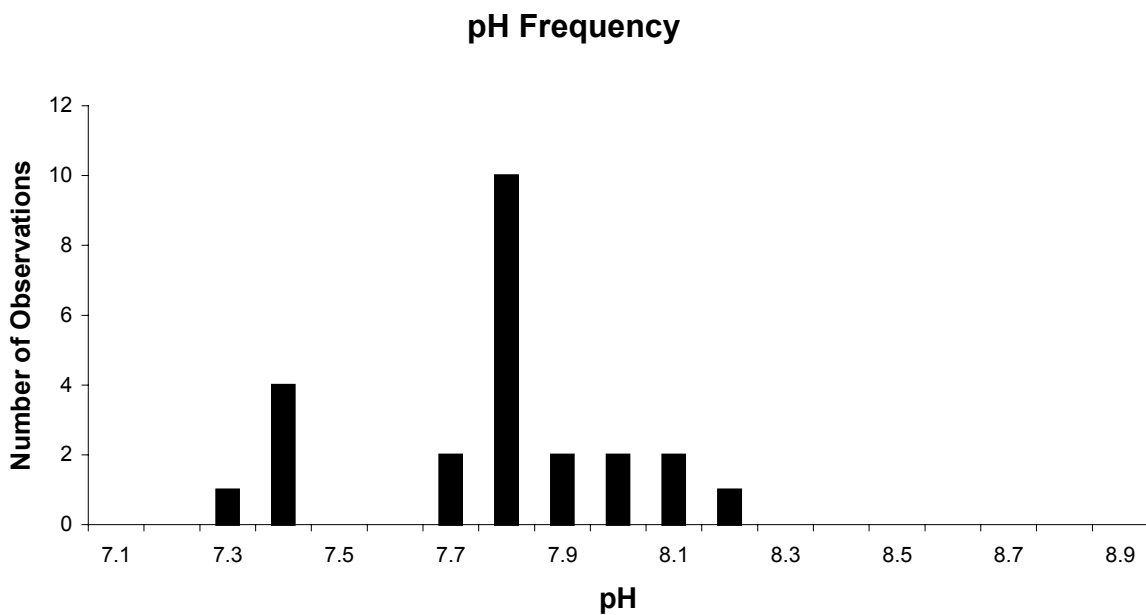
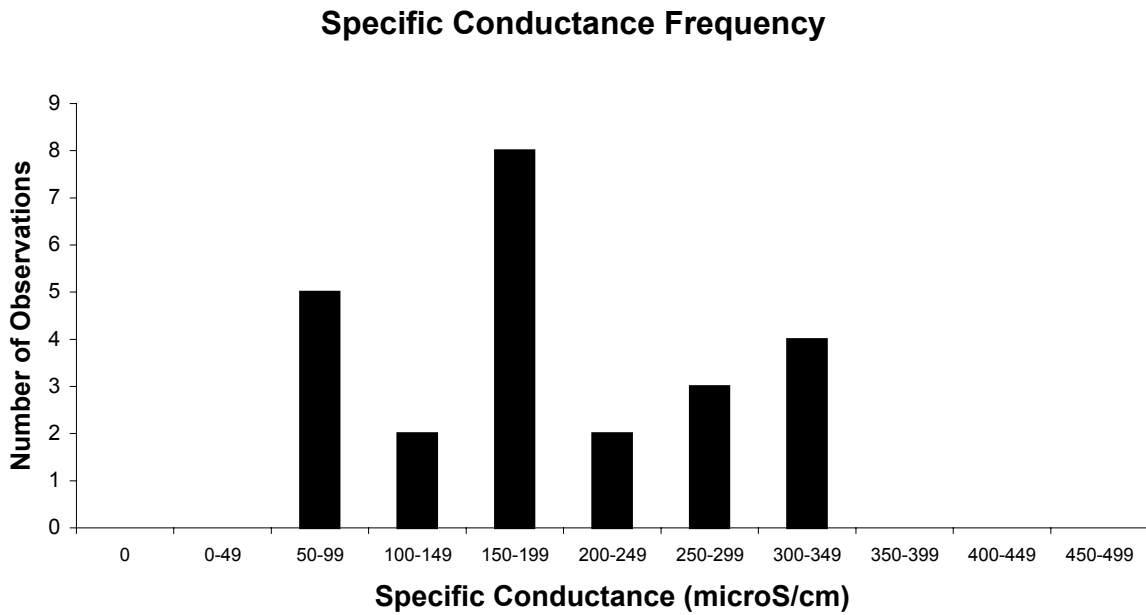
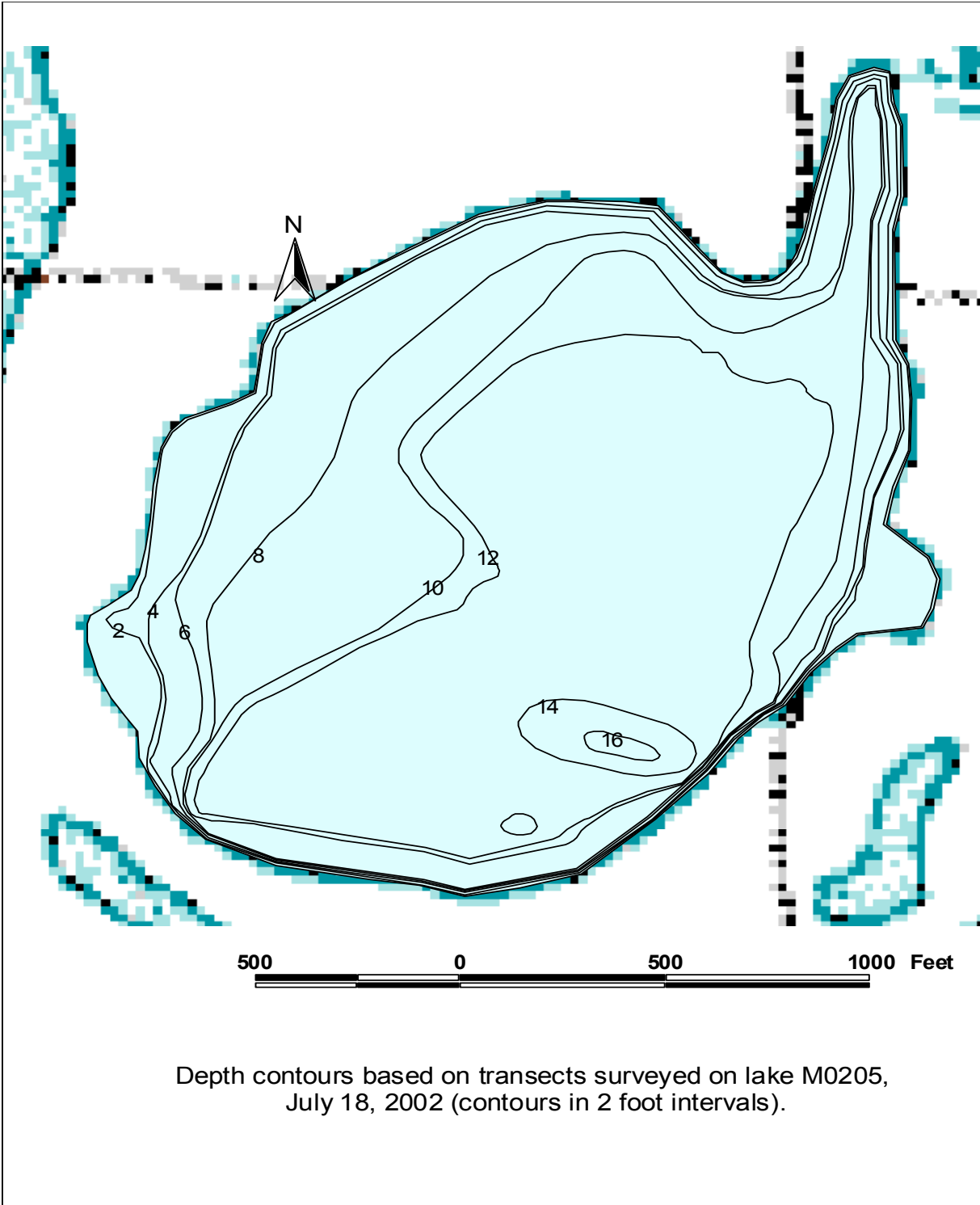


Figure 4. Frequency distribution of specific conductance and pH measurements taken during summer from 24 lakes near the Puviaq prospect, 2002.

Lake Summaries



Depth contours based on transects surveyed on lake M0205, July 18, 2002 (contours in 2 foot intervals).

Lake M0205

Other Names:

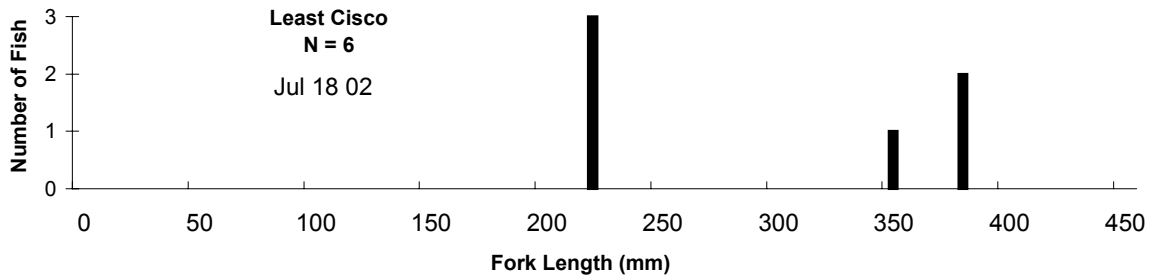
Location: 70° 42' 58.3"N 154° 27' 39.0"W
USGS Quad Sheet: T16N R10W, Sec. 28
Habitat:
Area: 66 acres
Maximum Depth: 18.8 feet
Active Outlet:
Turbidity: 0.63 NTU
Spec. Conductance: 105 µS/cm
pH: 7.8
Calculated Volume: 212.99 million gallons
Permittable Volume: 9.02 million gallons
Potential Aggregate: 6.28 acres (water depth 4 ft or less)

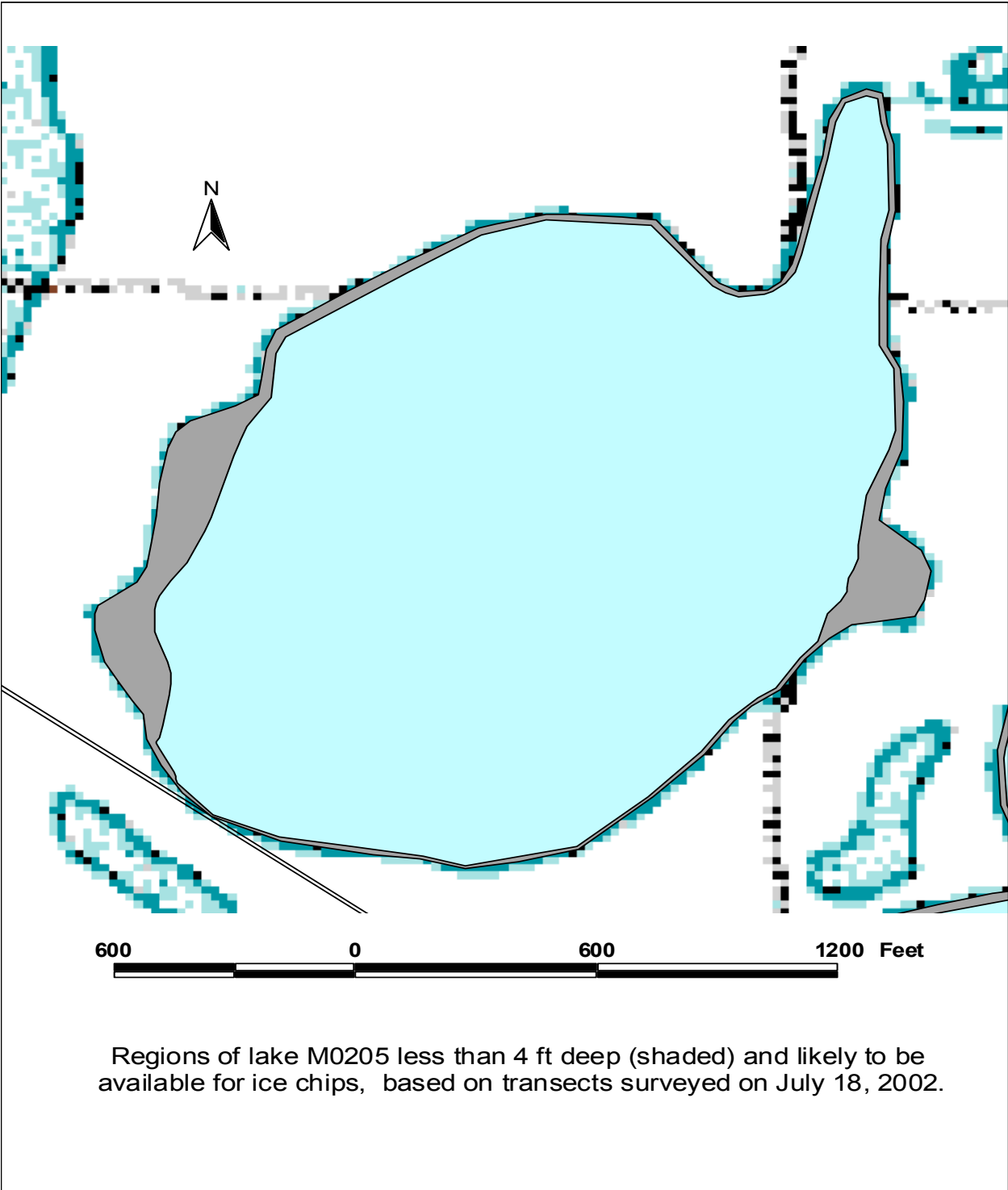
Water Quality:

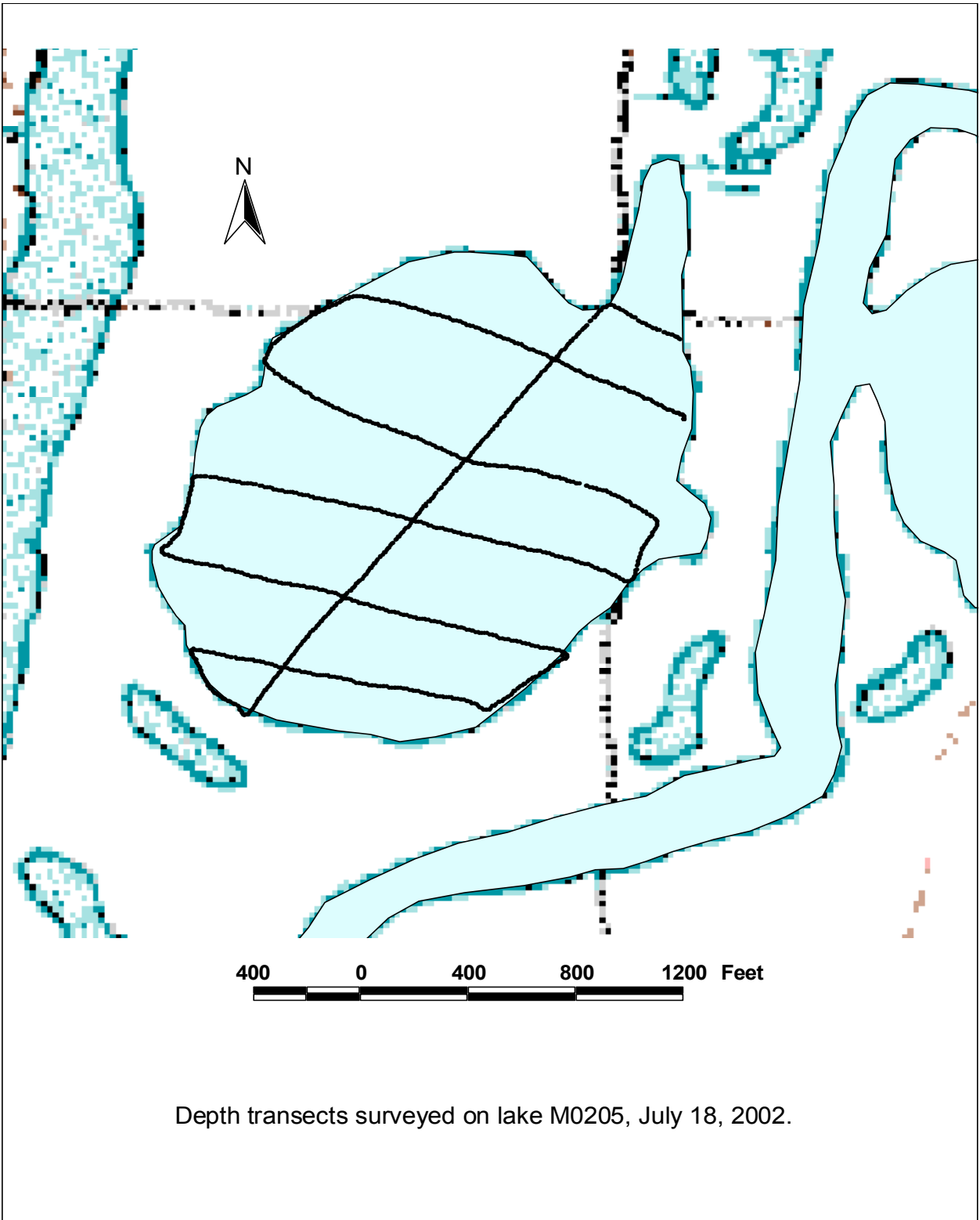
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	16.8	2.5	1.3	2.3	52	80	this study

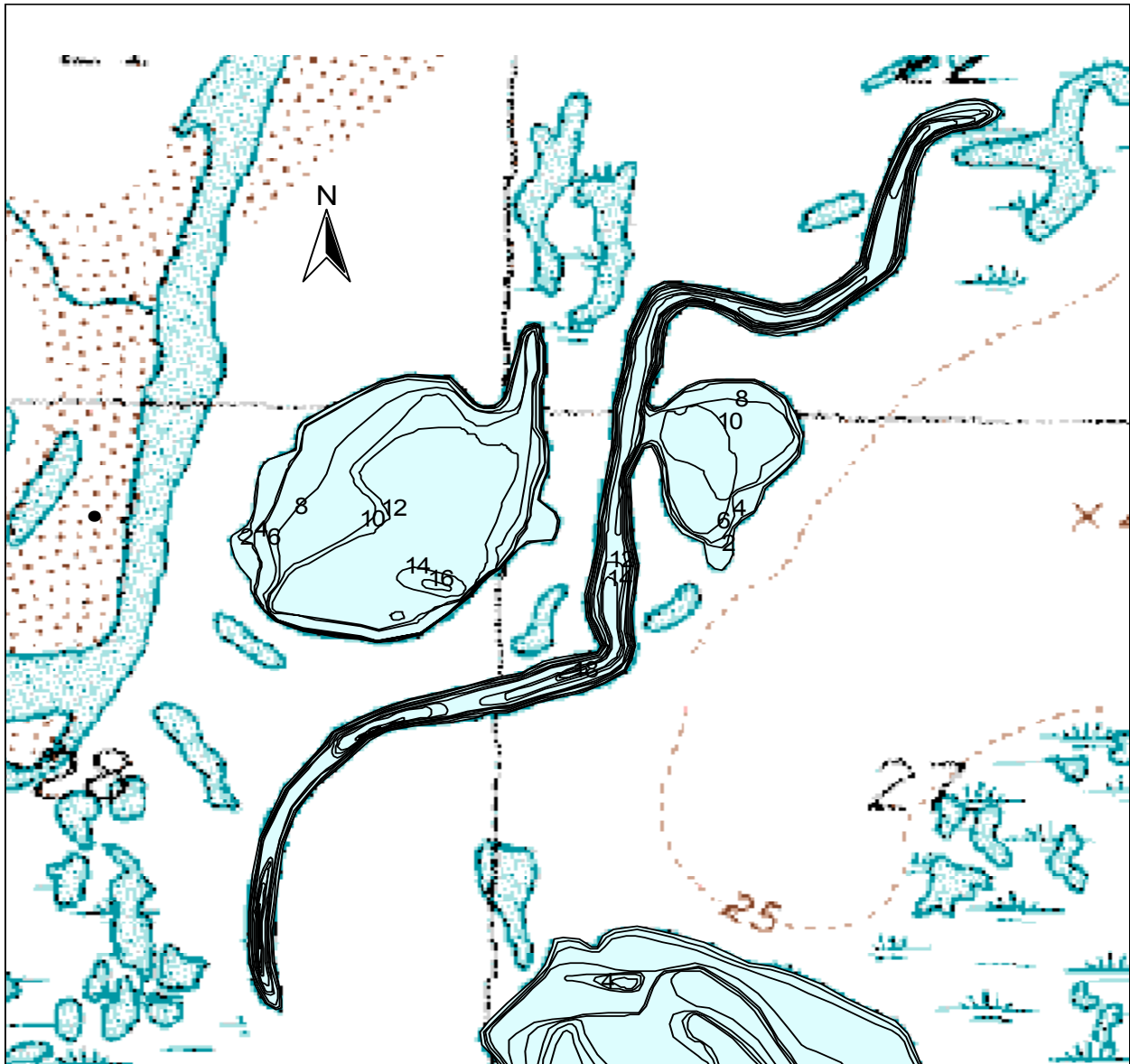
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 18 02	1.3	Least cisco	6	220-385
Minnow Trap	Jul 18 02	2.2	None	0	
Ninespine stickleback observed					









Depth contours based on transects surveyed on lake M0206, July 18, 2002 (contours in 2 foot intervals).

Lake M0206

Other Names:

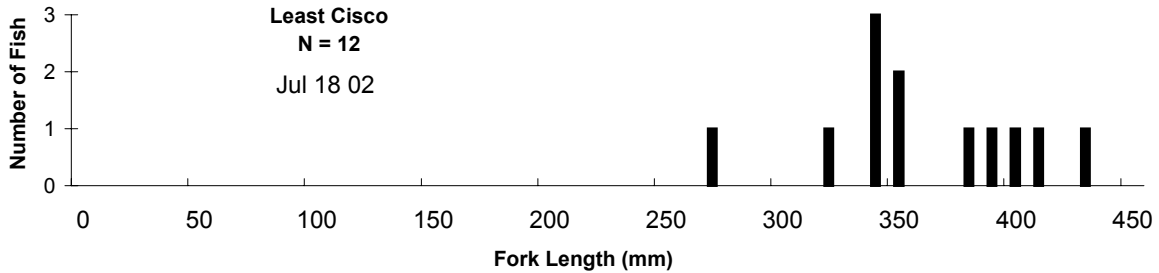
Location: 70° 43' 2.7"N 154° 26' 43.3"W
USGS Quad Sheet: T16N R10W, Sec. 22/27/28
Habitat:
Area: 63.5 acres
Maximum Depth: 19.5 feet
Active Outlet:
Turbidity: 1.3 NTU
Spec. Conductance: 97.7 μ S/cm
pH: 7.9
Calculated Volume: 168.77 million gallons
Permittable Volume: 6.29 million gallons
Potential Aggregate: 12.05 acres (water depth 4 ft or less)

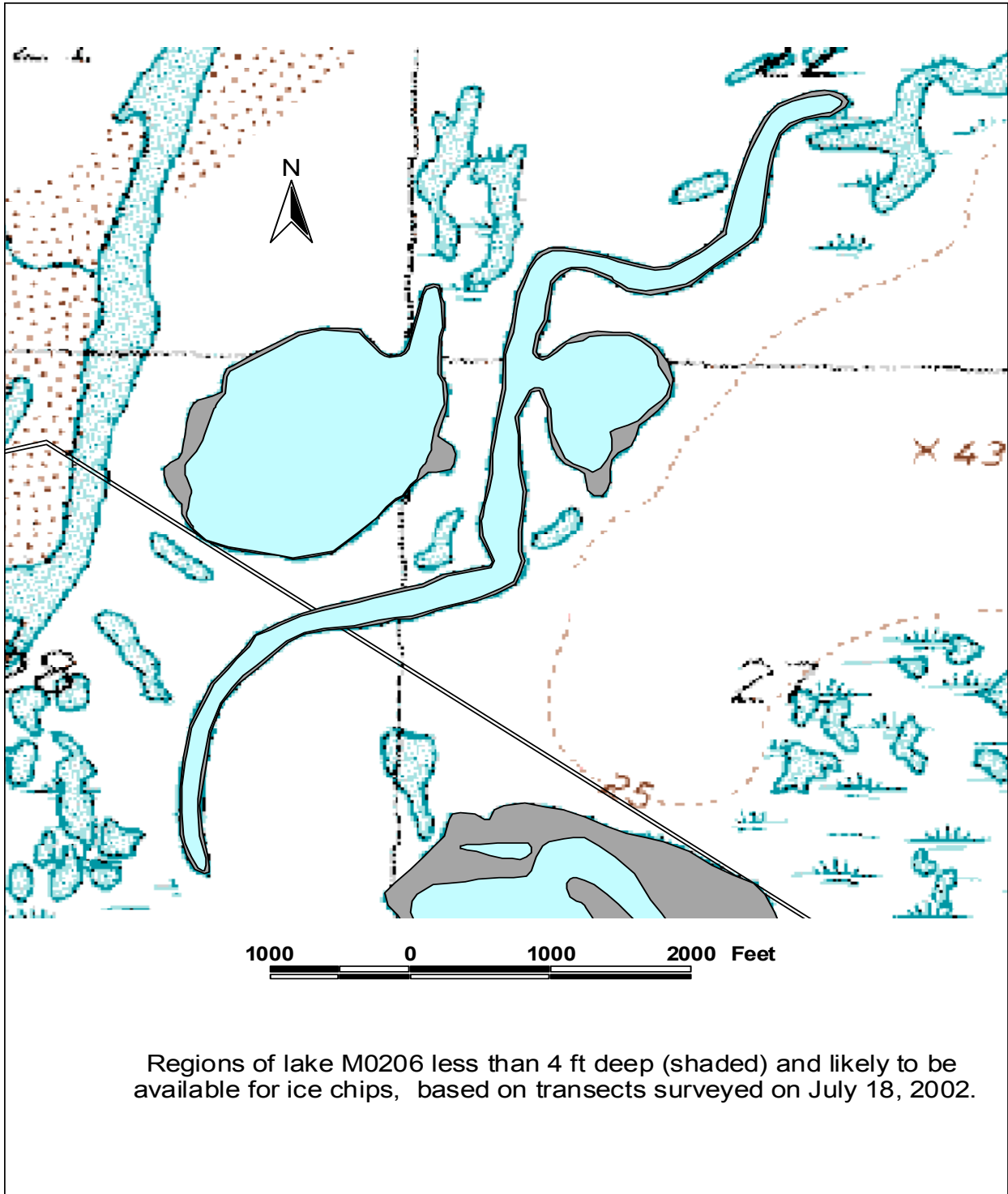
Water Quality:

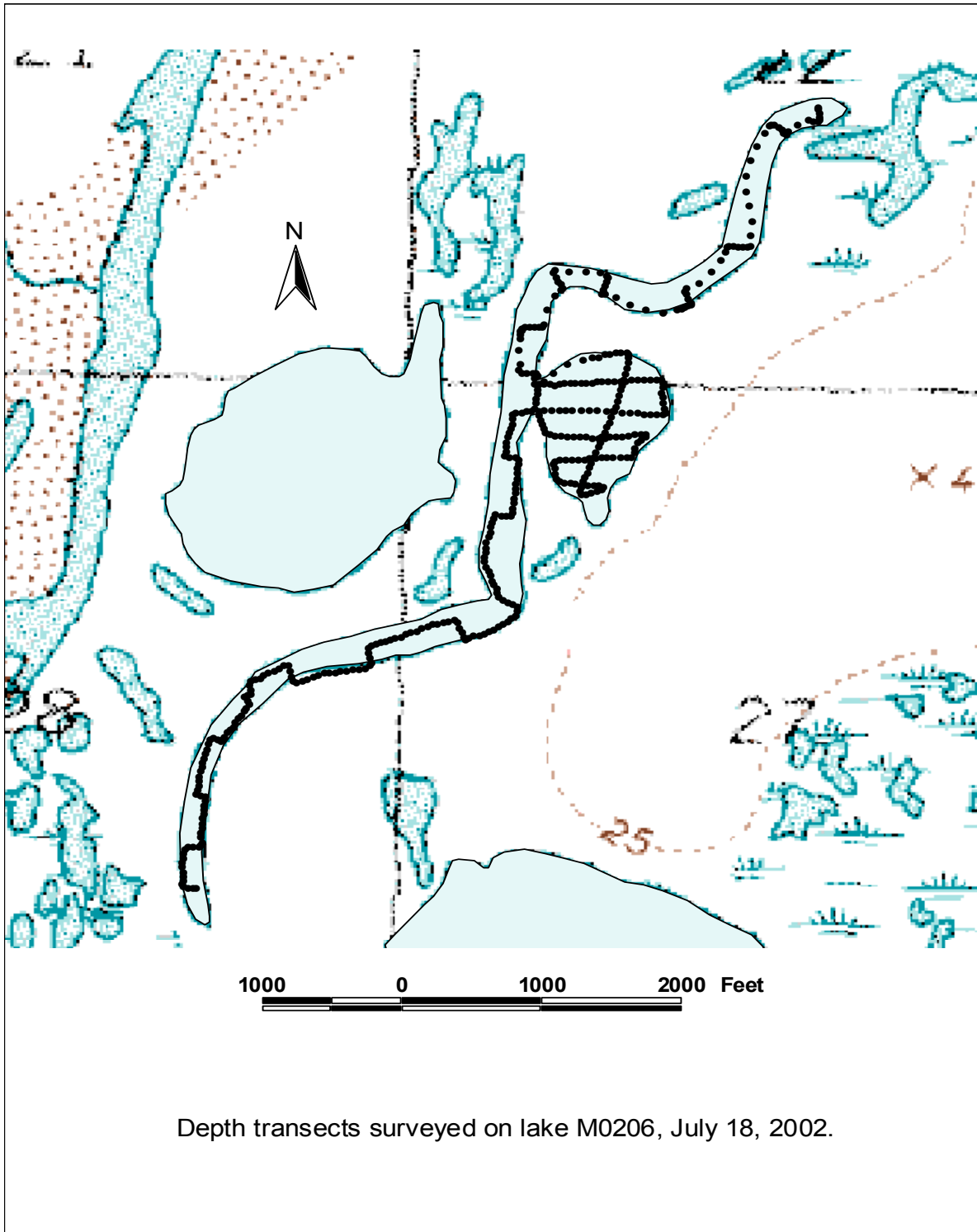
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	12.2	2.4	2.9	5.8	40	80	this study

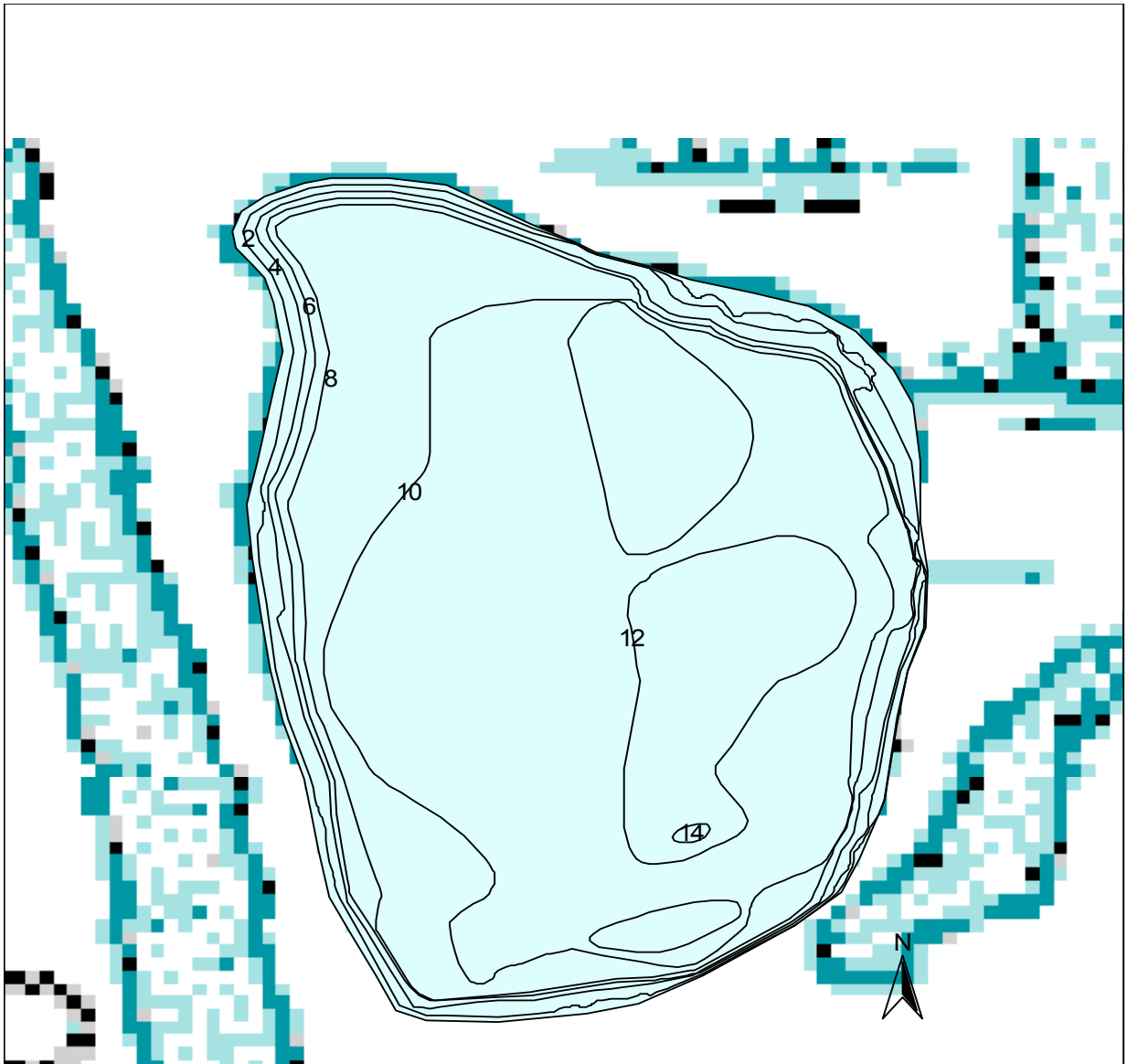
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 18 02	2.2	Least cisco	13	275-419
Minnow Trap	Jul 18 02	3.0	None	0	
			Ninespine stickleback observed		









200 0 200 400 600 Feet

Depth contours based on transects surveyed on lake M0207,
July 18, 2002 (contours in 2 foot intervals).

Lake M0207

Other Names:

Location: 70° 41' 57.2"N 154° 28' 7.6"W

USGS Quad Sheet: T16N R10W, Sec. 33

Habitat:

Area: 26.1 acres

Maximum Depth: 14.5 feet

Active Outlet:

Turbidity: 1.1 NTU

Spec. Conductance: 78.4 μ S/cm

pH: 7.9

Calculated Volume: 81.84 million gallons

Permittable Volume: 3.13 million gallons

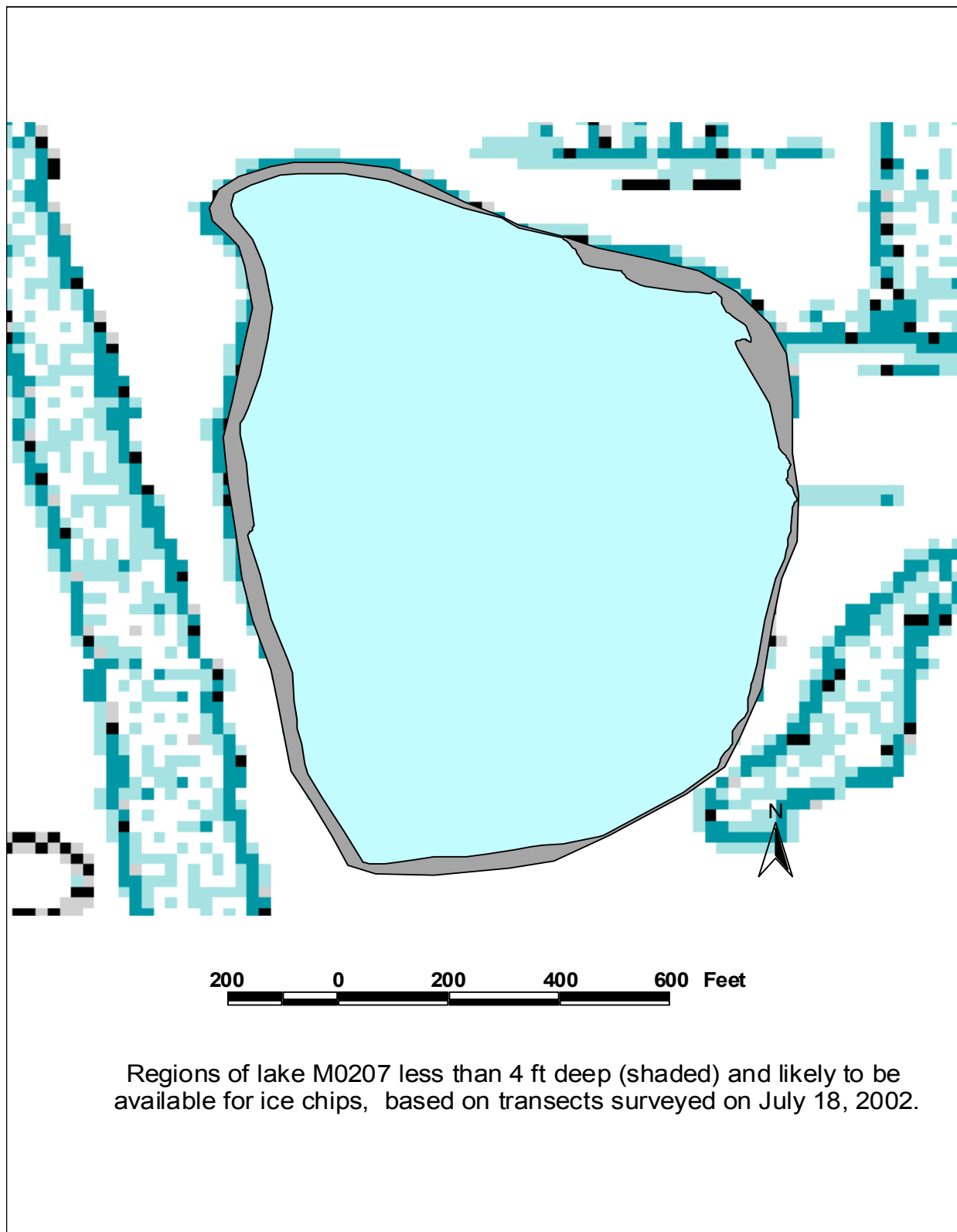
Potential Aggregate: 2.35 acres (water depth 4 ft or less)

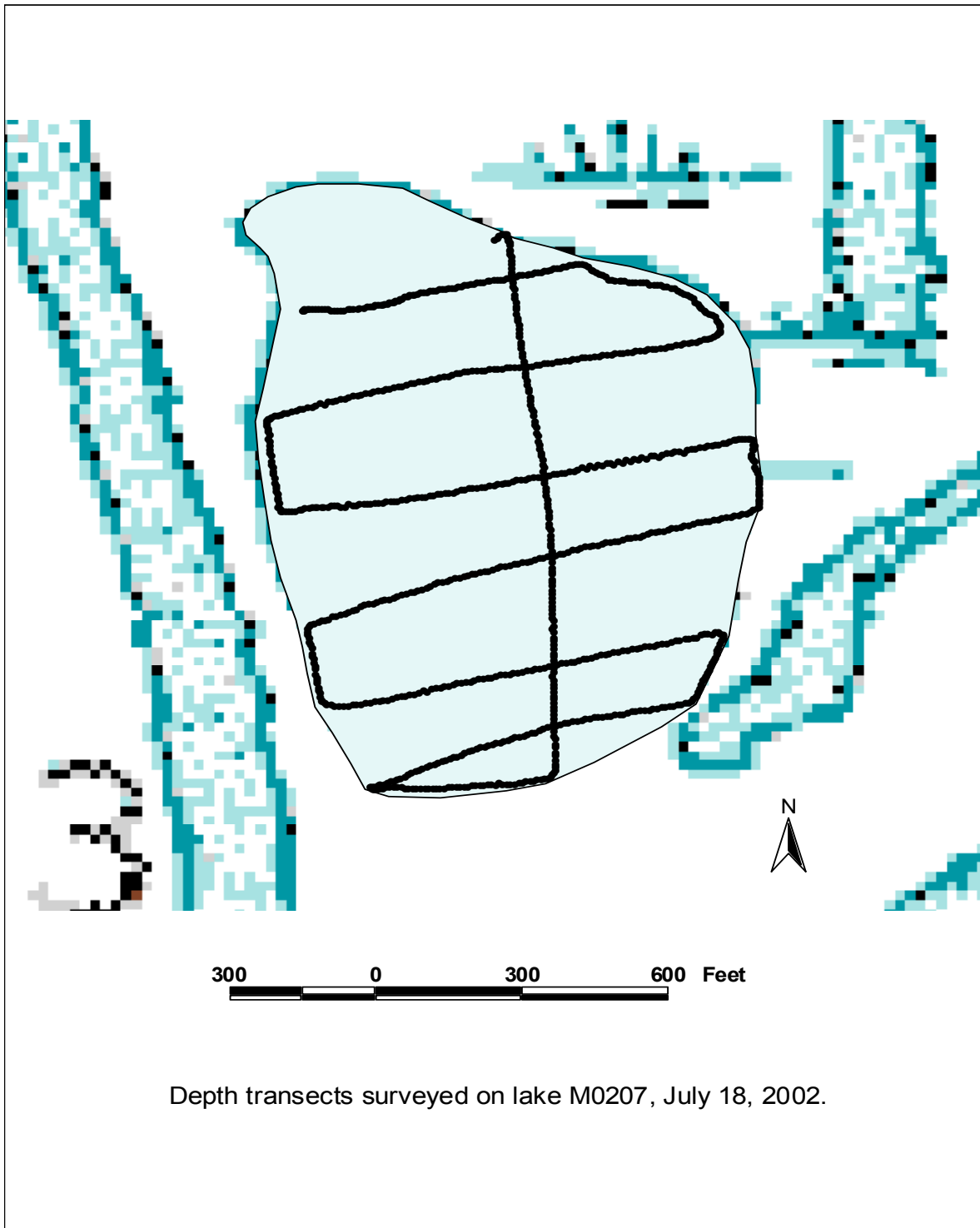
Water Quality:

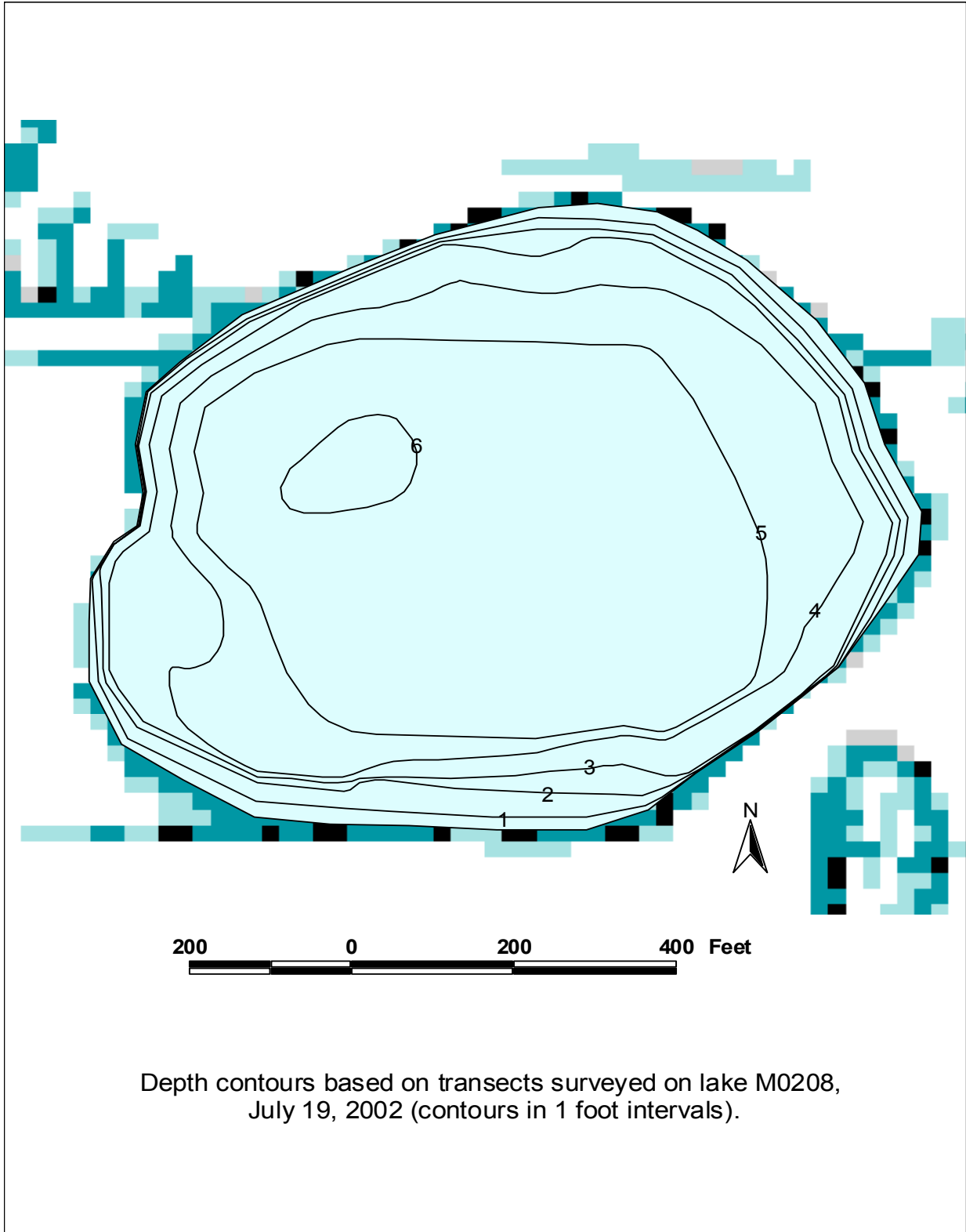
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	8.0	1.5	1.4	2.7	26	30	this study

Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 18 02	1.4	Least cisco	2	483-510
Minnow Trap	Jul 18 02	2.3	None	0	







Lake M0208

Other Names:

Location: 70° 42' 51.8"N 154° 24' 13.6"W

USGS Quad Sheet: T16N R10W, Sec. 26

Habitat:

Area: 14.8 acres

Maximum Depth: 6.5 feet

Active Outlet:

Turbidity: 0.8 NTU

Spec. Conductance 209.5 μ S/cm

pH: 7.5

Calculated Volume: 21.00 million gallons

Permittable Volume 0.31 million gallons

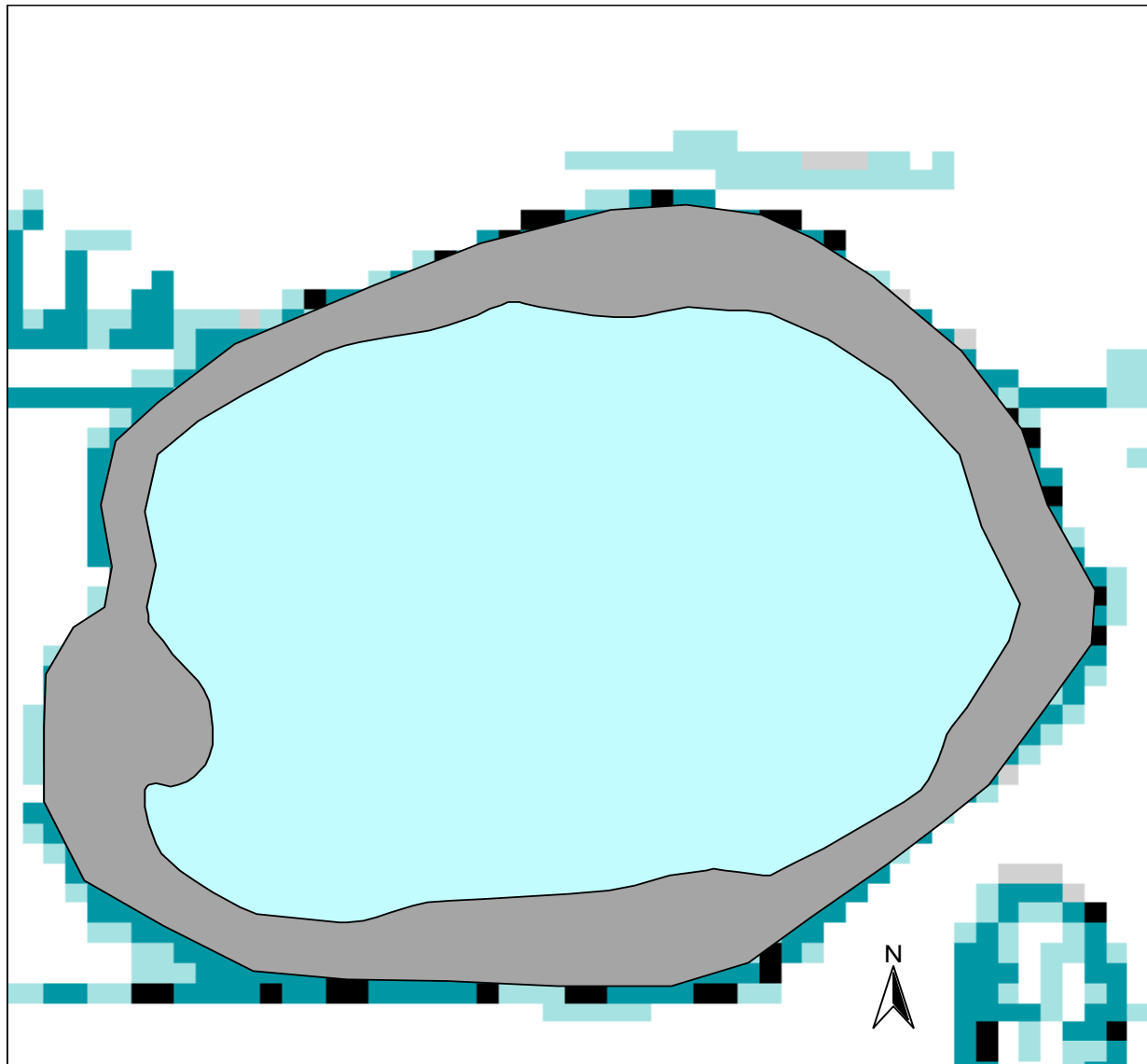
Potential Aggregate 4.64 acres (water depth 4 ft or less)

Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	10.6	3.3	22.1	47.2	40	130	this study

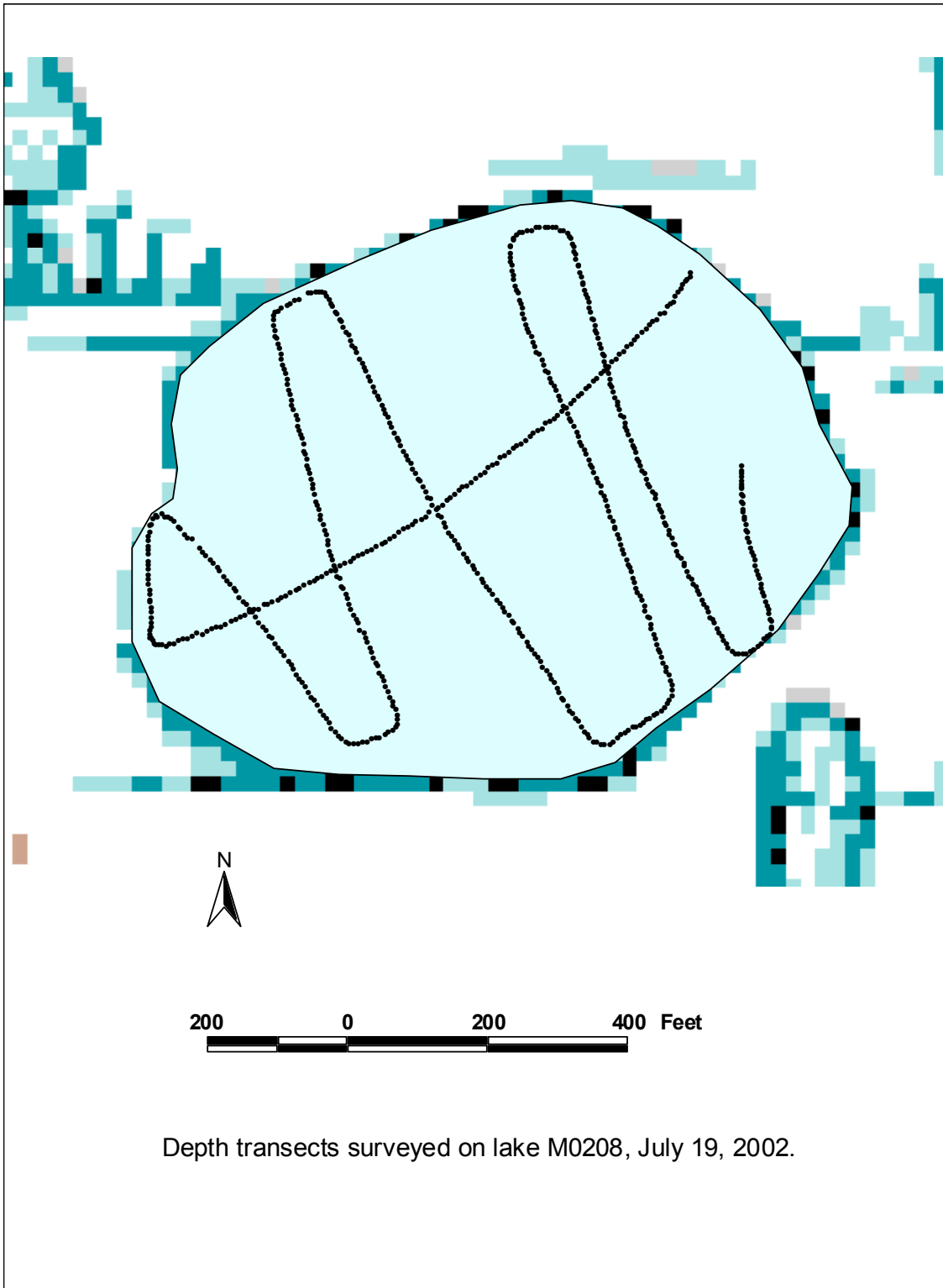
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
Ninespine stickleback observed				



200 0 200 400 Feet

Regions of lake M0208 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 19, 2002.





Depth contours based on transects surveyed on lake M0209, July 19, 2002 (contours on 1 foot intervals).

Lake M0209

Other Names:

Location: 70° 42' 16.9"N 154° 26' 24.4"W

USGS Quad Sheet: T16N R10W, Sec. 27/34

Habitat:

Area: 159.3 acres

Maximum Depth: 10.0 feet

Active Outlet:

Turbidity: 0.6 NTU

Spec. Conductance: 70.6 μ S/cm

pH: 7.6

Calculated Volume: 236.79 million gallons

Permittable Volume: 12.21 million gallons

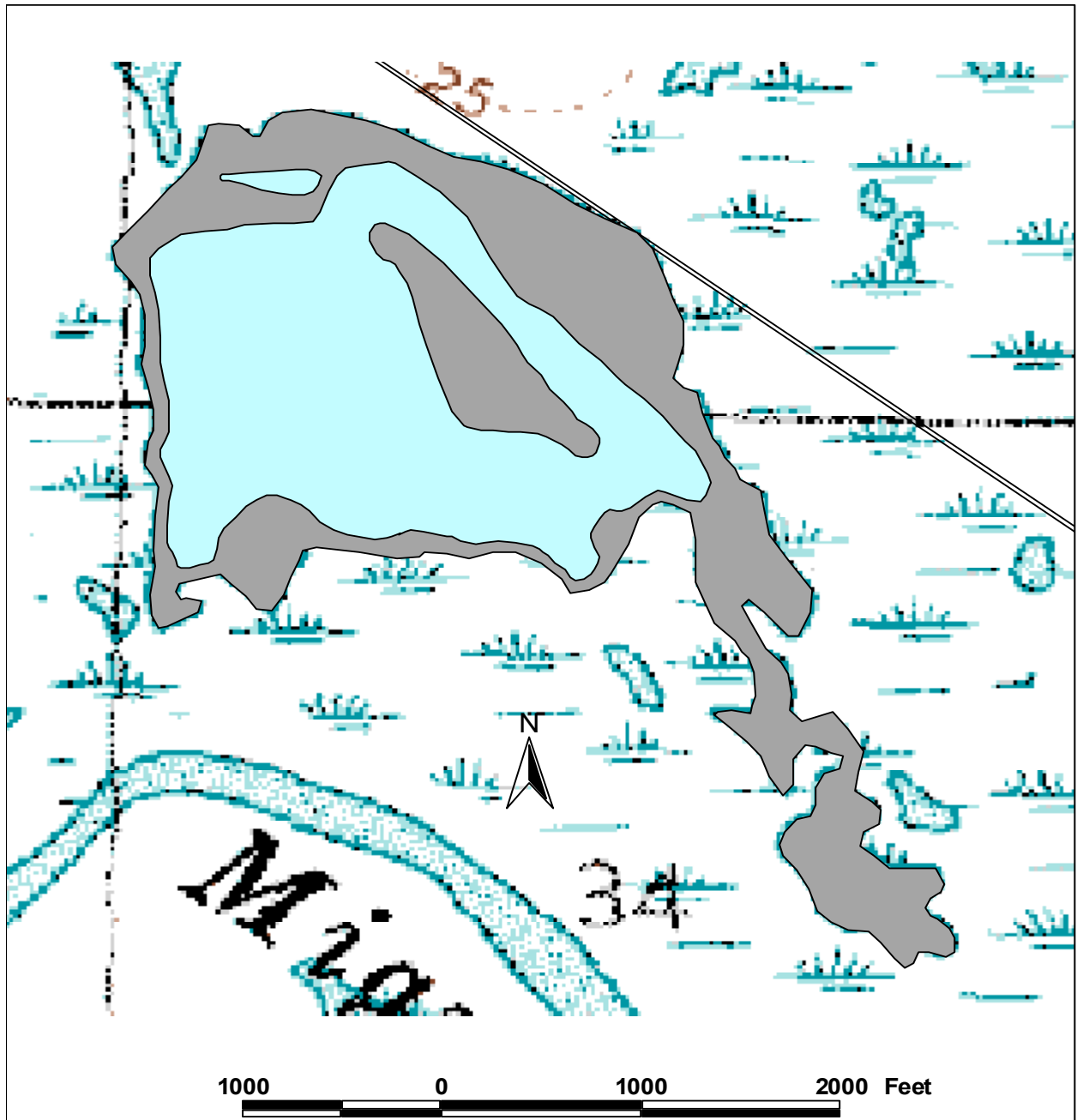
Potential Aggregate: 80.05 acres (water depth 4 ft or less)

Water Quality:

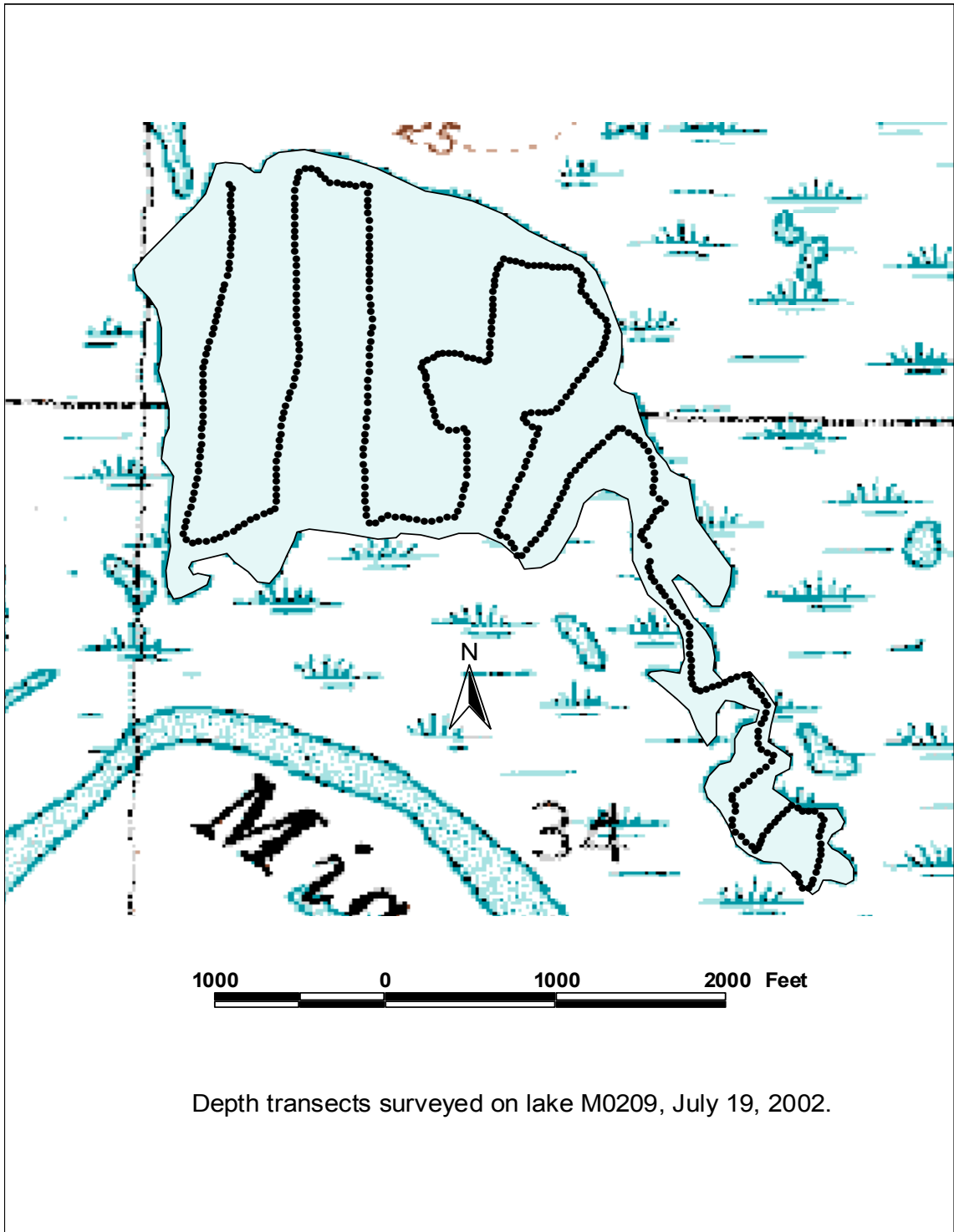
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	7.6	1.8	2.8	7.1	26	30	this study

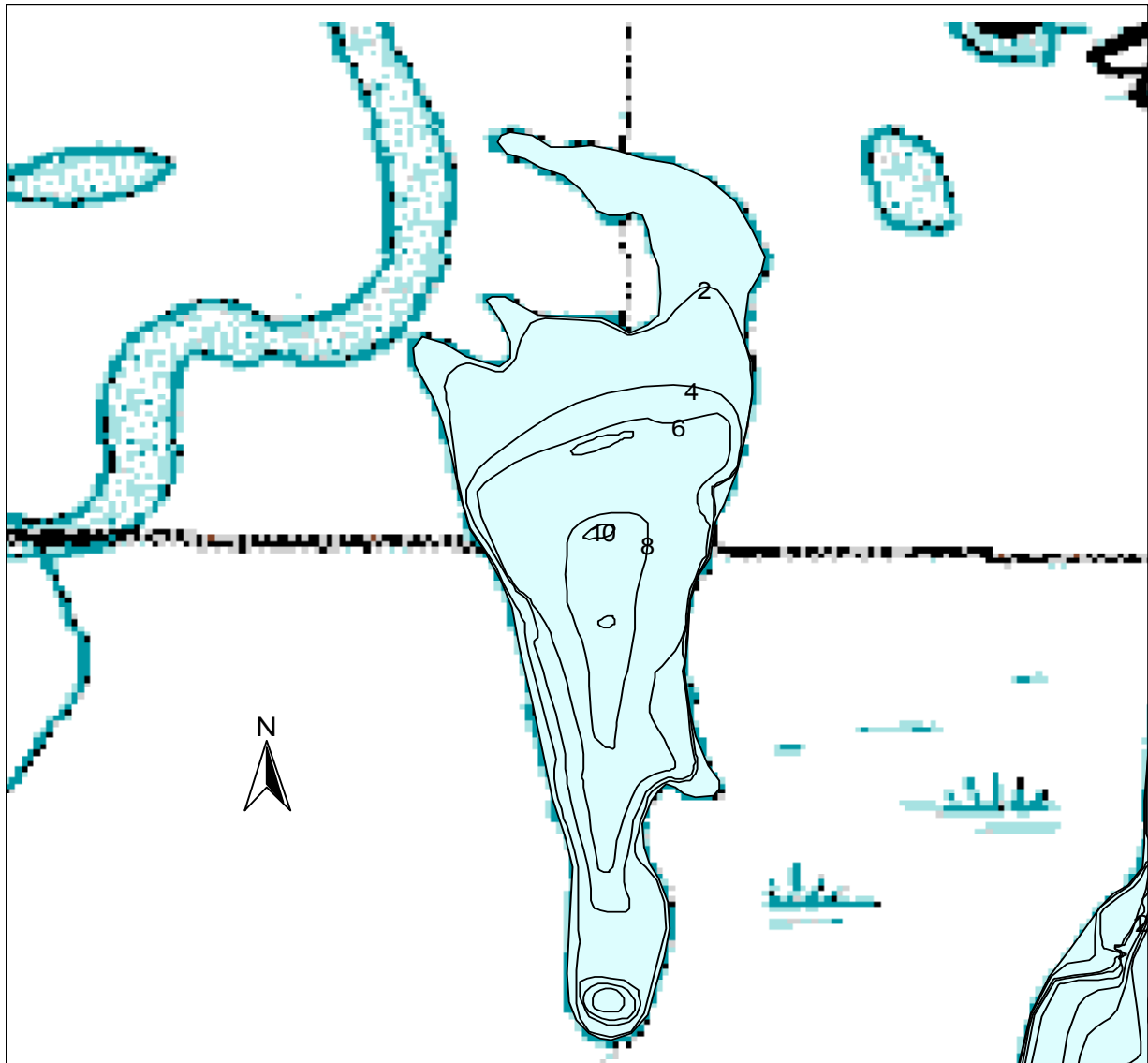
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
Gill Net	Jul 19 02	10.0	None	0
Minnow Trap	Jul 19 02	6.7	None	0
Ninespine stickleback observed				



Regions of lake M0209 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 19, 2002.





400 0 400 800 1200 1600 Feet

Depth contours based on transects surveyed on lake M0210,
July 19, 2002 (contours in 2 foot intervals).

Lake M0210

Other Names:

Location: 70° 41' 22.3"N 154° 27' 19.5"W

USGS Quad Sheet: T15/16N R10W, Sec. 3/4/33/34

Habitat:

Area: 43.4 acres

Maximum Depth: 11.4 feet

Active Outlet:

Turbidity: 0.7 NTU

Spec. Conductance: 61.2 μ S/cm

pH: 7.5

Calculated Volume: 64.57 million gallons

Permittable Volume: 0.40 million gallons

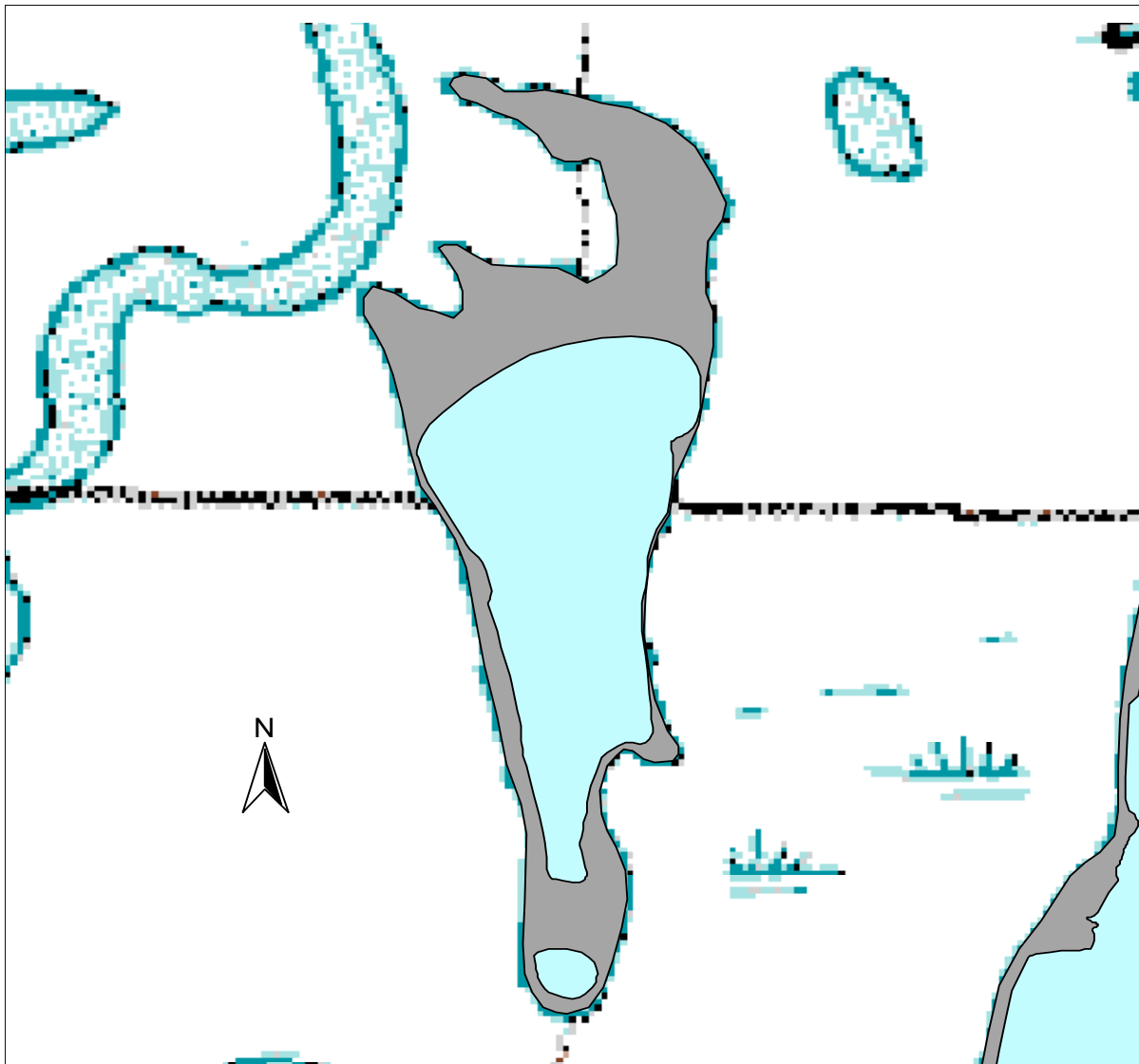
Potential Aggregate: 20.20 acres (water depth 4 ft or less)

Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	10.8	1.9	1.0	1.9	35	50	this study

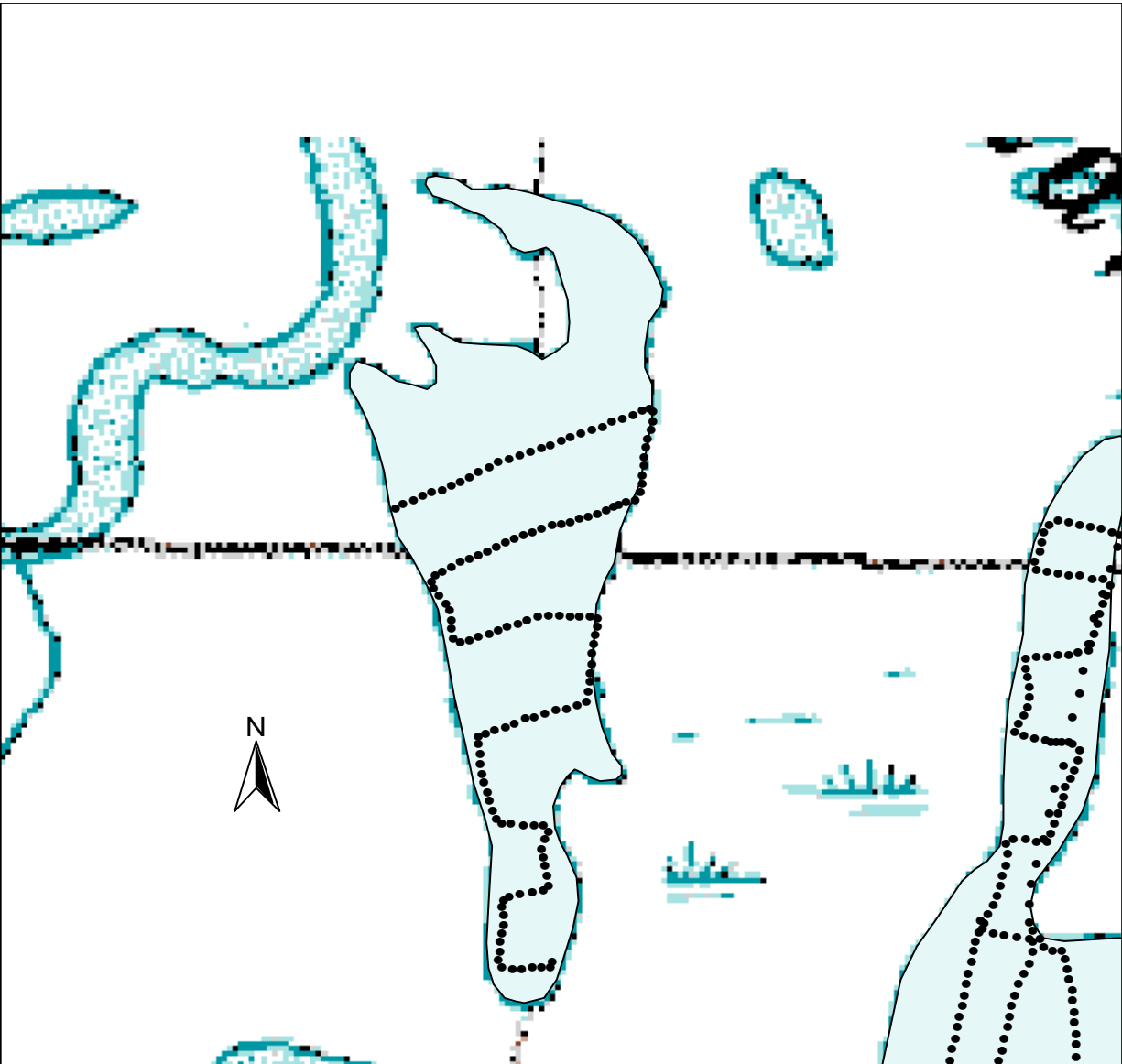
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 19 02	8.3	Broad whitefish	1	540
Minnow Trap	Jul 19 02	4.4	None	0	
			Ninespine stickleback observed		

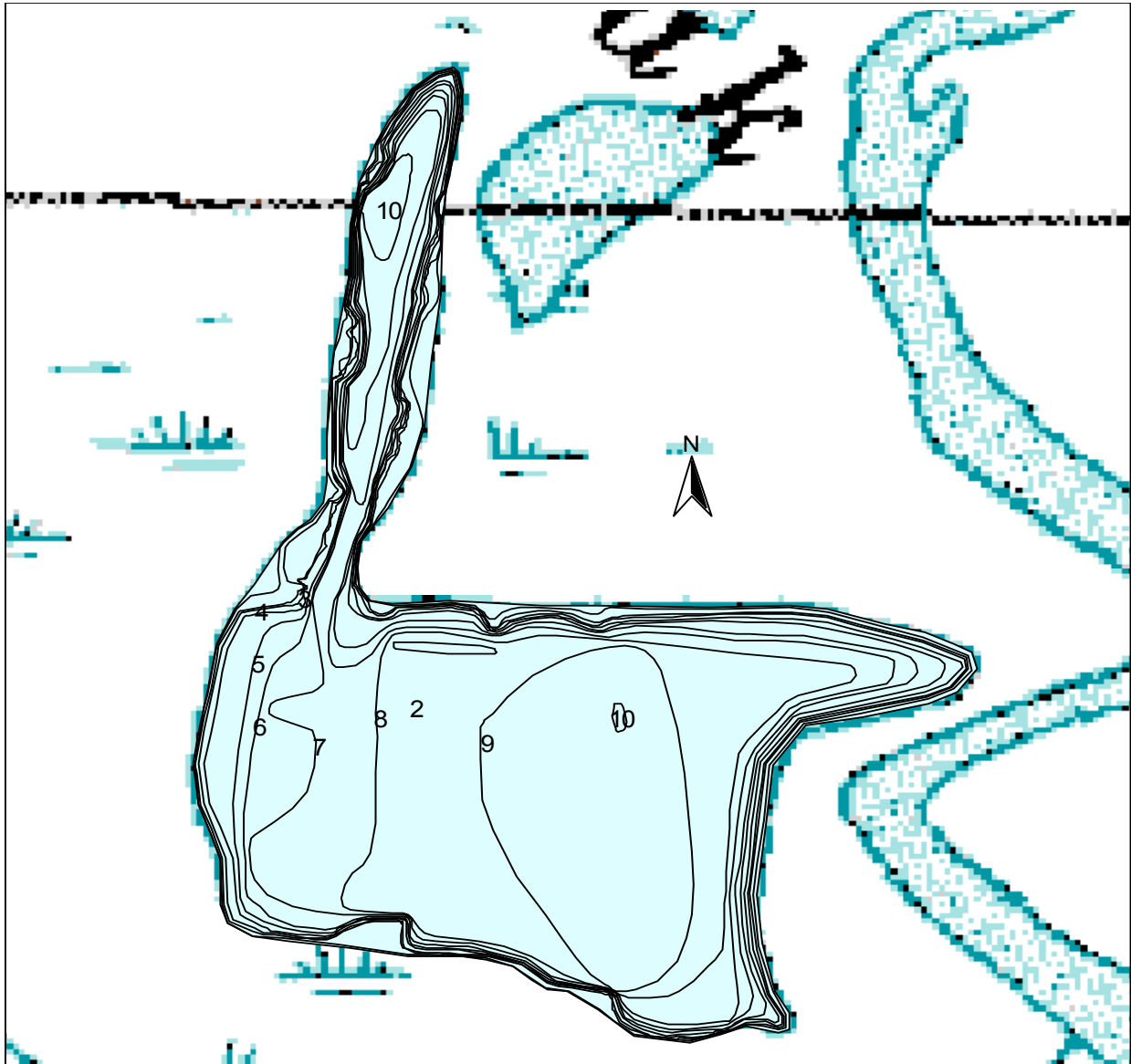


400 0 400 800 1200 1600 Feet

Regions of lake M0210 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 19, 2002.



Depth transects surveyed on lake M0210, July 19, 2002.



Depth contours based on transects surveyed on lake M0211,
July 20, 2002 (contours in 1 foot intervals).

Lake M0211

Other Names:

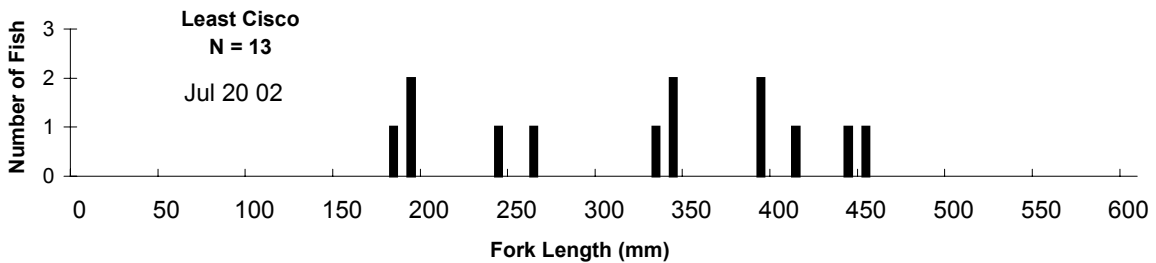
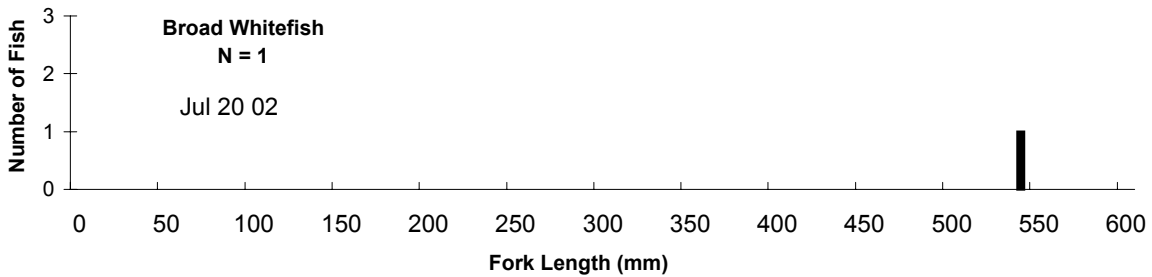
Location: 70° 41' 0.4"N 154° 26' 3.2"W
USGS Quad Sheet: T15N R10W, Sec. 3
Habitat:
Area: 87.0 acres
Maximum Depth: 11.0 feet
Active Outlet:
Turbidity: 0.9 NTU
Spec. Conductance: 71.8 µS/cm
pH: 7.6
Calculated Volume: 203.66 million gallons
Permittable Volume: 5.16 million gallons
Potential Aggregate: 12.87 acres (water depth 4 ft or less)

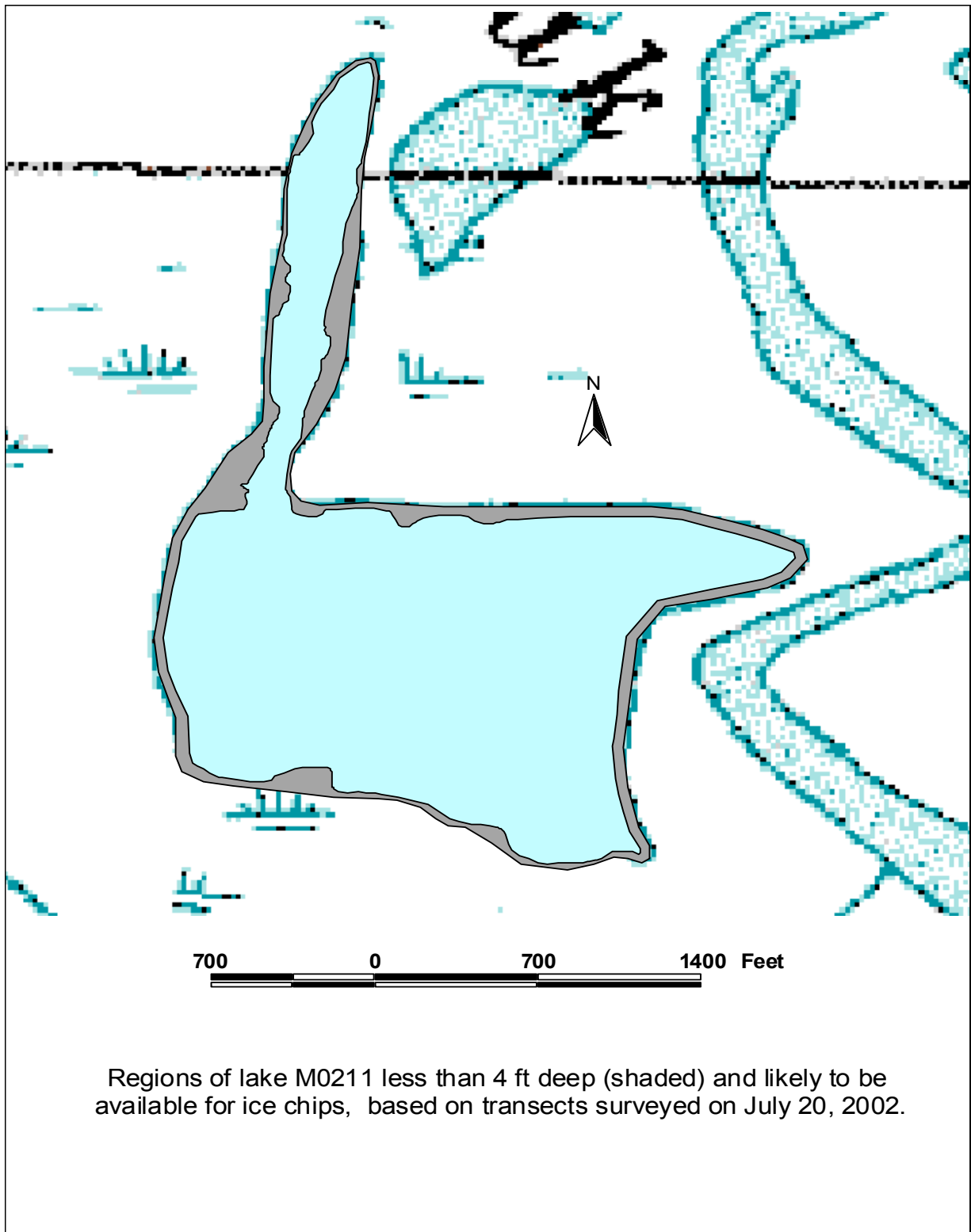
Water Quality:

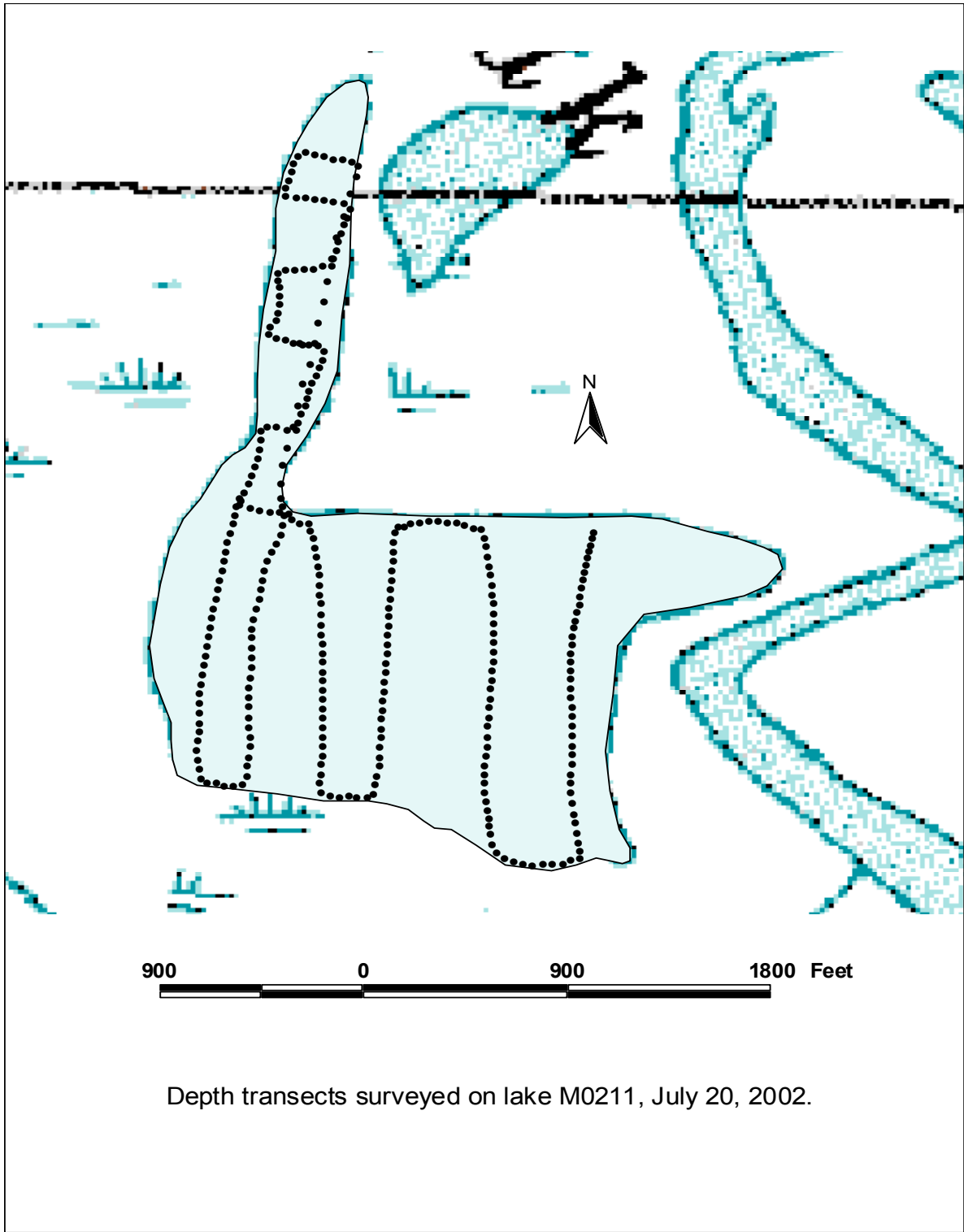
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	9.0	1.6	1.5	3.1	29	30	this study

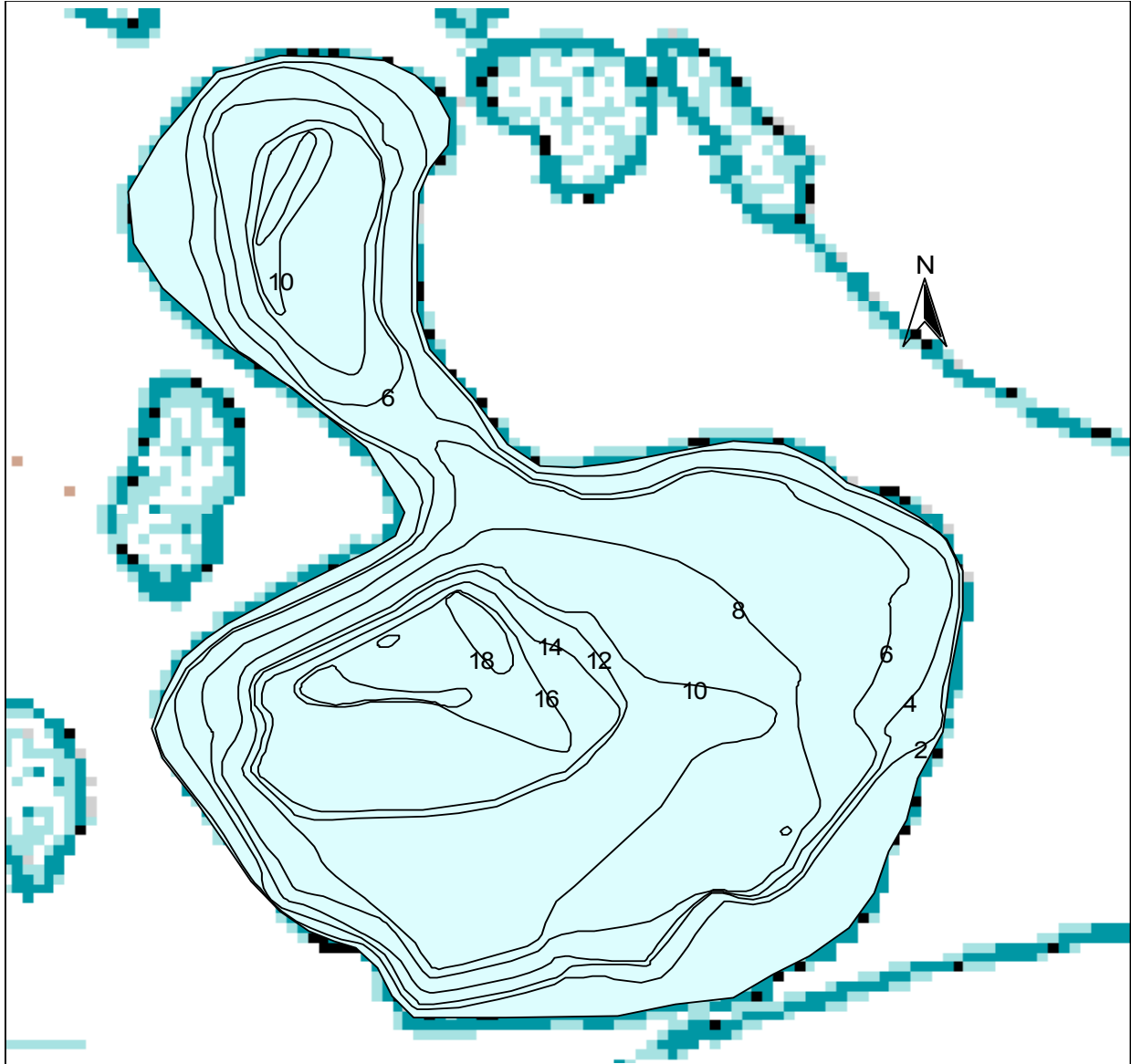
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 20 02	1.5	Broad whitefish	1	545
			Least cisco	13	185-450
Minnow Trap	Jul 20 02	3.2	Ninespine stickleback		









Depth contours based on transects surveyed on lake M0212, July 20, 2002 (contours in 2 foot intervals).

Lake M0212

Other Names:

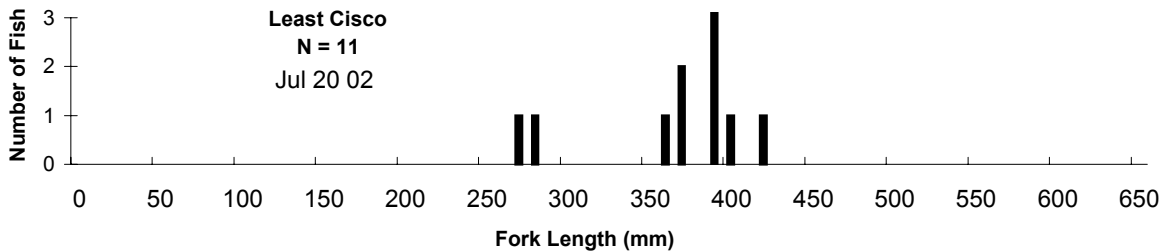
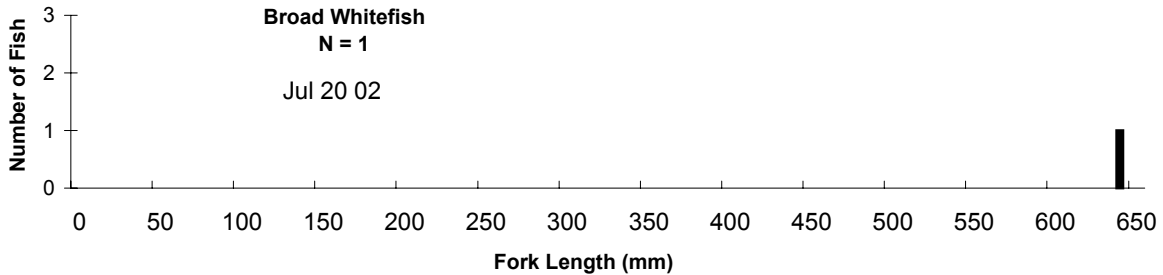
Location: 70° 40' 7.9"N 154° 28' 25.5"W
USGS Quad Sheet: T15N R10W, Sec. 9
Habitat:
Area: 43.6 acres
Maximum Depth: 21.3 feet
Active Outlet:
Turbidity: 0.7 NTU
Spec. Conductance: 146.8 µS/cm
pH: 8.0
Calculated Volume: 112.36 million gallons
Permittable Volume: 4.10 million gallons
Potential Aggregate: 9.89 acres (water depth 4 ft or less)

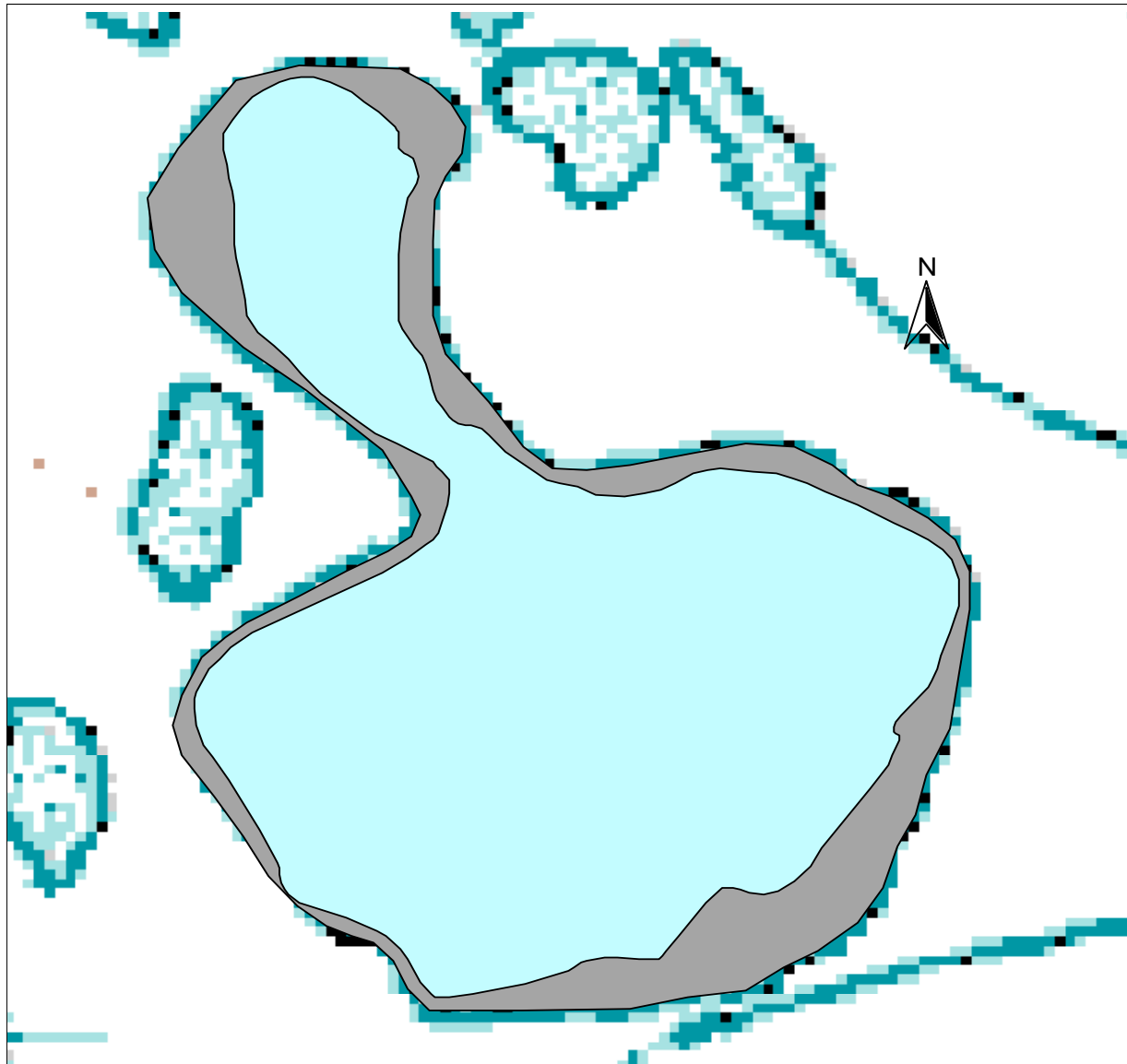
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	20.3	3.5	2.9	6.1	65	90	this study

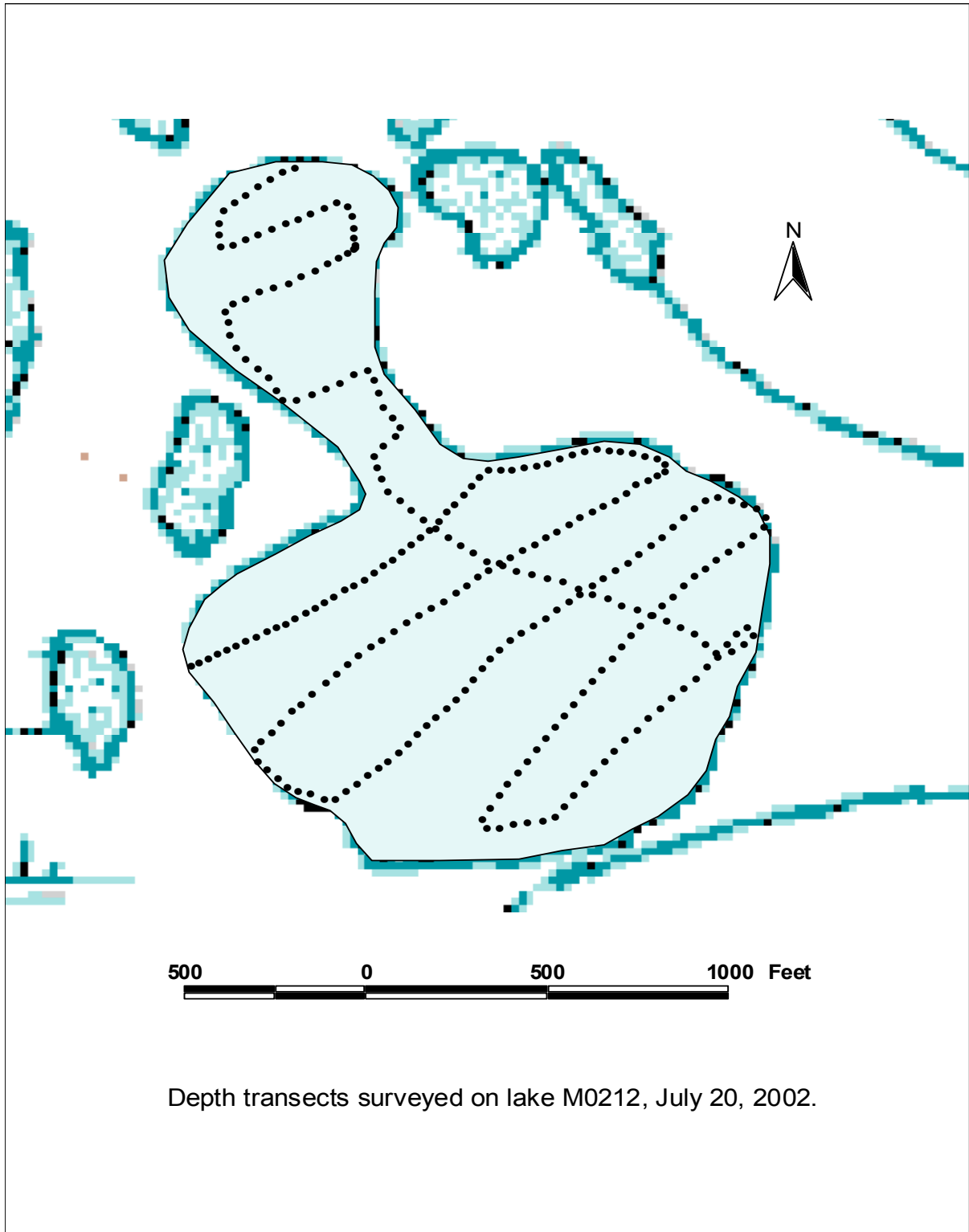
Catch Record:

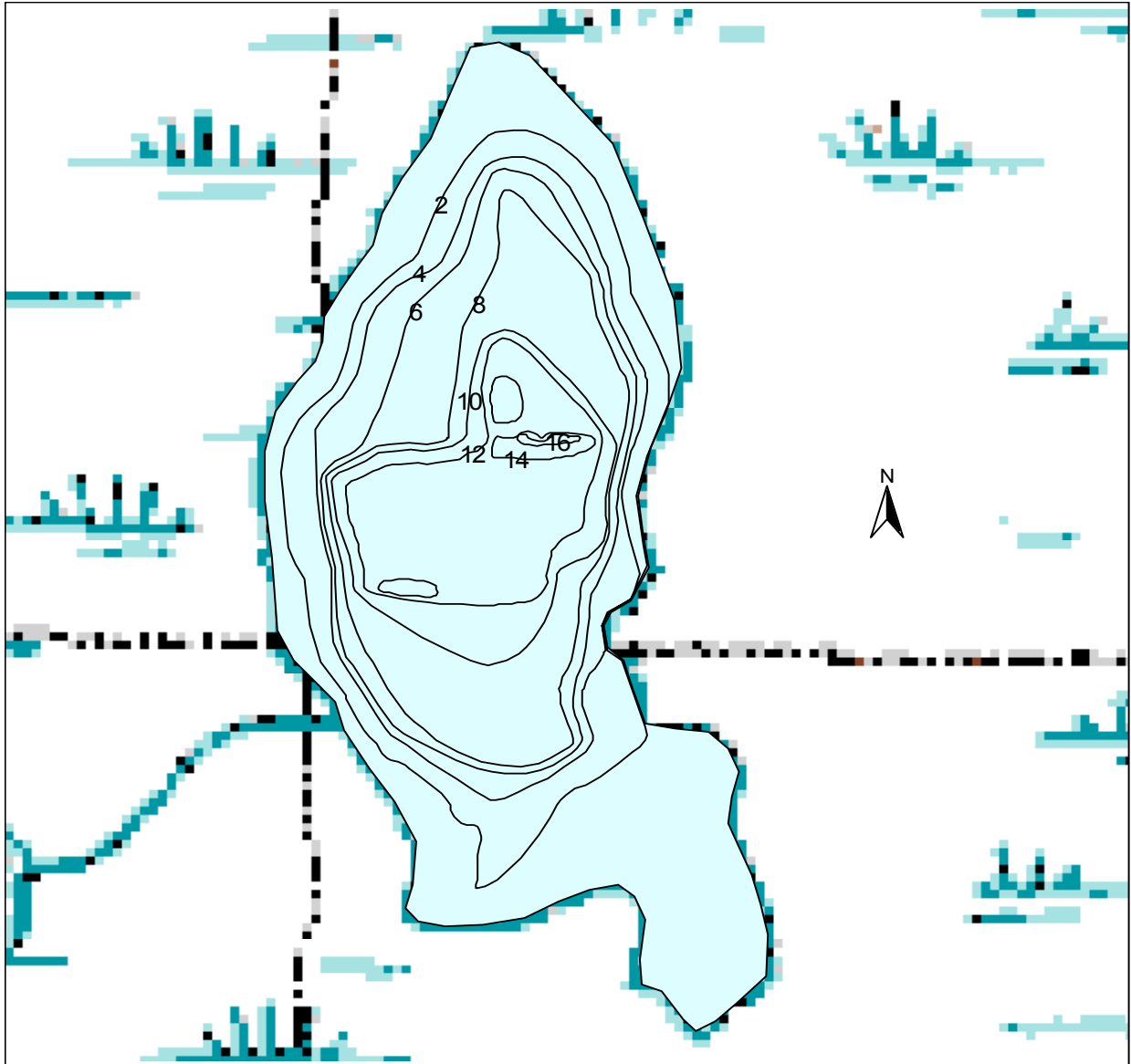
Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 20 02	3.8	Broad whitefish	1	645
			Least cisco	13	270-420
Minnow Trap	Jul 20 02	2.8	None	0	





Regions of lake M0212 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 20, 2002.





400 0 400 800 1200 Feet

Depth contours based on transects surveyed on lake M0213,
July 20, 2002 (contours in 2 foot intervals).

Lake M0213

Other Names:

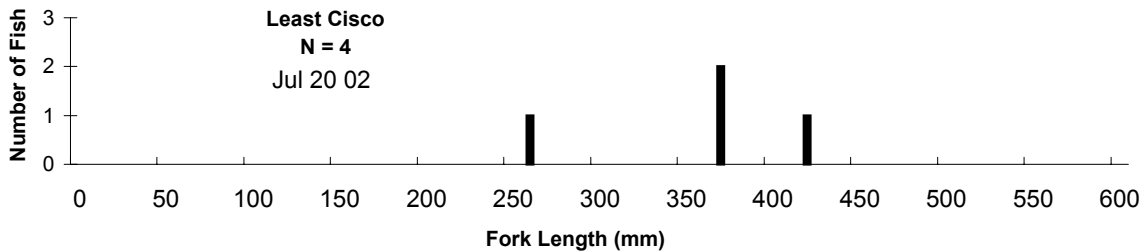
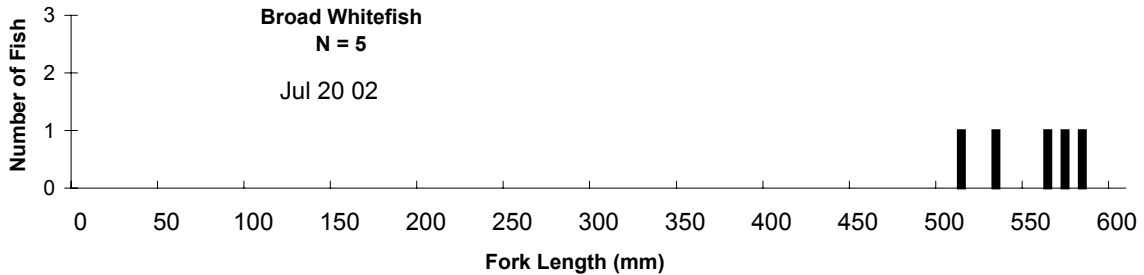
Location: 70° 39' 42.6"N 154° 27' 7.7"W
USGS Quad Sheet: T15N R10W, Sec. 10/15
Habitat:
Area: 38.2 acres
Maximum Depth: 18.4 feet
Active Outlet:
Turbidity: 0.8 NTU
Spec. Conductance: 150.1 µS/cm
pH: 8.1
Calculated Volume: 71.24 million gallons
Permittable Volume: 2.20 million gallons
Potential Aggregate: 17.88 acres (water depth 4 ft or less)

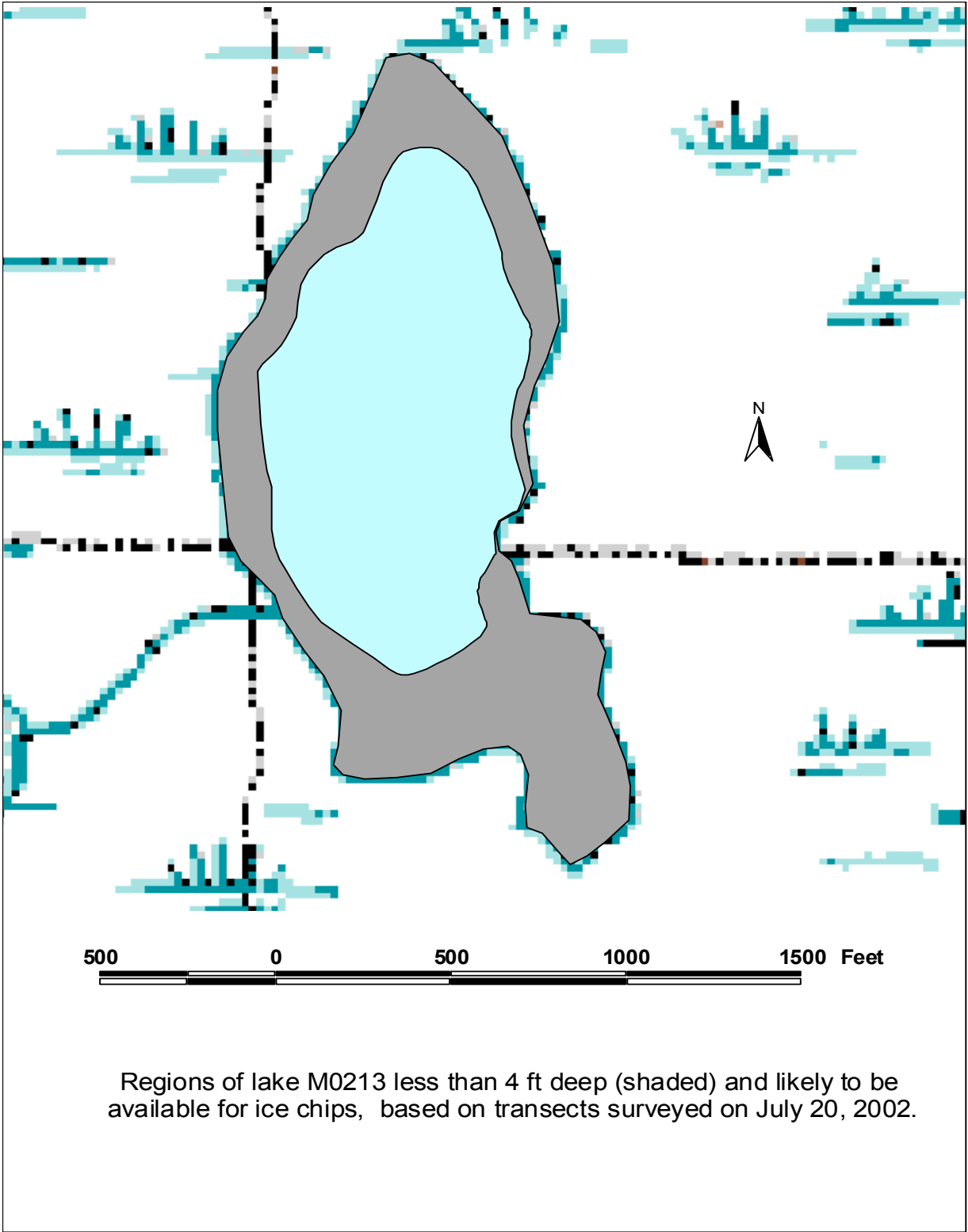
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	20.3	3.4	3.2	6.7	65	110	this study

Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 20 02	0.9	Broad whitefish	5	518-580
			Least cisco	5	260-422
Minnow Trap	Jul 20 02	1.5	None	0	



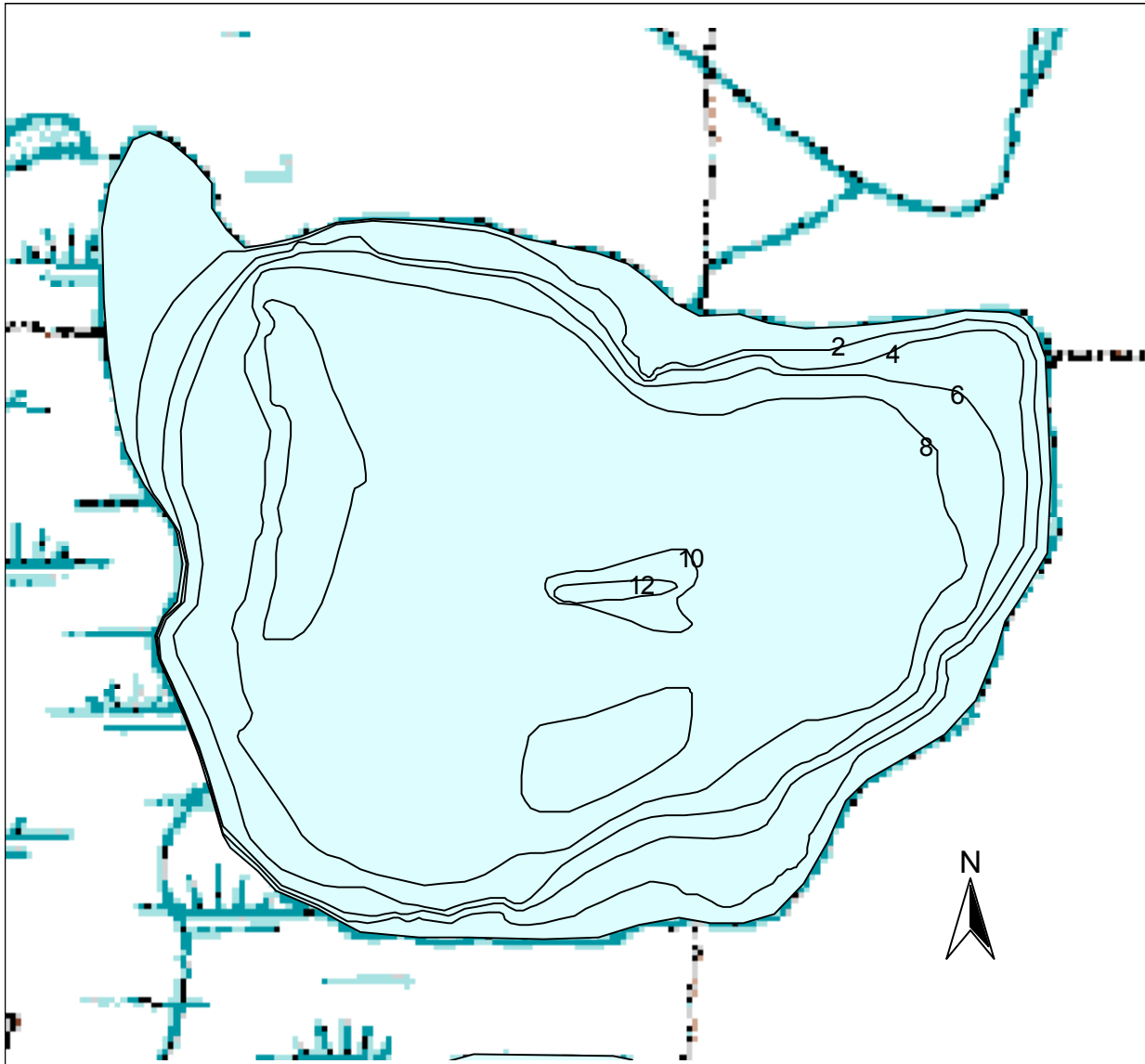


Regions of lake M0213 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 20, 2002.



600 0 600 1200 Feet

Depth transects surveyed on lake M0213, July 20, 2002.



800 0 800 1600 Feet

Depth contours based on transects surveyed on lake M0214, July 20, 2002 (contours in 2 foot intervals).

Lake M0214

Other Names:

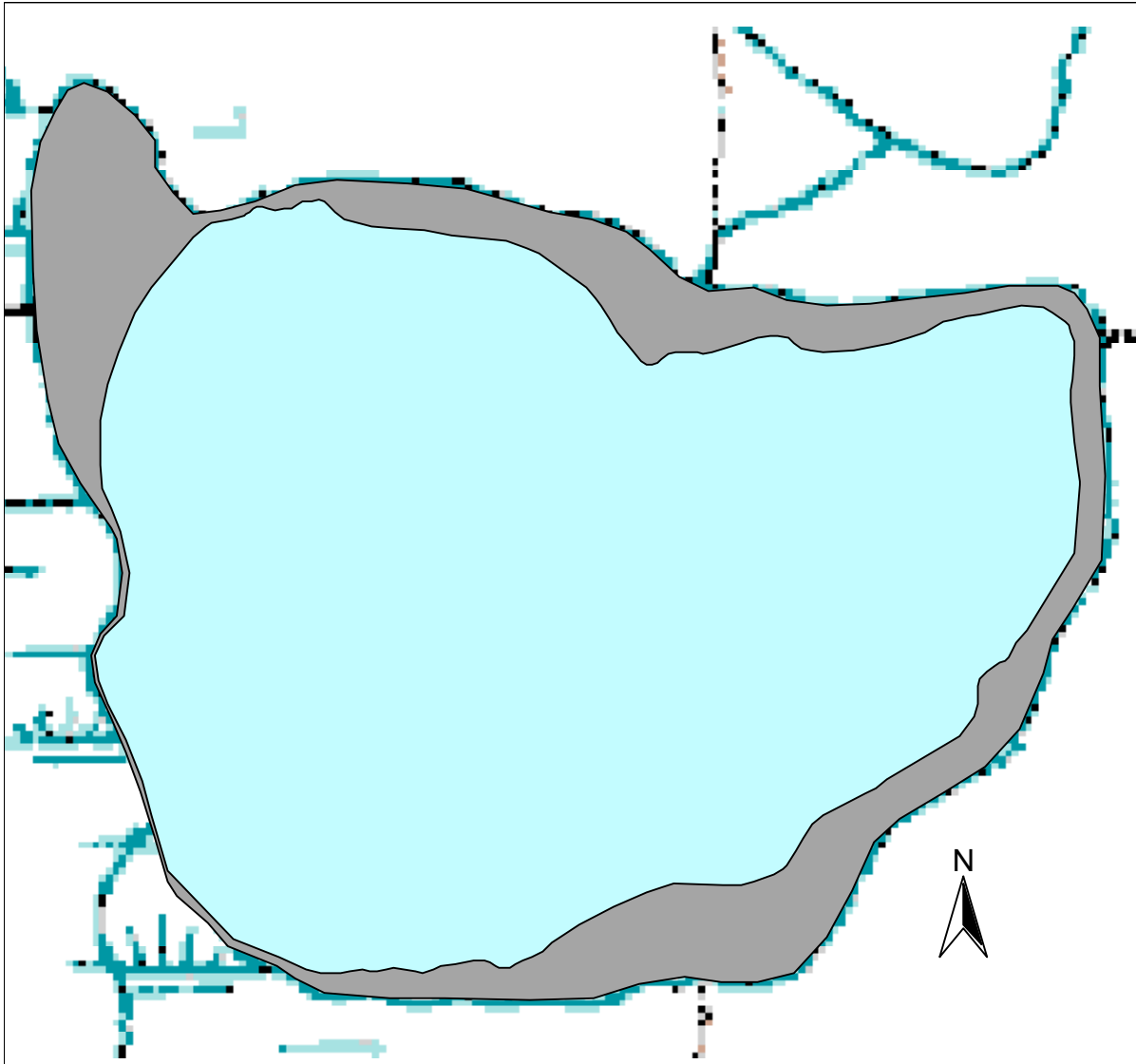
Location: 70° 39' 30.1"N 154° 30' 5.3"W
USGS Quad Sheet: T15N R10W, Sec. 16/17
Habitat:
Area: 162.0 acres
Maximum Depth: 18.1 feet
Active Outlet:
Turbidity: 0.6 NTU
Spec. Conductance: 169.5 μ S/cm
pH: 8.2
Calculated Volume: 184.84 million gallons
Permittable Volume: No fish concern
Potential Aggregate: 32.23 acres (water depth 4 ft or less)

Water Quality:

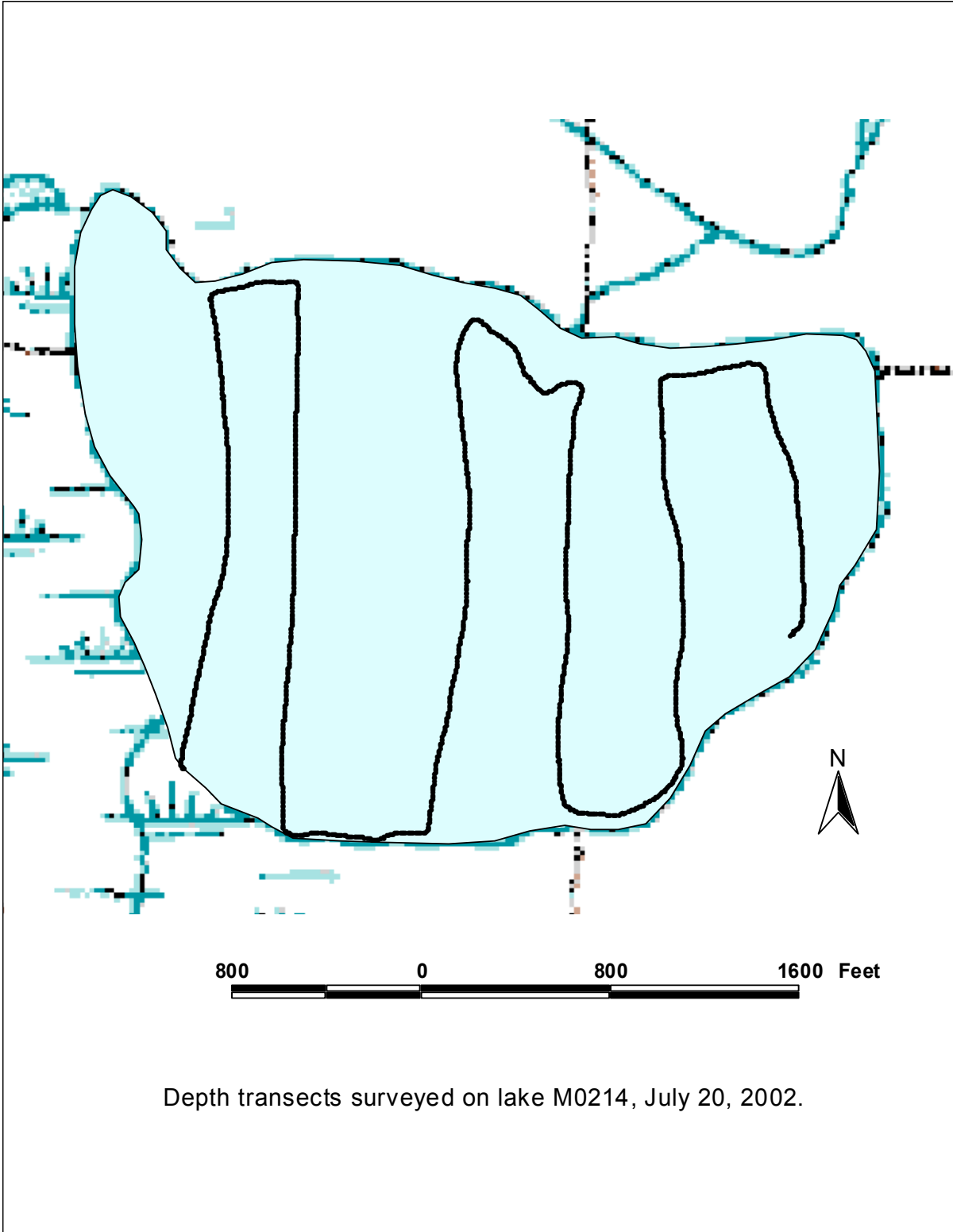
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	24.4	3.8	3.0	6.1	76	80	this study

Catch Record:

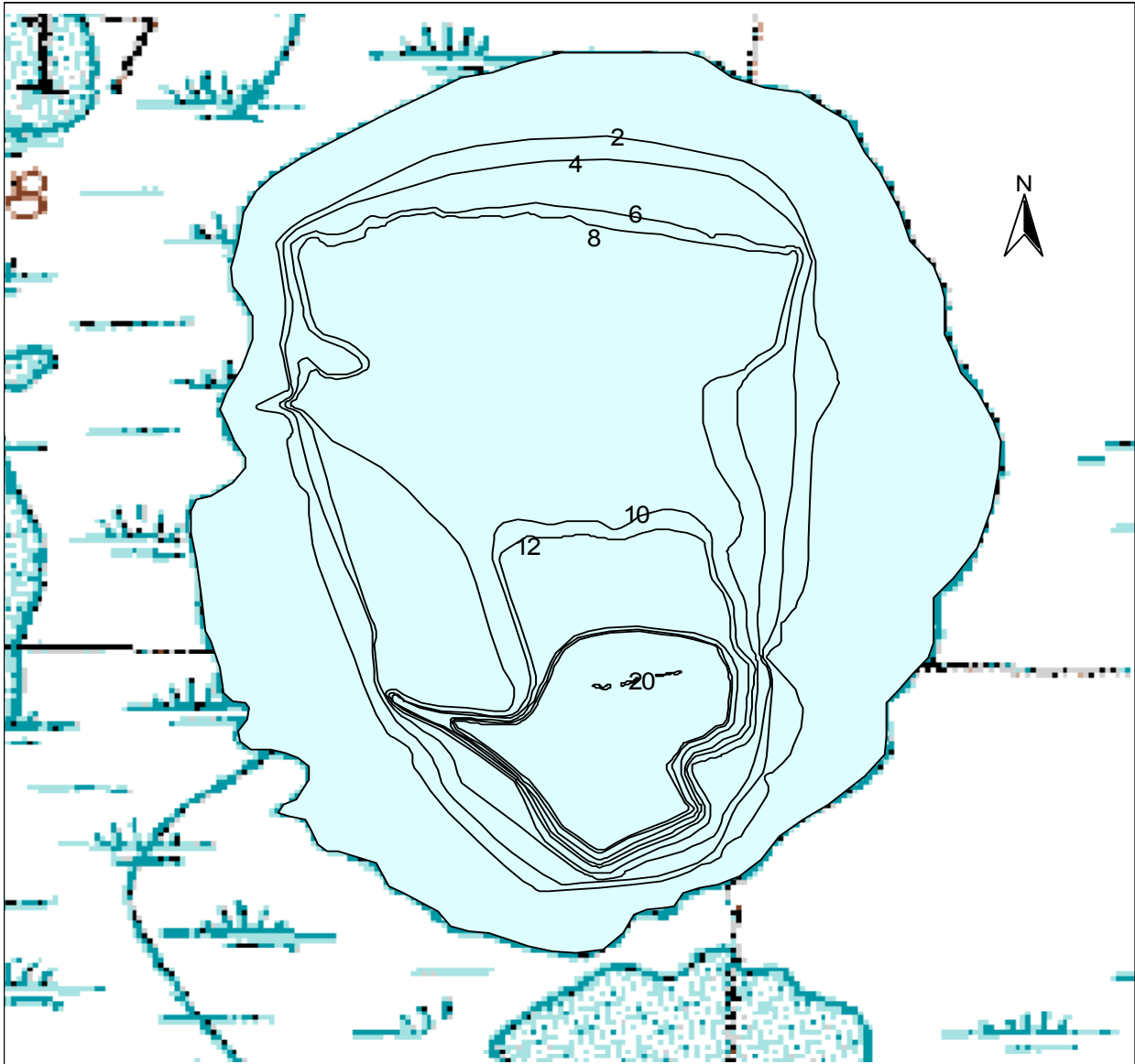
Gear	Date	Effort (hours)	Species	Number Caught
Gill Net	Jul 20 02	11.0	None	0
Minnow Trap	Jul 20 02	4.2	None	0



Regions of lake M0214 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 20, 2002.



Depth transects surveyed on lake M0214, July 20, 2002.



800 0 800 1600 Feet

Depth contours based on transects surveyed on lake M0215, July 21, 2002 (contours in 2 foot intervals).

Lake M0215

Other Names:

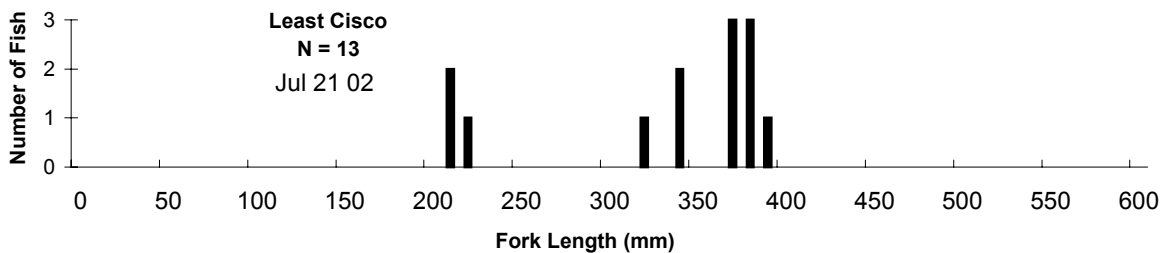
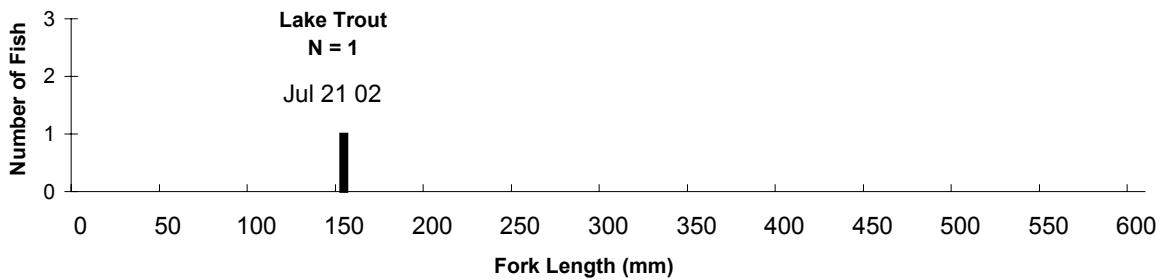
Location: 70° 38' 56.0"N 154° 30' 16.2"W
USGS Quad Sheet: T15N R10W, Sec. 16/17/20/21
Habitat:
Area: 219.1 acres
Maximum Depth: 23.2 feet
Active Outlet:
Turbidity: 0.2 NTU
Spec. Conductance: 230.1 µS/cm
pH: 8.1
Calculated Volume: 415.91 million gallons
Permittable Volume: 15.01 million gallons
Potential Aggregate: 98.95 acres (water depth 4 ft or less)

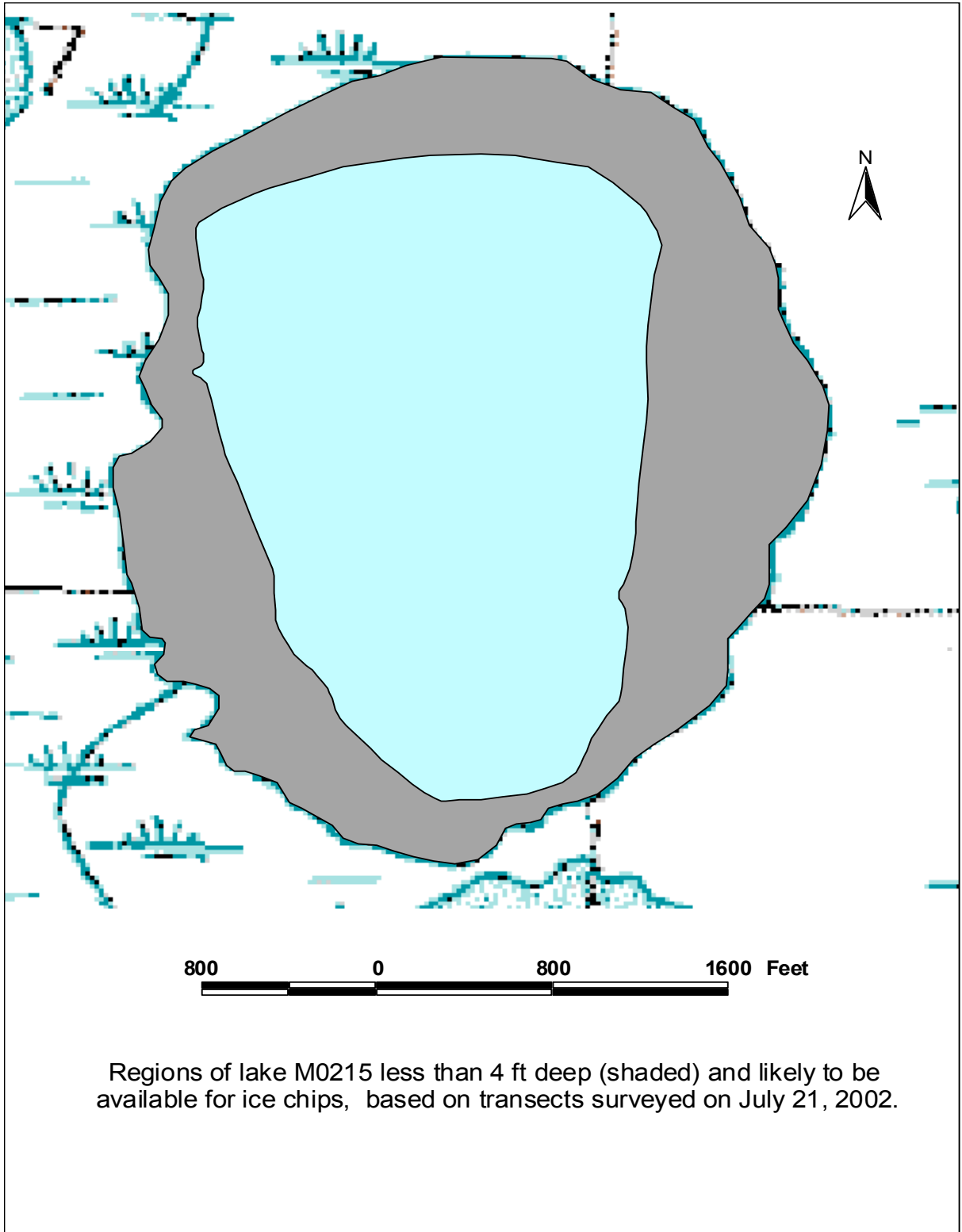
Water Quality:

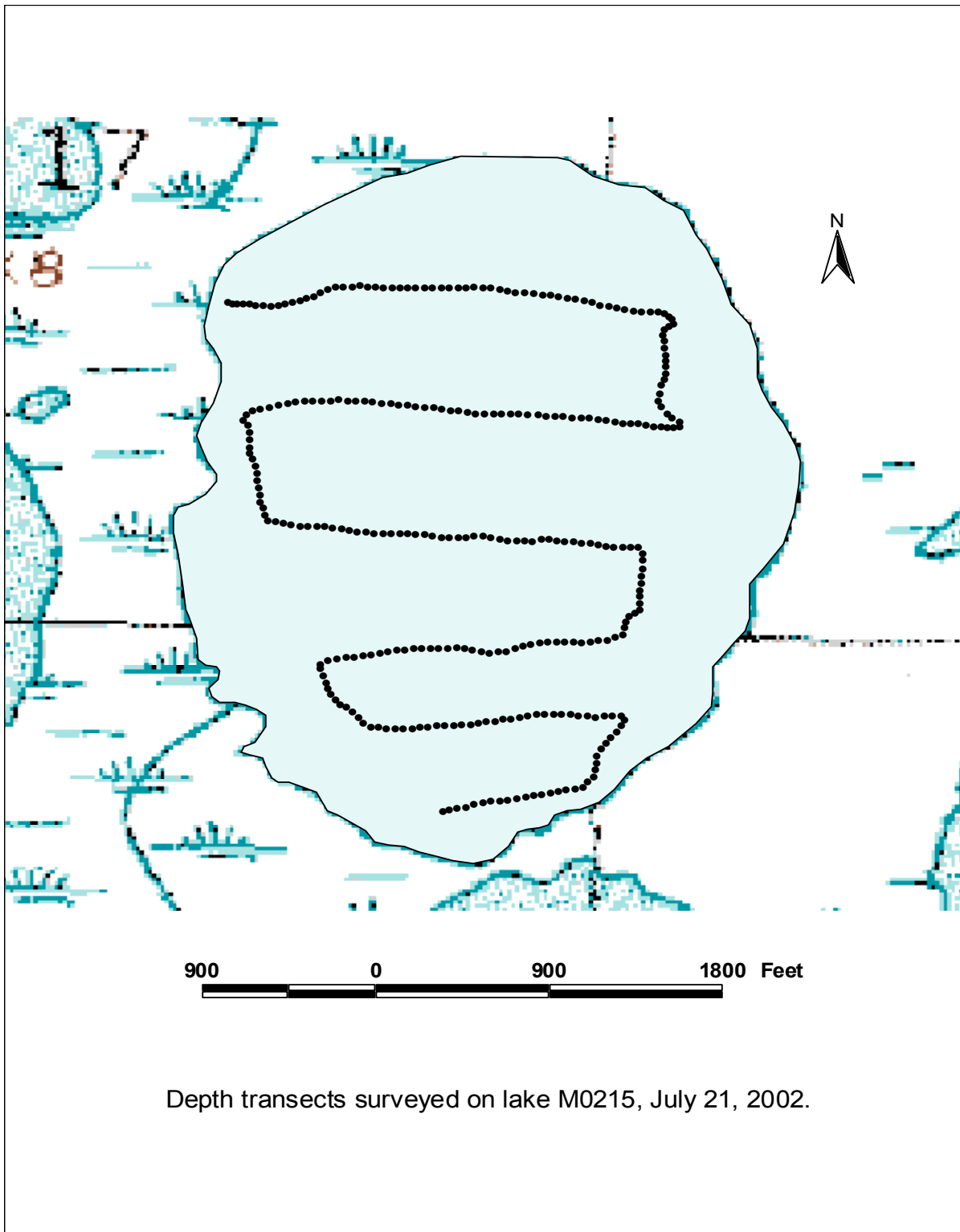
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	32.5	3.5	5.2	12.6	95	140	this study

Catch Record:

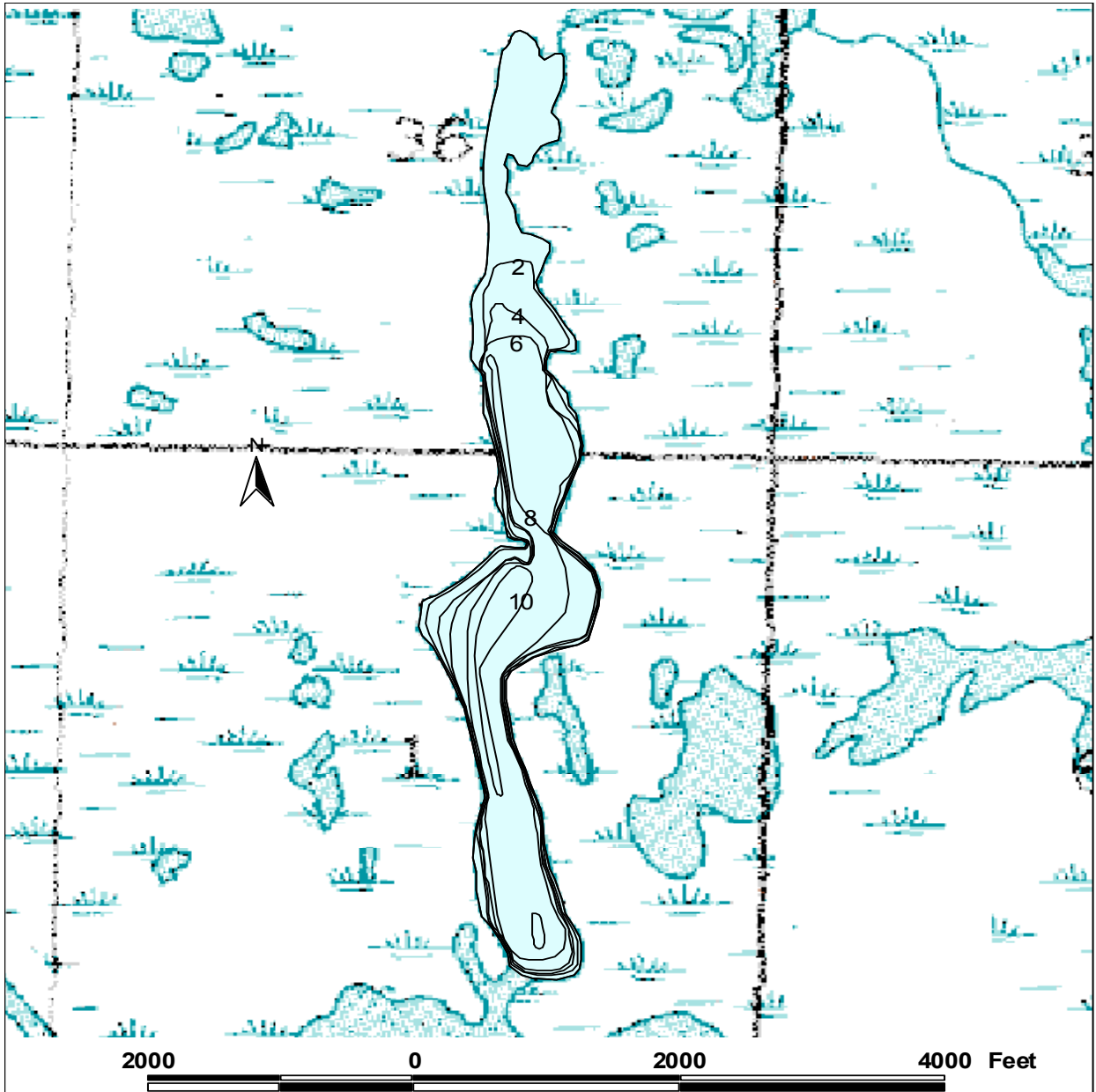
Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 21 02	5.7	Lake trout	1	155
			Least cisco	13	212-390
Minnow Trap	Jul 21 02	4.0	None	0	
			Ninespine stickleback observed		







Depth transects surveyed on lake M0215, July 21, 2002.



Depth contours based on transects surveyed on lake M0216,
July 21, 2002 (contours in 2 foot intervals).

Lake M0216

Other Names:

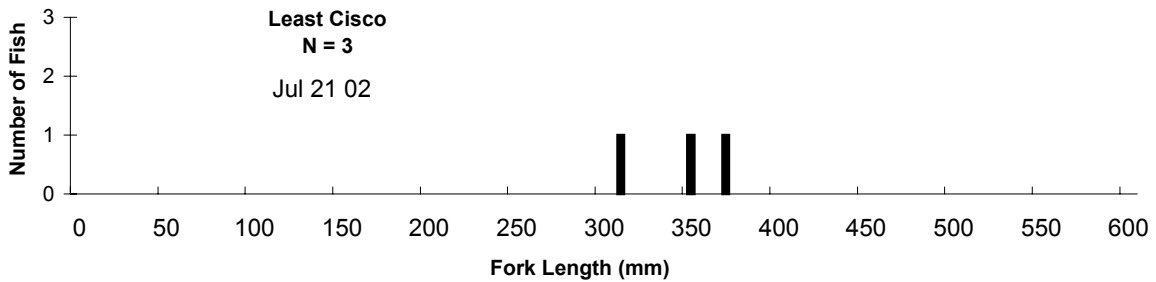
Location: 70° 41' 9.4"N 154° 20' 29.7"W
USGS Quad Sheet: T15/16N R10W, Sec. 1/36
Habitat:
Area: 100.4 acres
Maximum Depth: 12.3 feet
Active Outlet:
Turbidity: 1.1 NTU
Spec. Conductance: 198.4 µS/cm
pH: 8.0
Calculated Volume: 191.73 million gallons
Permittable Volume: 4.37 million gallons
Potential Aggregate: 35.10 acres (water depth 4 ft or less)

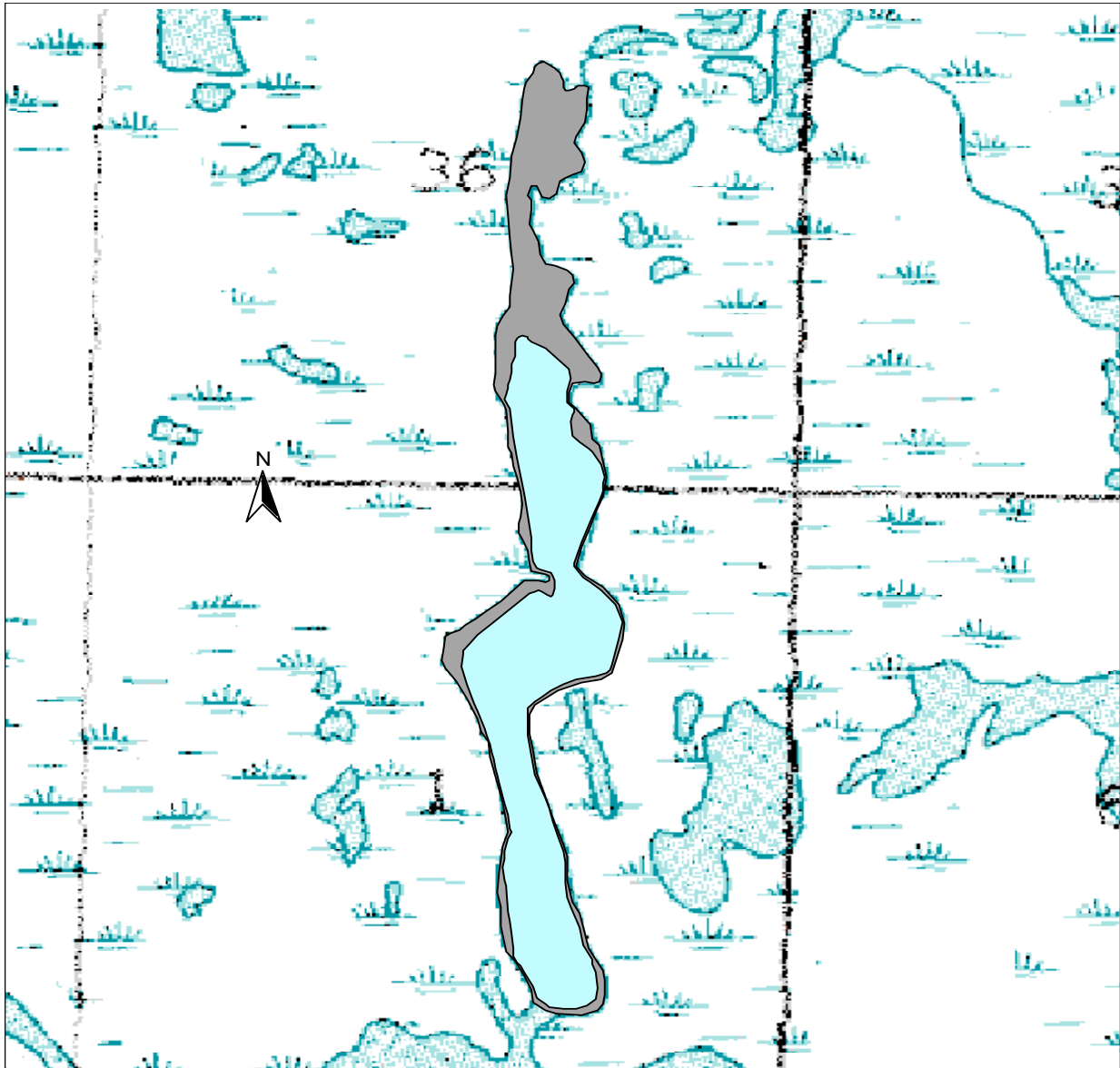
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	15.0	3.7	13.9	29.7	53	80	this study

Catch Record:

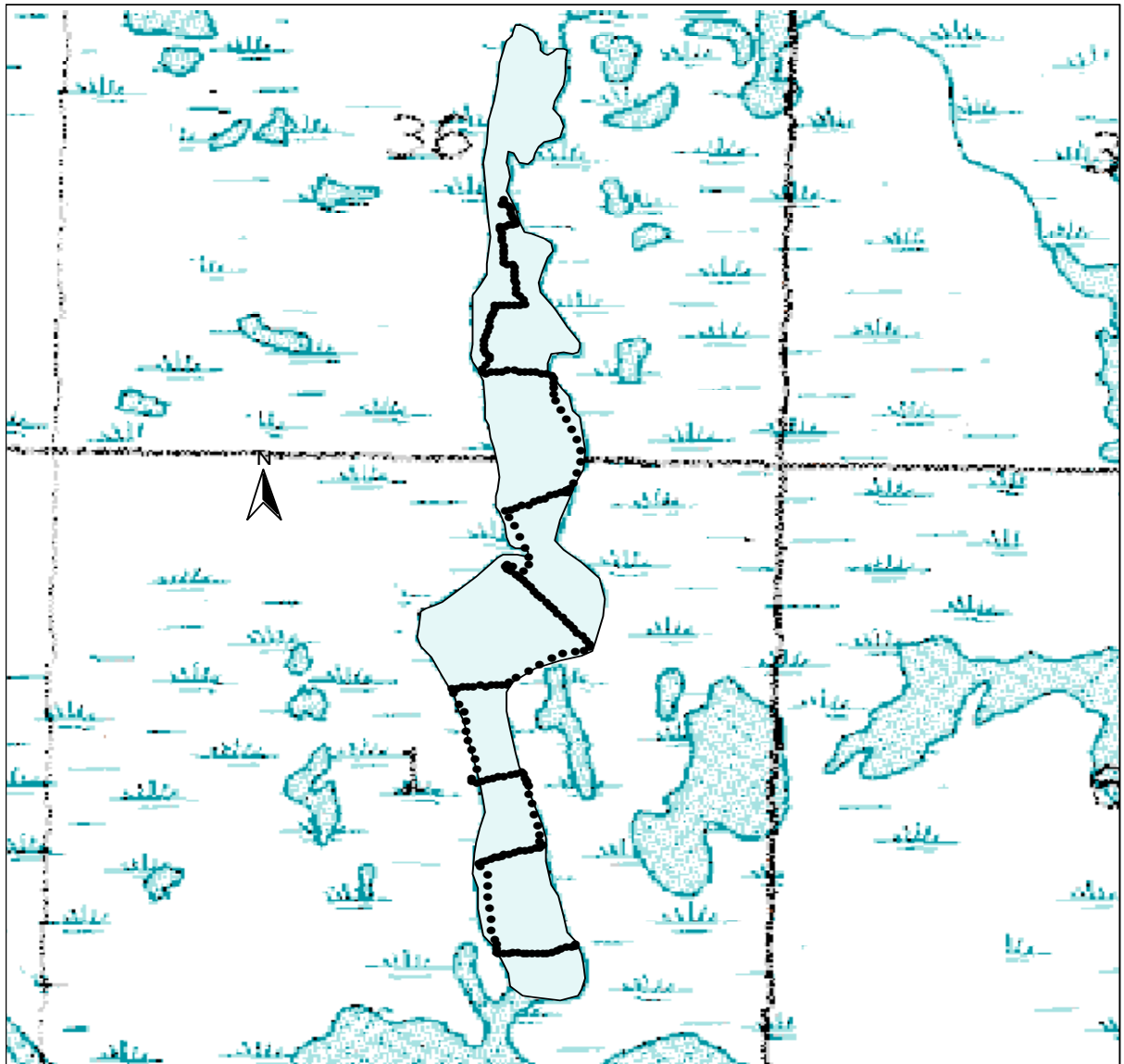
Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 21 02	0.5	Least cisco	3	318-370
Minnow Trap	Jul 21 02	2.2	None	0	





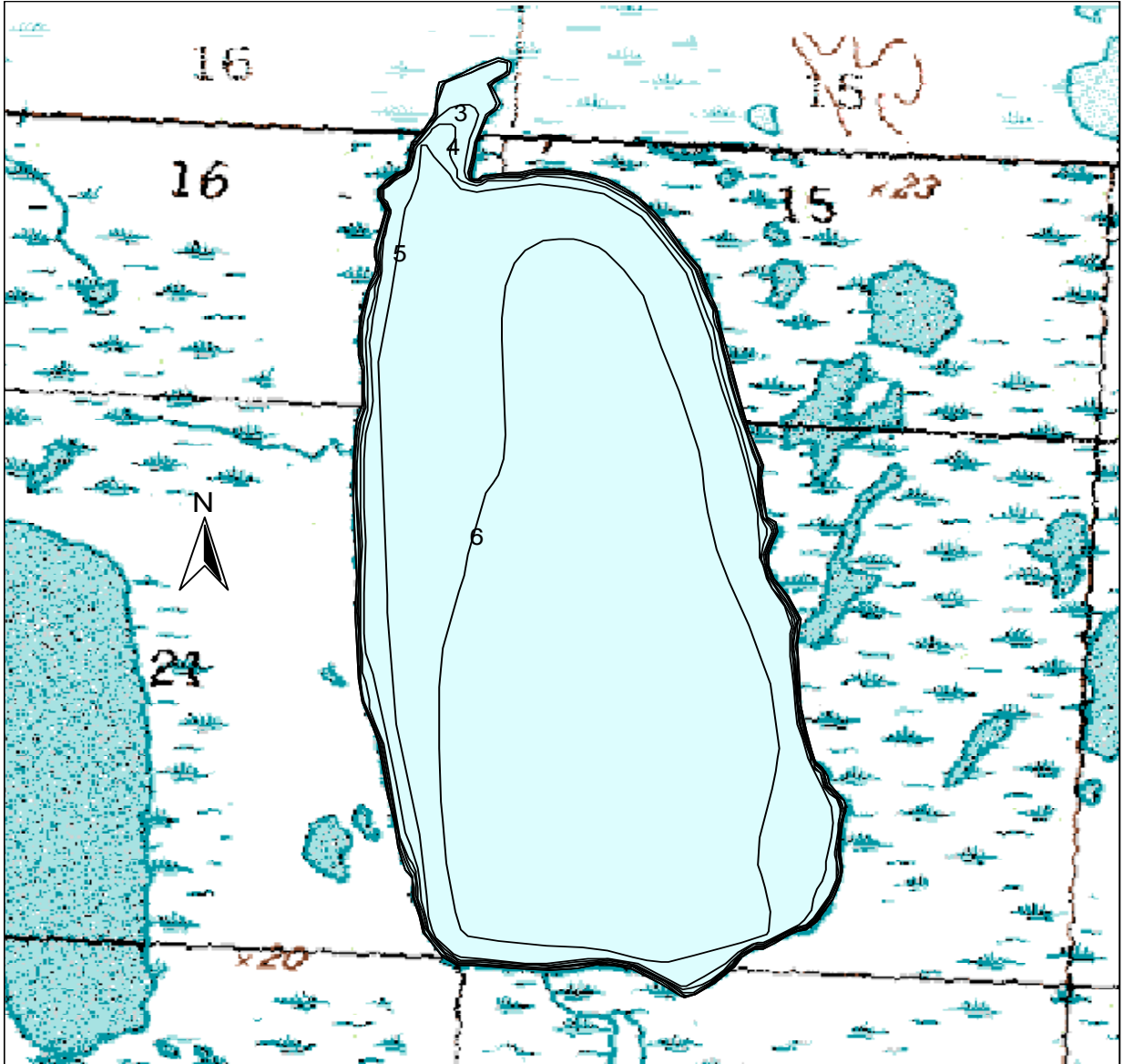
2000 0 2000 4000 Feet

Regions of lake M0216 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 21, 2002.



2000 0 2000 4000 Feet

Depth transects surveyed on lake M0216, July 21, 2002.



Depth contours based on transects surveyed on lake M0217, July 29, 2002 (contours in 1 foot intervals).

Lake M0217

Other Names:

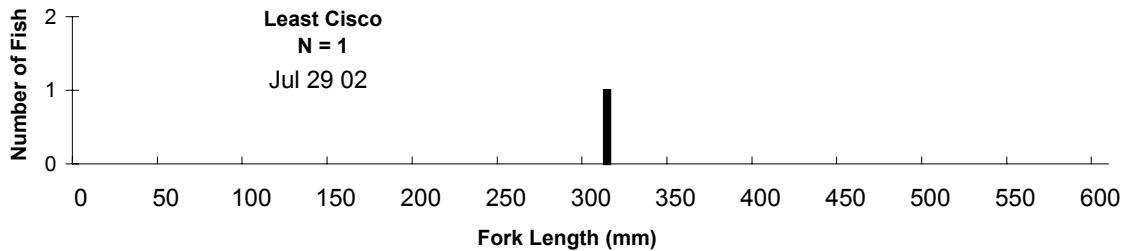
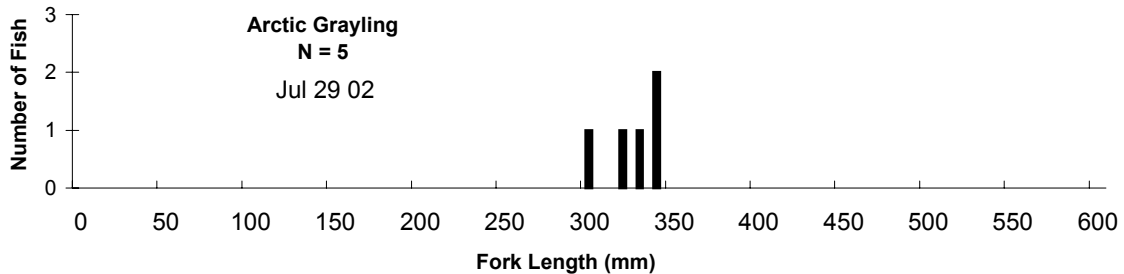
Location: 70° 59' 24.0"N 156° 4' 33.1"W
USGS Quad Sheet: T19N R16W, Sec. 15/16/21/22
Habitat:
Area: 614.4 acres
Maximum Depth: 6.9 feet
Active Outlet:
Turbidity: 6.0
Spec. Conductance: 149.8
pH: 7.5
Calculated Volume: 1146.16 million gallons
Permittable Volume: 0.00 million gallons
Potential Aggregate: 41.03 acres (water depth 4 ft or less)

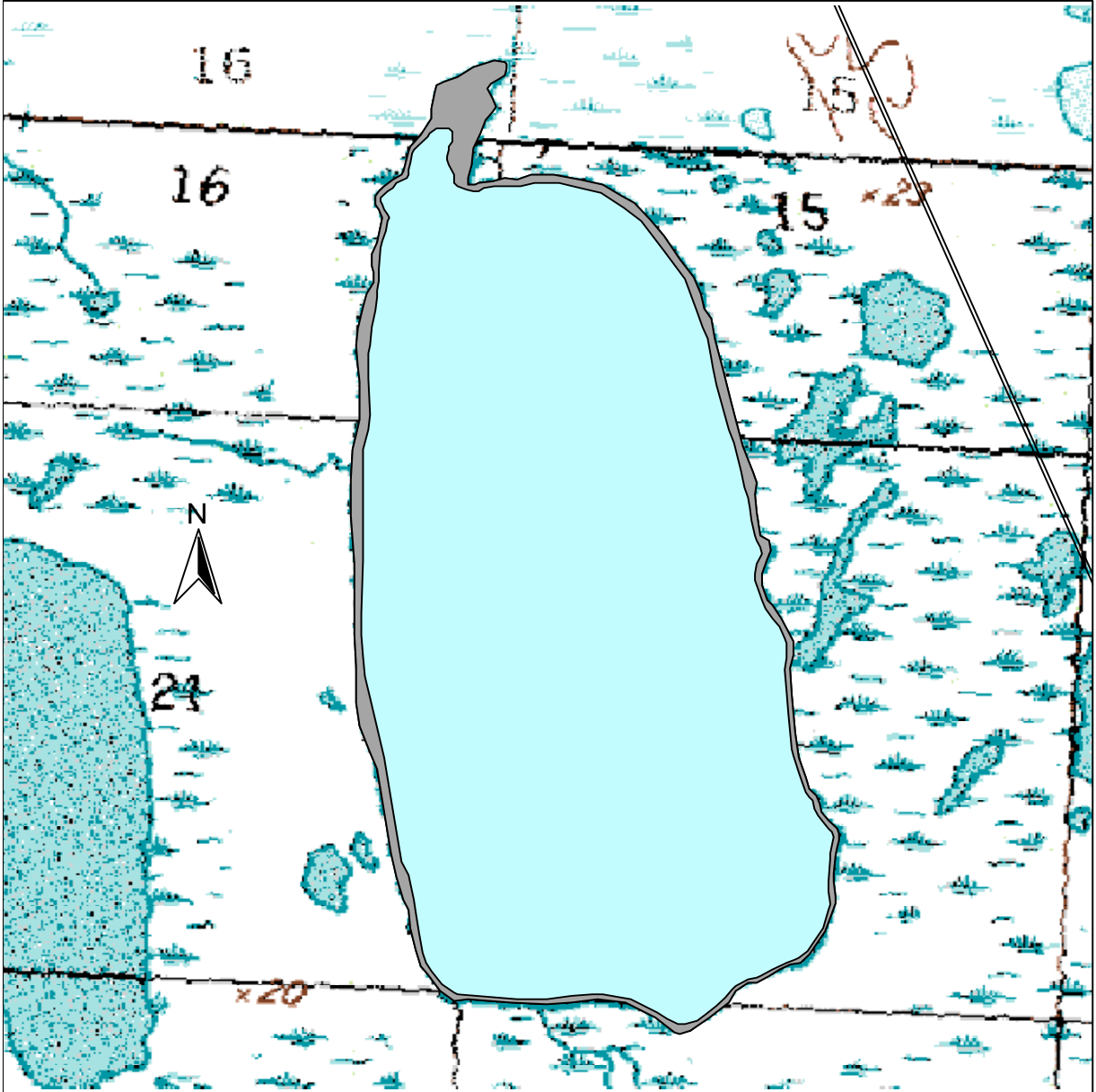
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	4.8	3.0	13.9	36.6	25		this study

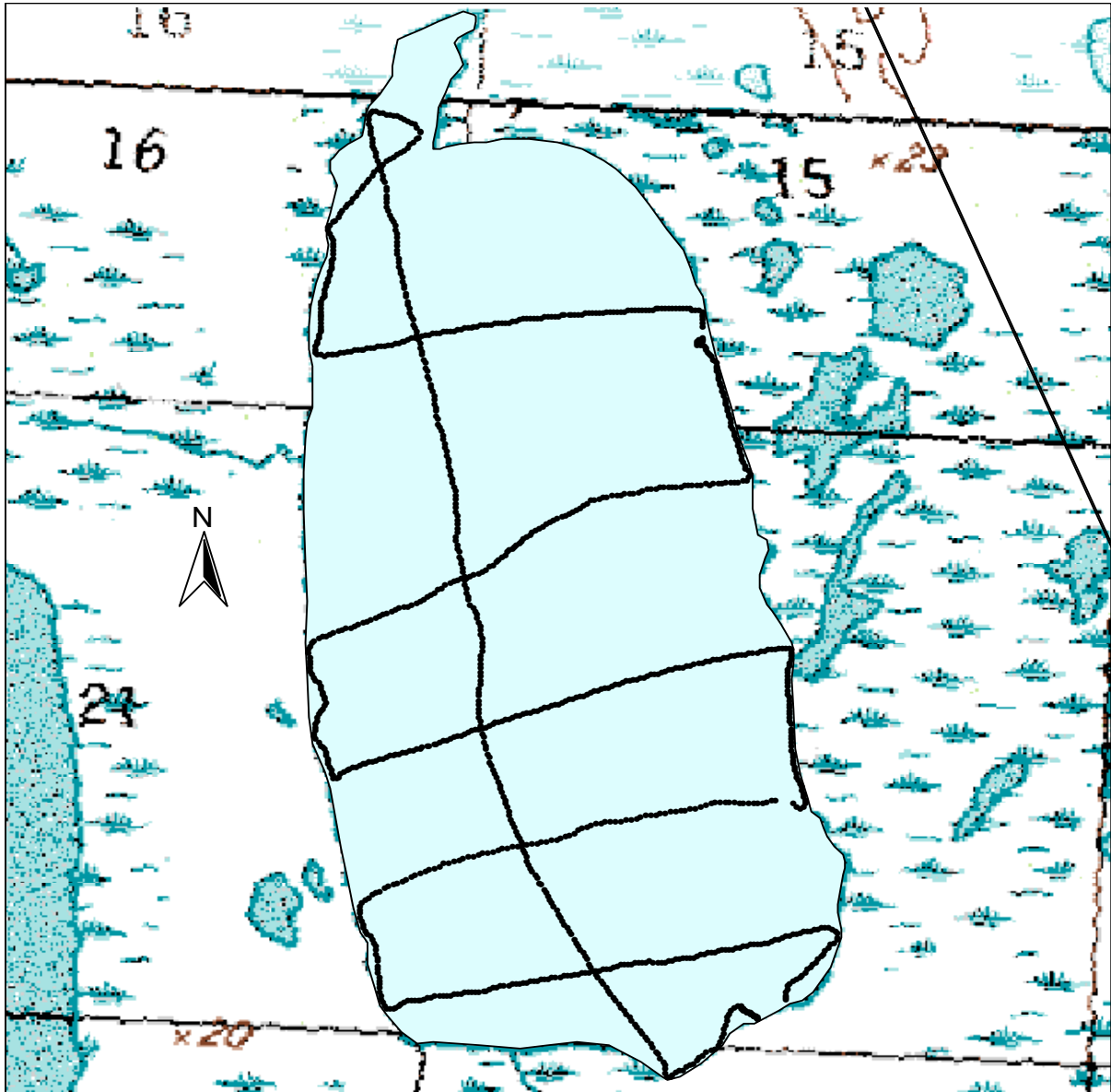
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 29 02	3.7	Arctic grayling	5	306-349
			Least cisco	1	310

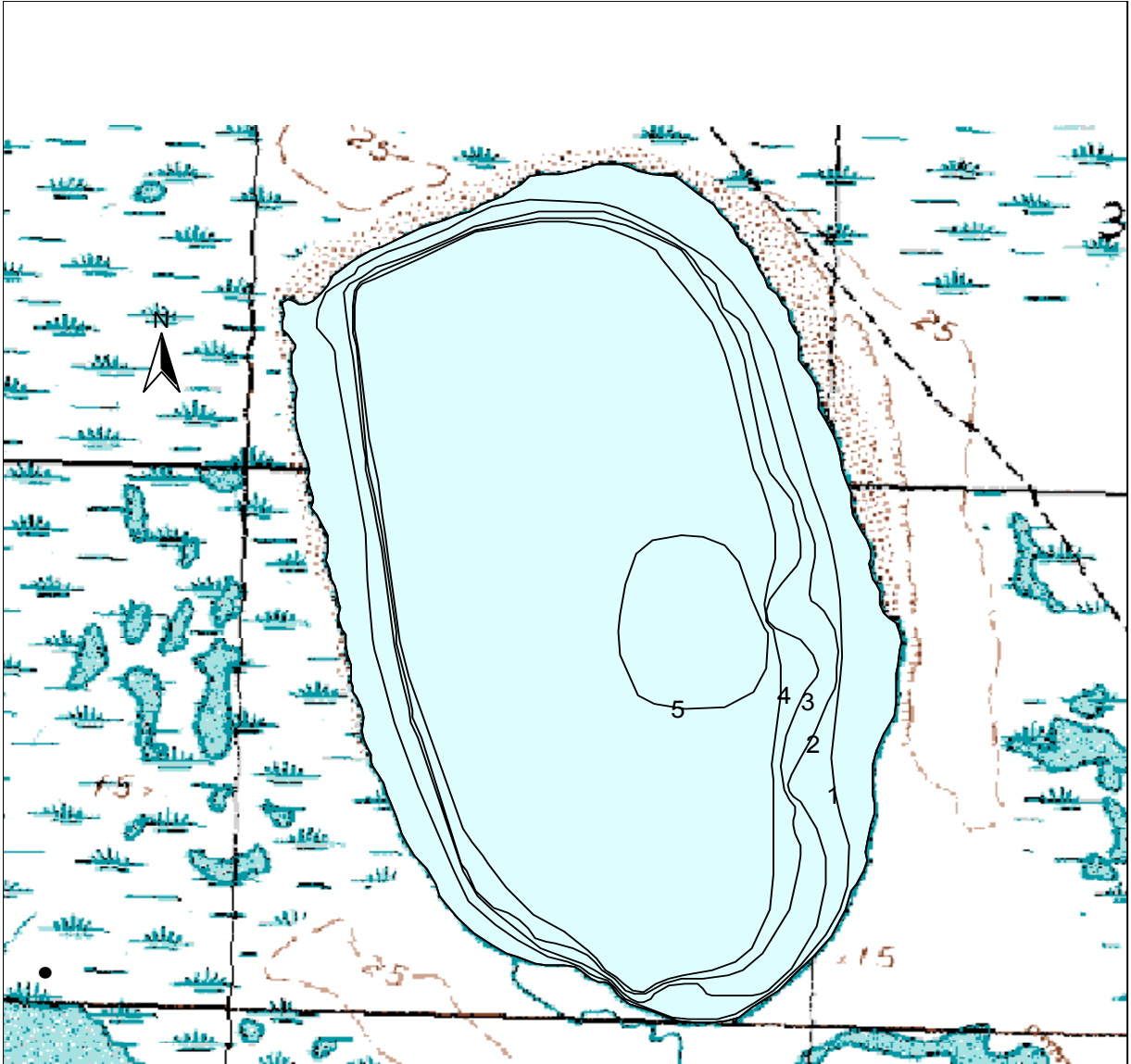




Regions of lake M0217 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 29, 2002.



Depth transects surveyed on lake M0217, July 29, 2002.



2000 0 2000 4000 Feet

Depth contours based on transects surveyed on lake M0218, July 30, 2002 (contours in 1 foot intervals).

Lake M0218

Other Names:

Location: 70° 51' 35.2"N 154° 59' 41.6"W

USGS Quad Sheet: T17/18N R12W, Sec. 3/34

Habitat:

Area: 717.2 acres

Maximum Depth: 7.5 feet

Active Outlet:

Turbidity: 5.8 NTU

Spec. Conductance: 249.3 μ S/cm

pH: 7.9

Calculated Volume: 872.73 million gallons

Permittable Volume: 0.00 million gallons

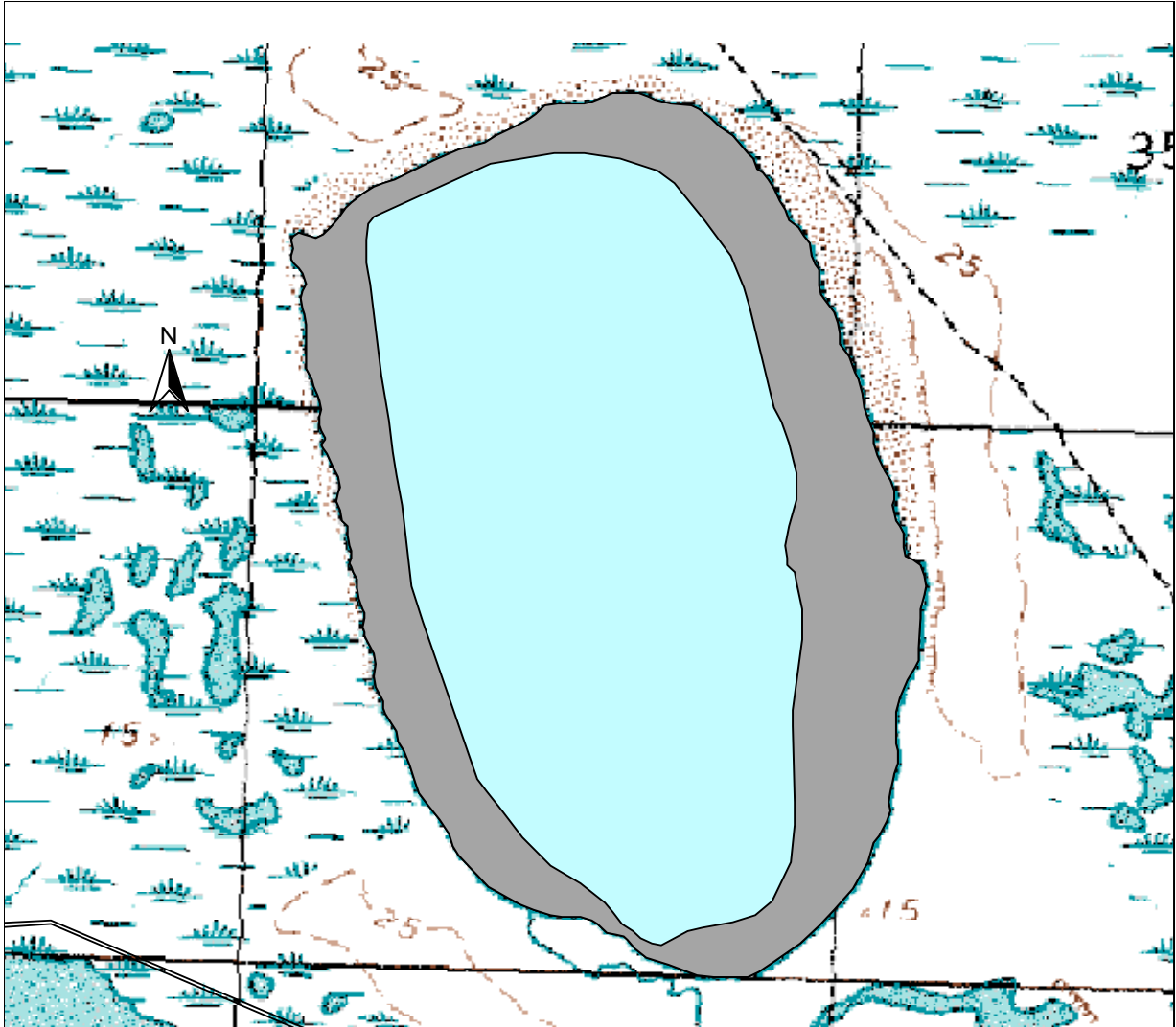
Potential Aggregate: 278.00 acres (water depth 4 ft or less)

Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	21.6	5.5	16.8	34.1	75		this study

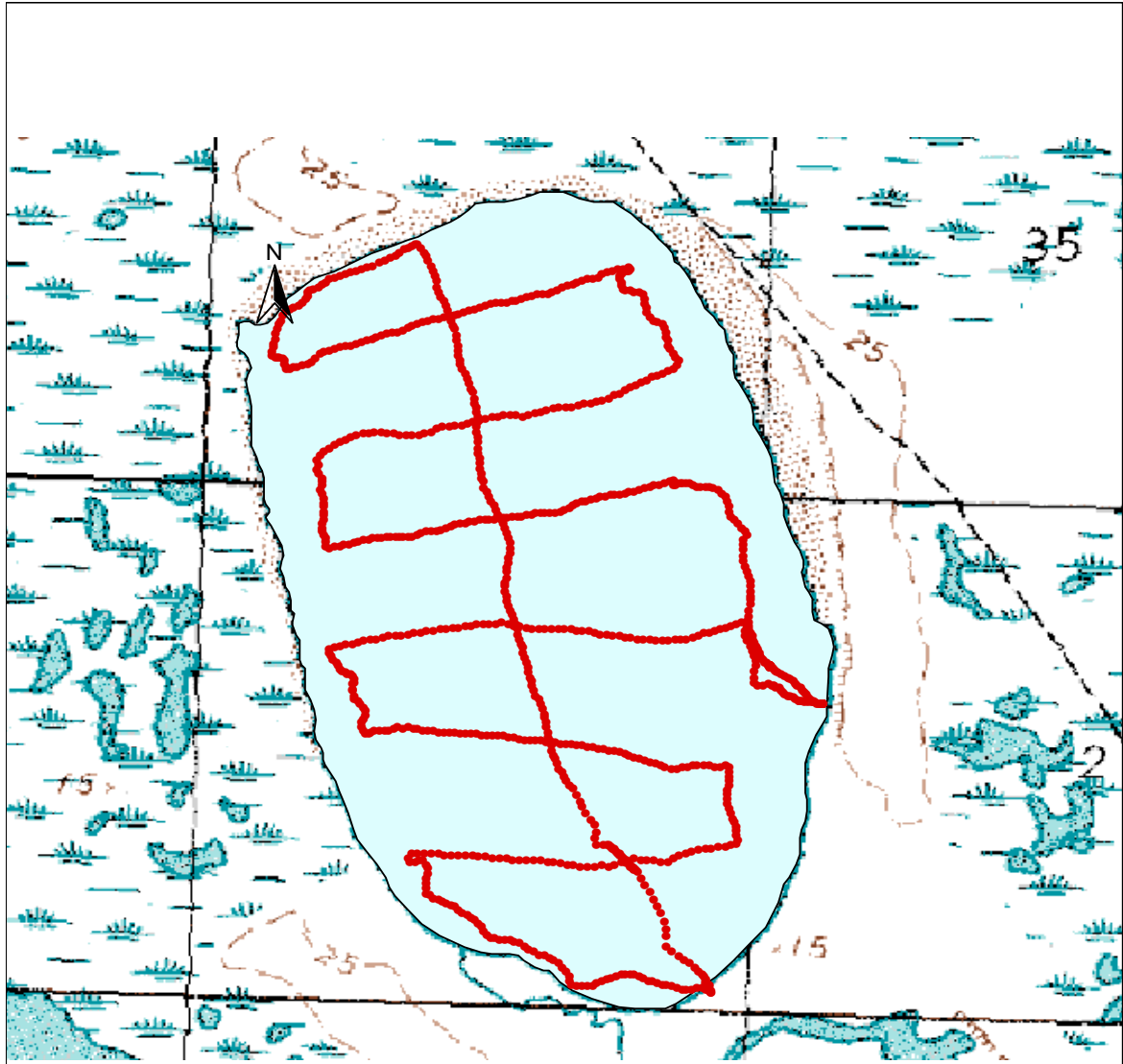
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
not sampled - connected to river				



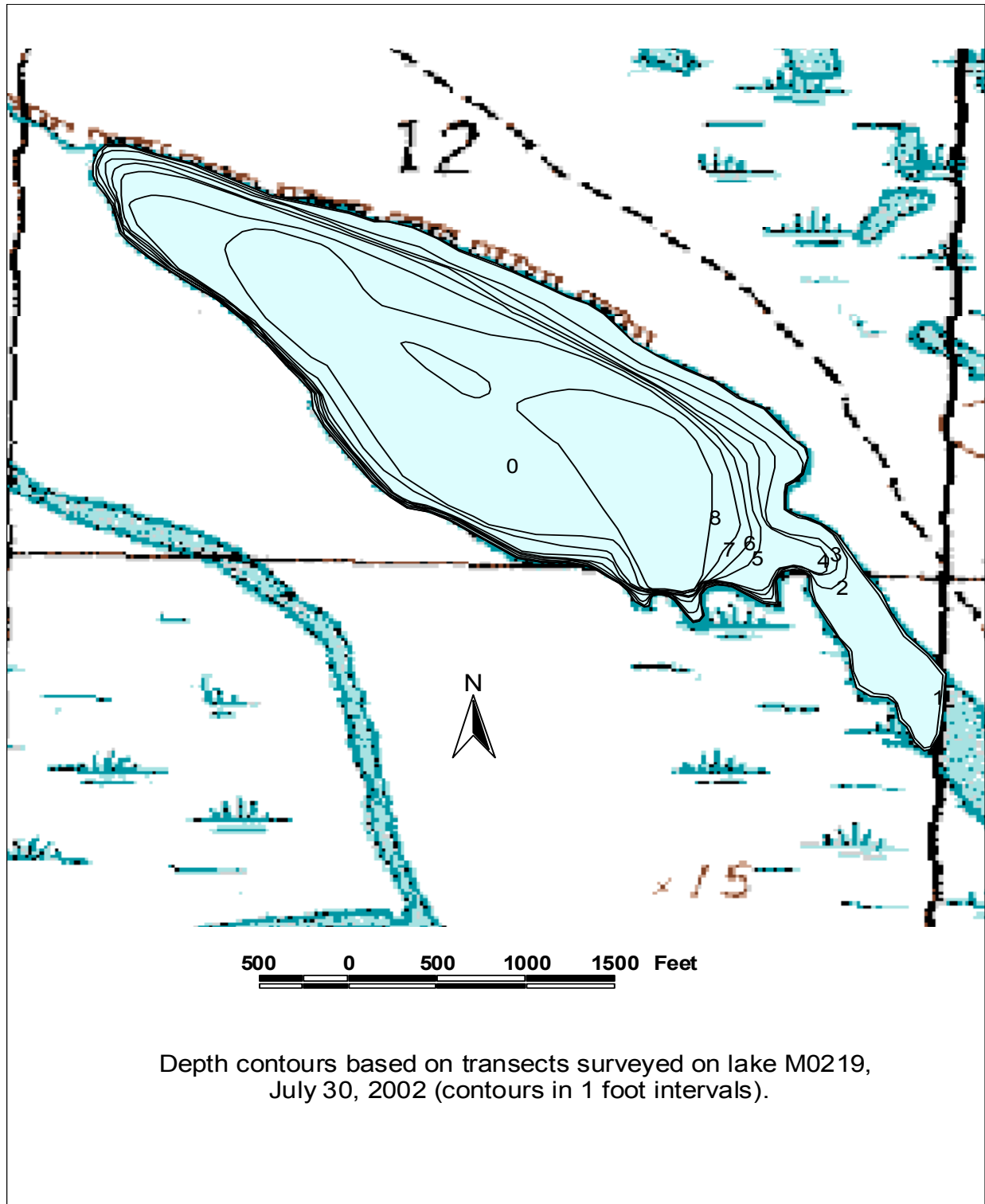
2000 0 2000 4000 Feet

Regions of lake M0218 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 30, 2002.



2000 0 2000 4000 Feet

Depth transects surveyed on lake M0218, July 30, 2002.



Lake M0219

Other Names:

Location: 70° 50' 11.4"N 154° 54' 42.2"W

USGS Quad Sheet: T17N R12W, Sec. 12

Habitat:

Area: 129.6 acres

Maximum Depth: 9.8 feet

Active Outlet:

Turbidity: 2.0 NTU

Spec. Conductance: 304.1 μ S/cm

pH: 7.9

Calculated Volume: 245.75 million gallons

Permittable Volume: 2.20 million gallons

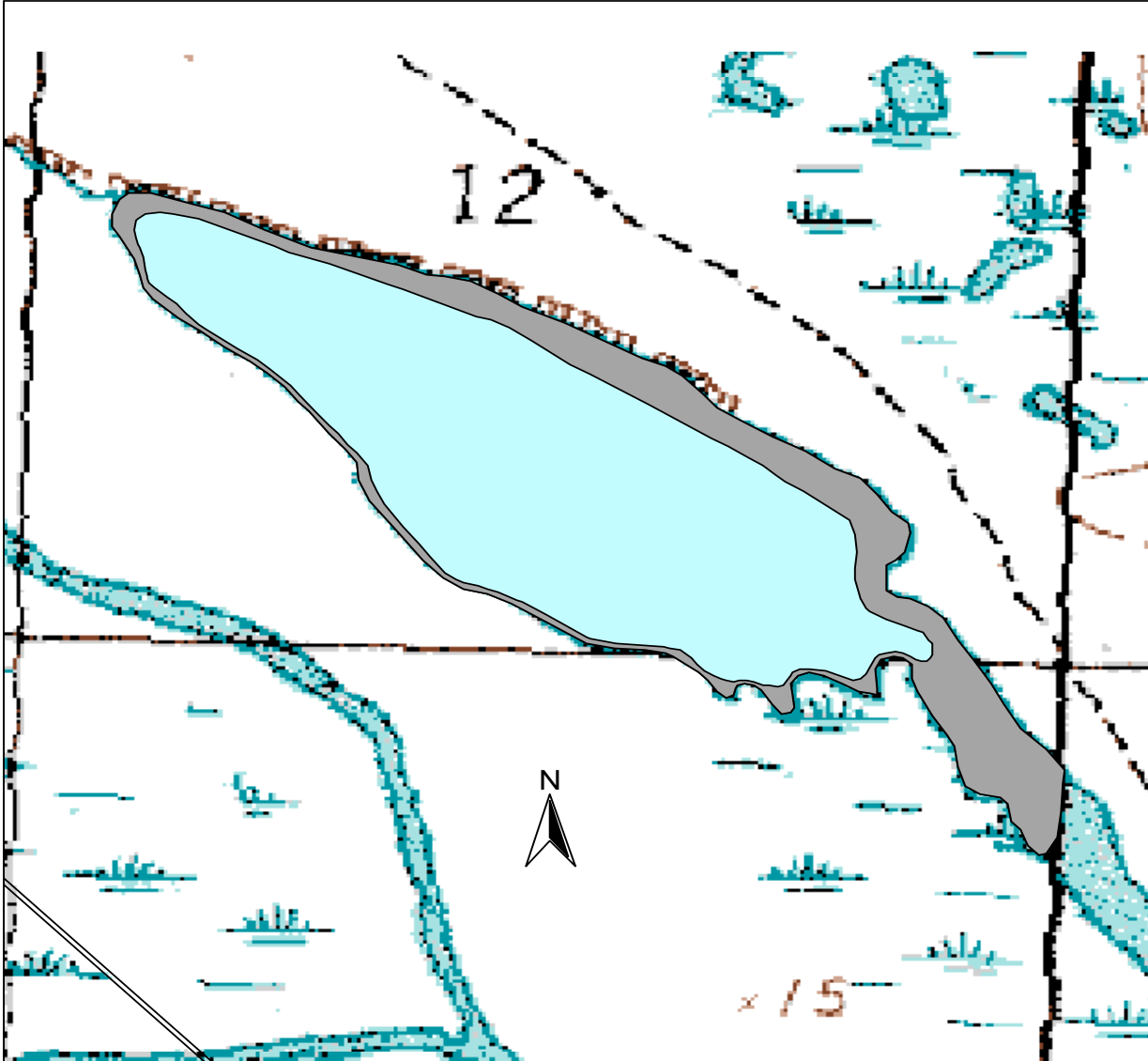
Potential Aggregate: 33.20 acres (water depth 4 ft or less)

Water Quality:

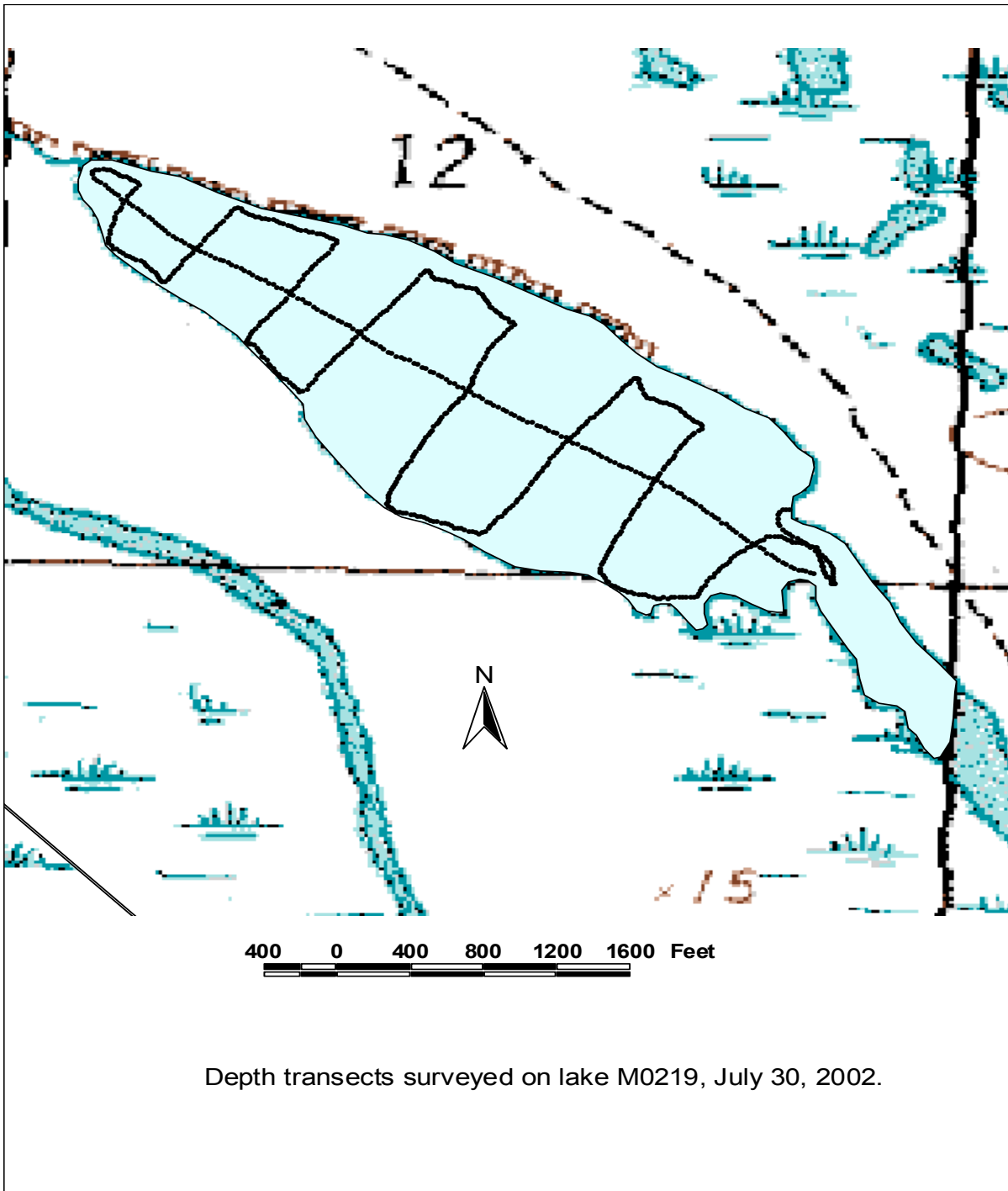
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	23.5	6.0	24.1	49.6	84		this study

Catch Record:

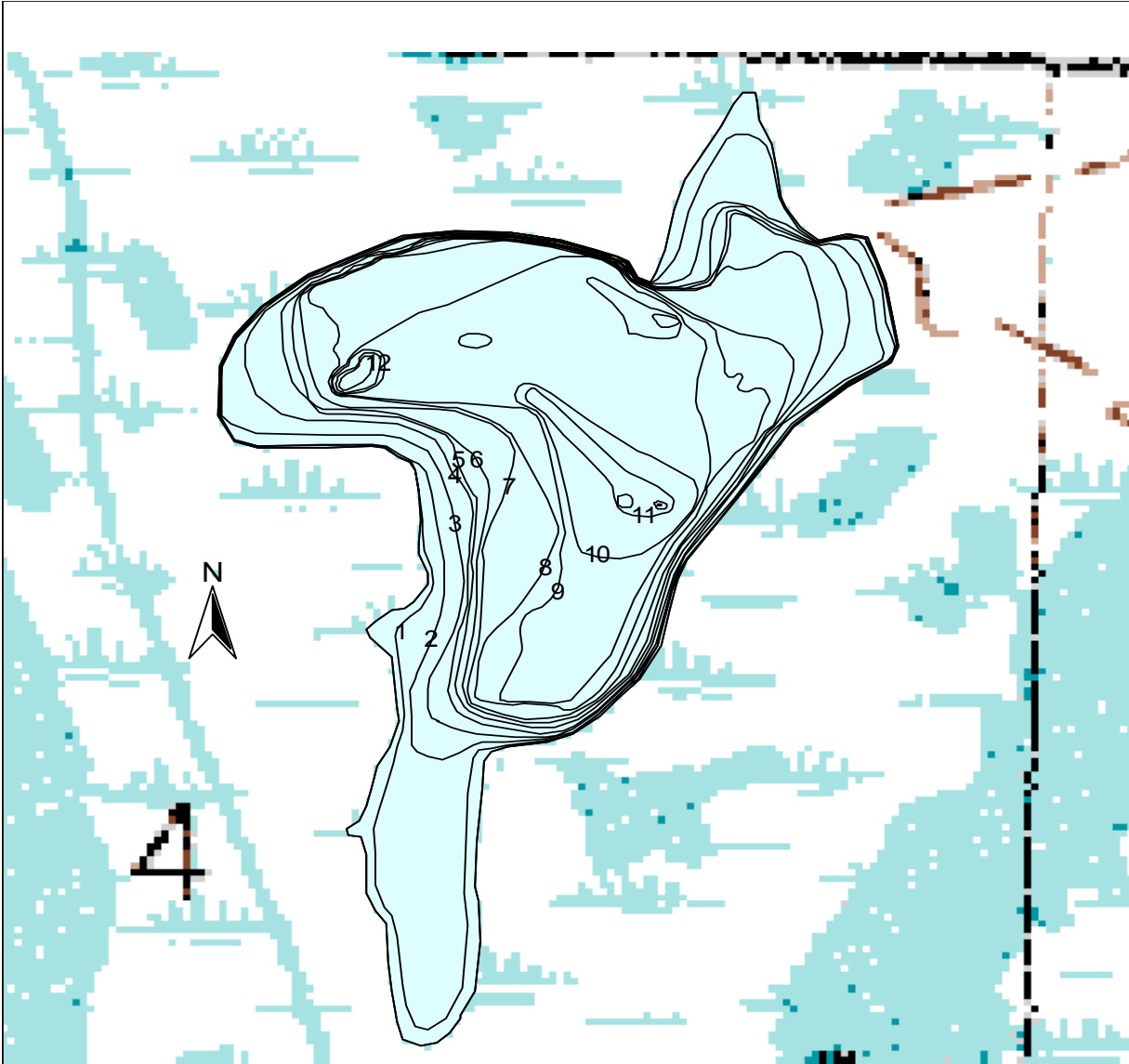
Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 30 02	2.8	Least cisco	1	257



Regions of lake M0219 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 30, 2002.



Depth transects surveyed on lake M0219, July 30, 2002.



400 0 400 800 Feet

Depth contours based on transects surveyed on lake M0220, July 31, 2002 (contours in 1 foot intervals).

Lake M0220

Other Names:

Location: 70° 46' 20.1"N 154° 43' 28.6"W

USGS Quad Sheet: T16N R11W, Sec. 4

Habitat:

Area: 51.6 acres

Maximum Depth: 13.3 feet

Active Outlet:

Turbidity: 1.1 NTU

Spec. Conductance: 316.6 μ S/cm

pH: 8.0

Calculated Volume: 106.92 million gallons

Permittable Volume: 11.34 million gallons

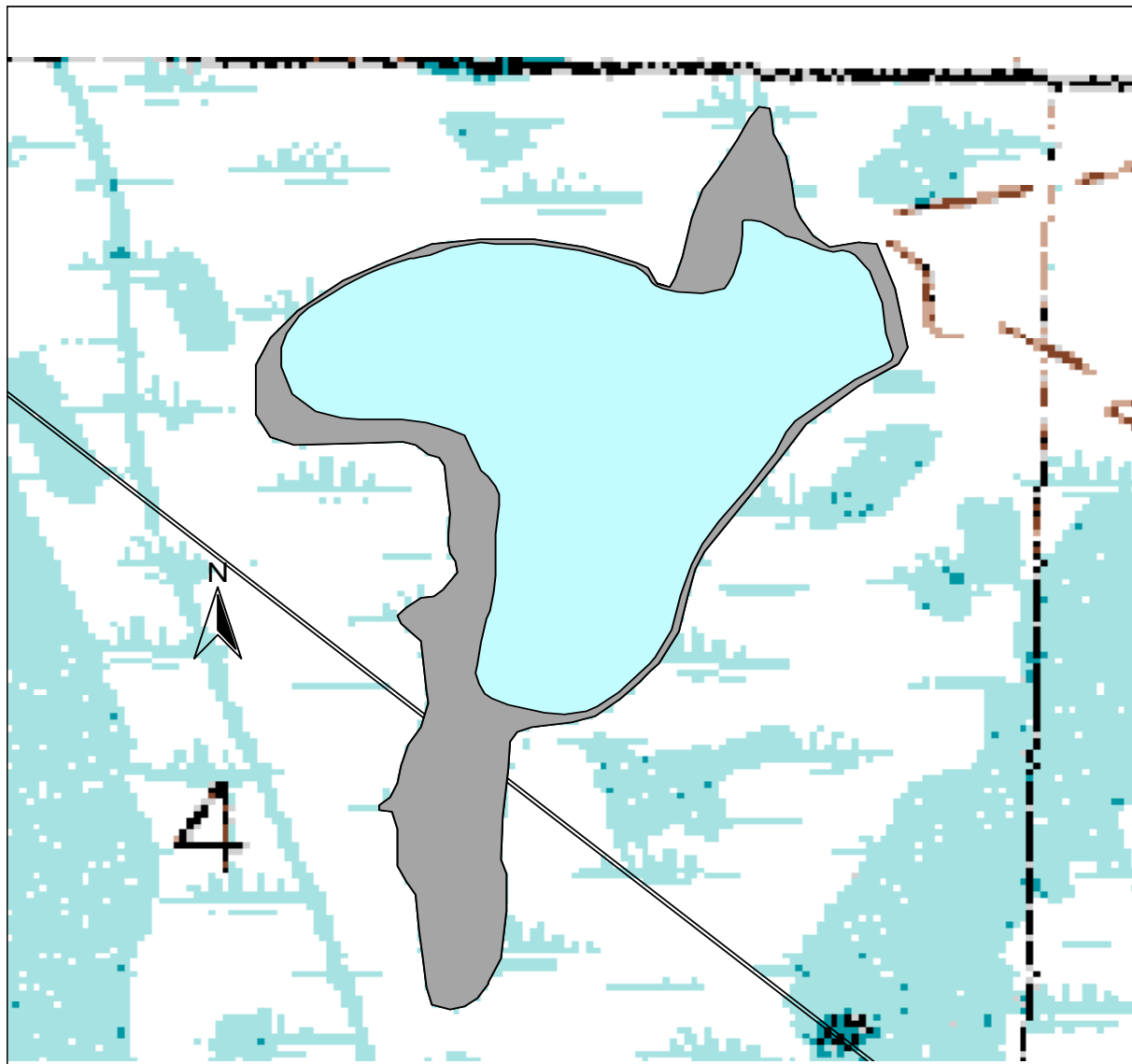
Potential Aggregate: 16.73 acres (water depth 4 ft or less)

Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	38.5	7.0	32.6	75.0	125		this study

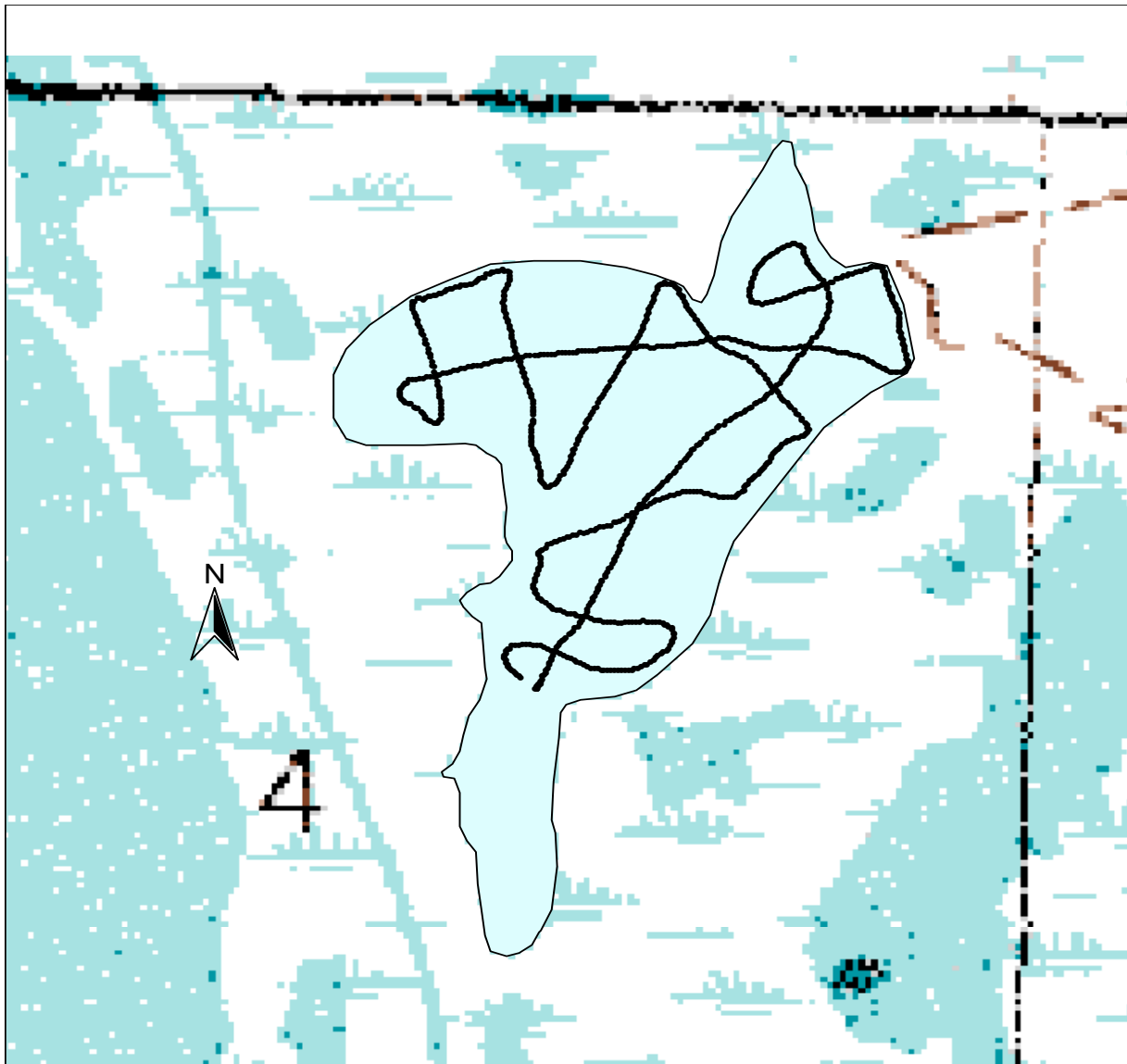
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
Gill Net	Jul 31 02	2.1	None Ninespine stickleback observed	

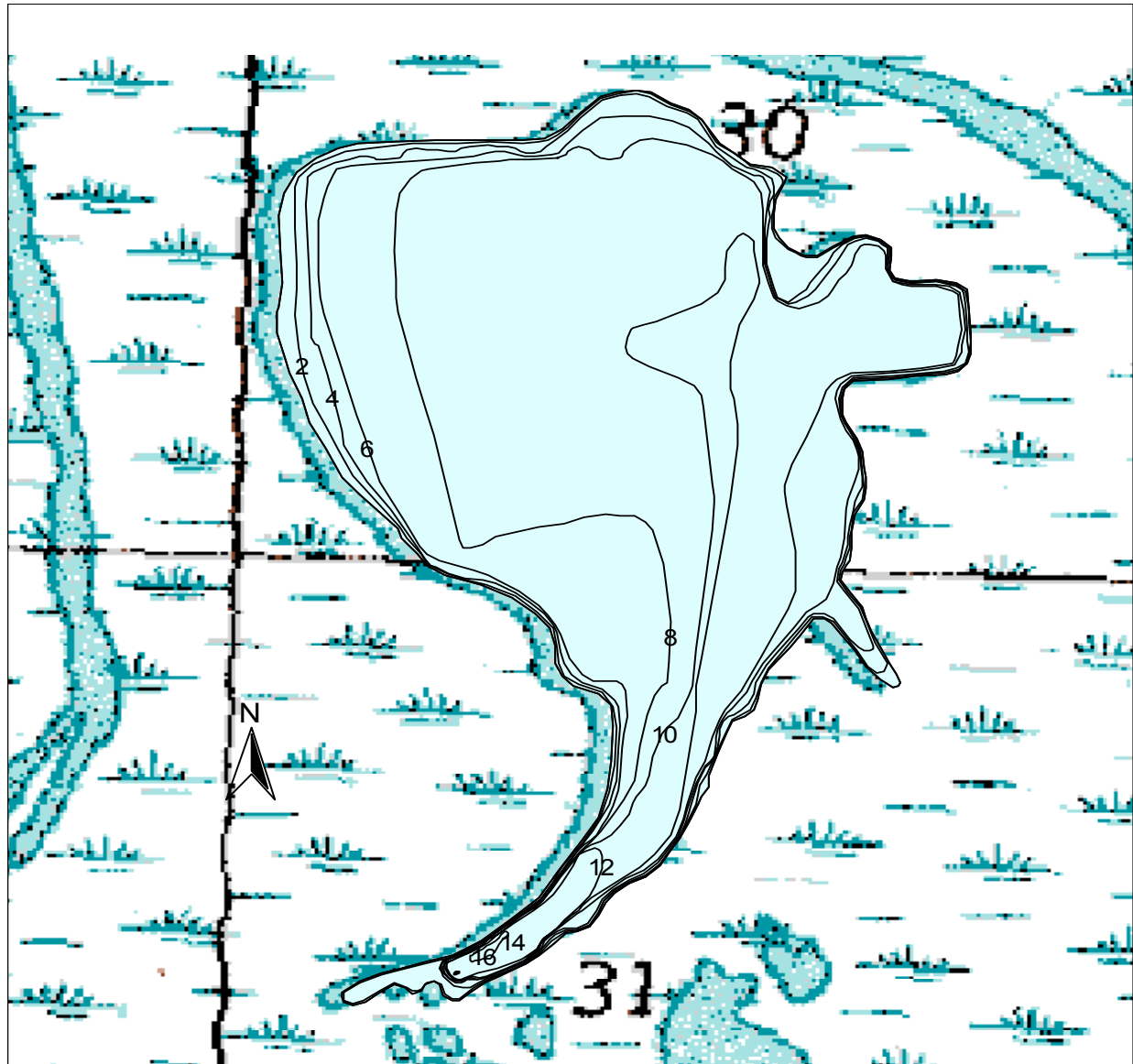


400 0 400 800 Feet

Regions of lake M0220 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 31, 2002.



Depth transects surveyed on lake M0220, July 31, 2002.



400 0 400 800 1200 1600 Feet

Depth contours based on transects surveyed on lake M0221, July 31, 2002 (contours in 2 foot intervals).

Lake M0221

Other Names:

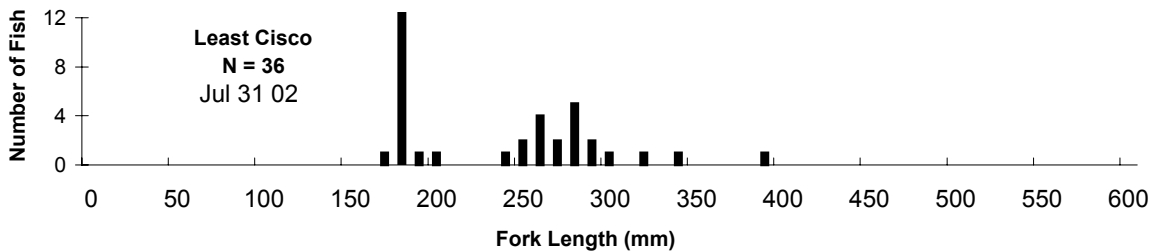
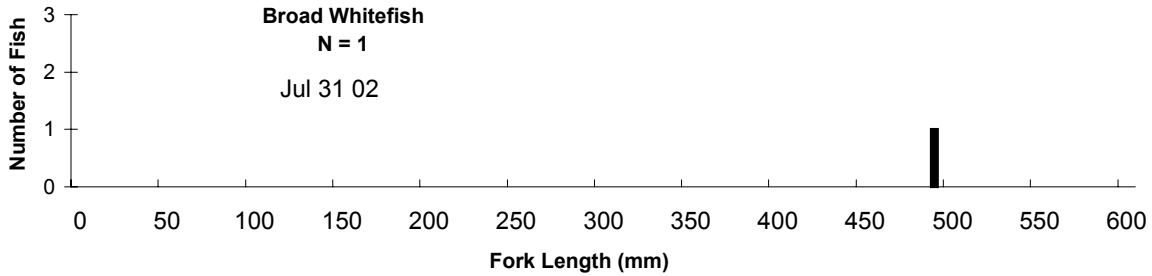
Location: 70° 47' 36.6"N 154° 52' 33.2"W
USGS Quad Sheet: T17N R11W, Sec. 30/31
Habitat:
Area: 452.1 acres
Maximum Depth: 17.6 feet
Active Outlet:
Turbidity: 1.3 NTU
Spec. Conductance: 262.6 µS/cm
pH: 8.0
Calculated Volume: 586.36 million gallons
Permittable Volume: 13.07 million gallons
Potential Aggregate: 19.75 acres (water depth 4 ft or less)

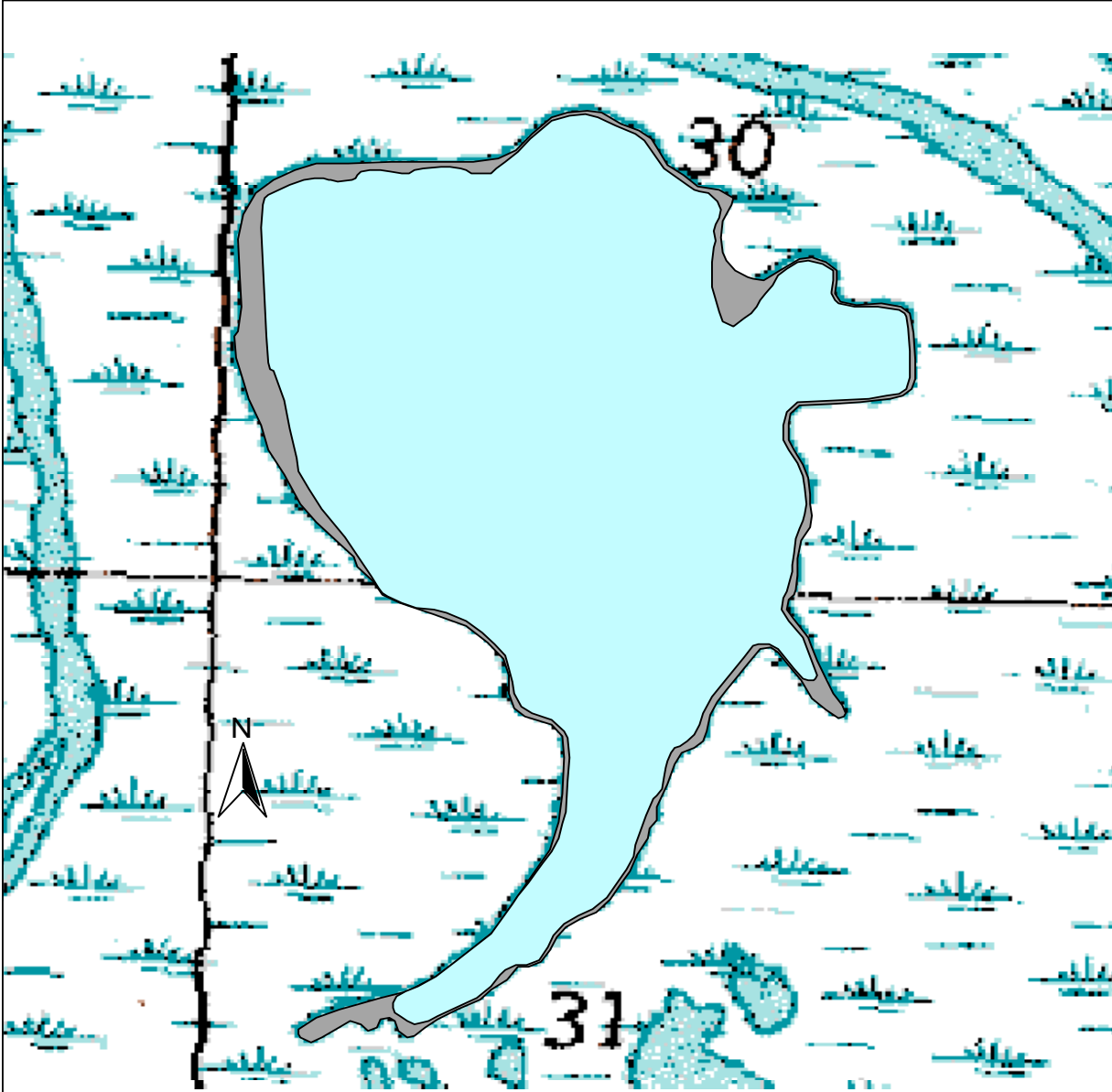
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	27.4	5.1	16.1	32.2	90		this study

Catch Record:

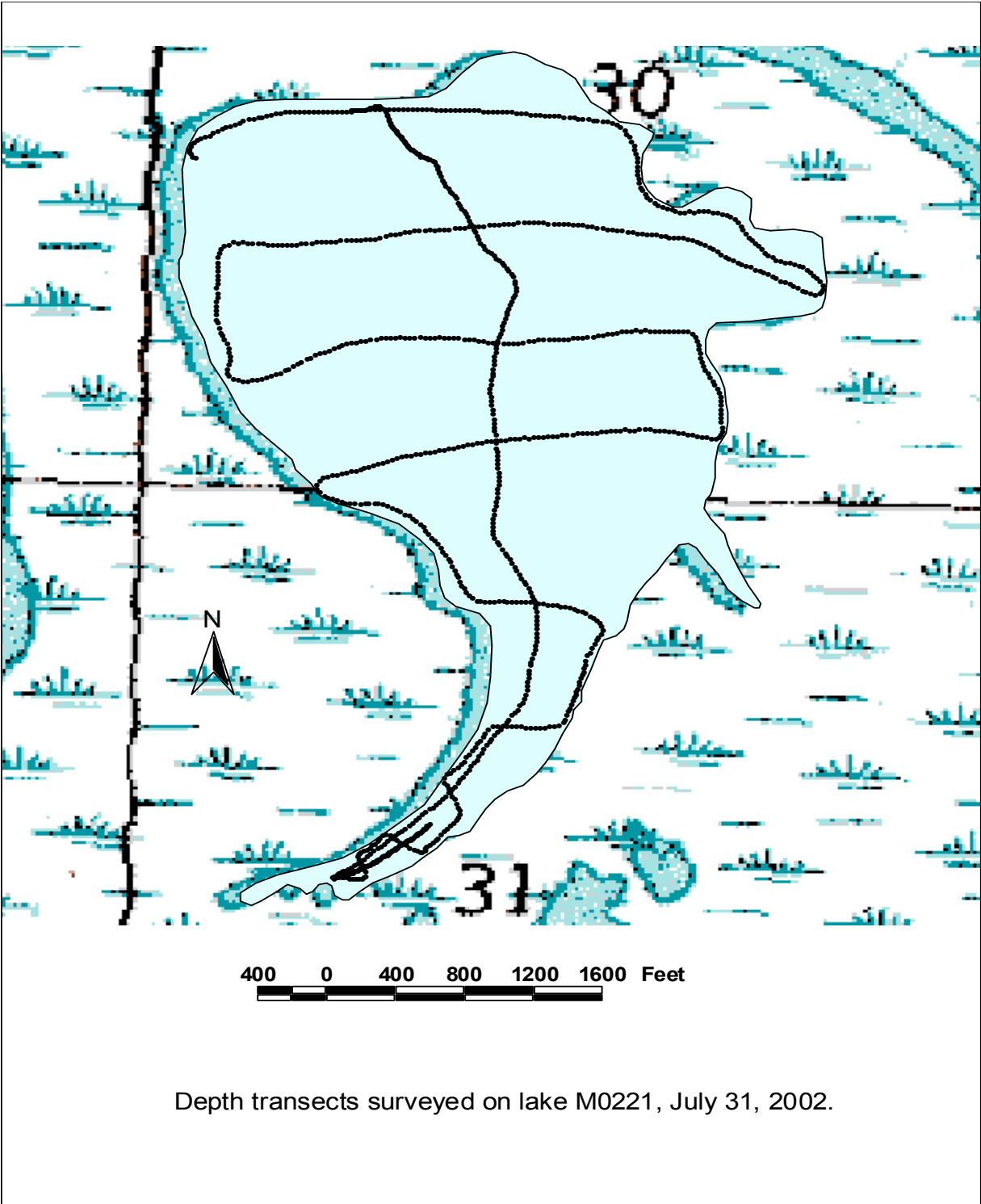
Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Jul 31 02	5.2	Broad whitefish	1	490
			Least cisco	36	178-390



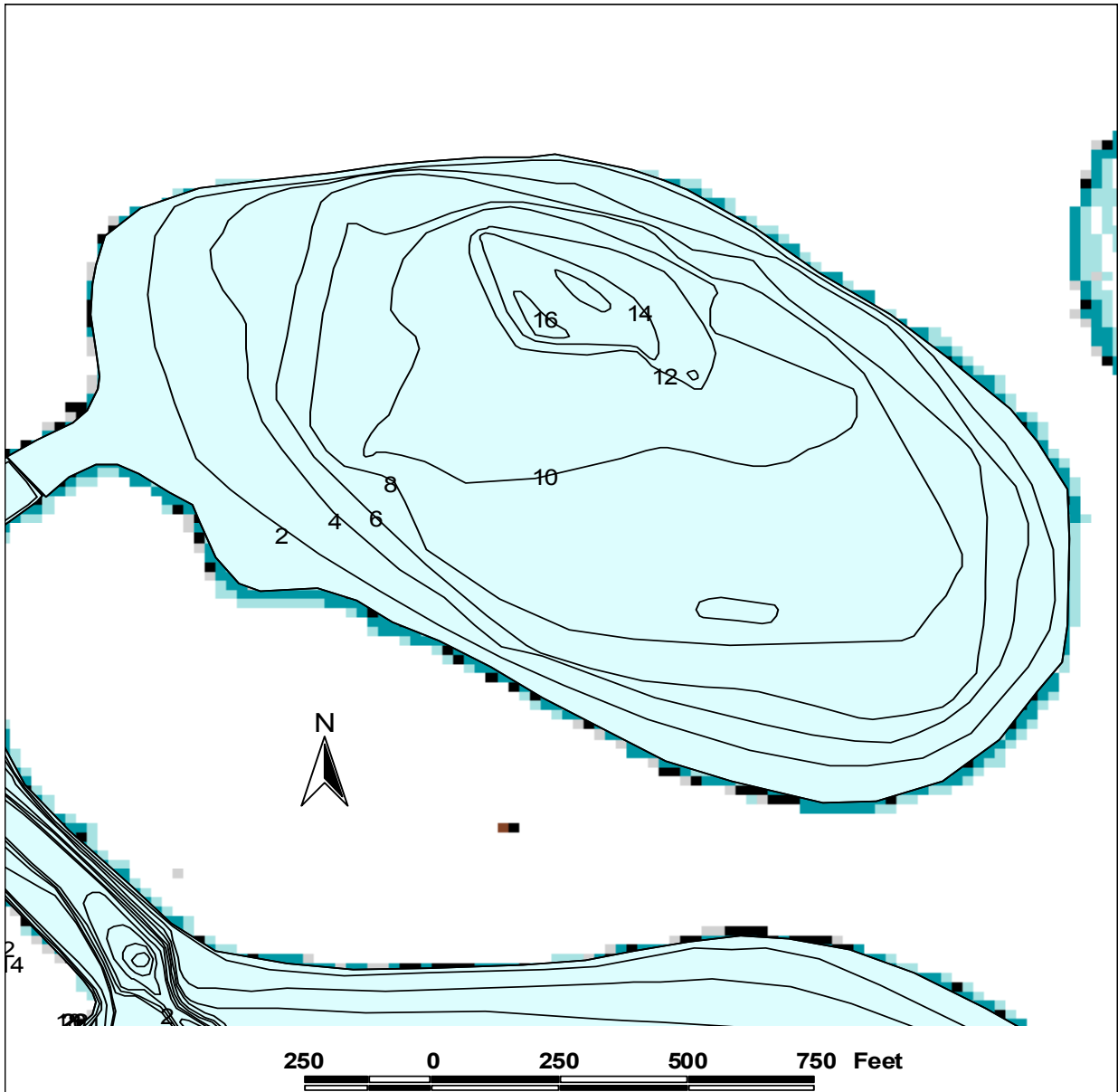


400 0 400 800 1200 1600 Feet

Regions of lake M0221 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on July 31, 2002.



Depth transects surveyed on lake M0221, July 31, 2002.



Depth contours based on transects surveyed on lake M0222, August 1, 2002 (contours in 2 foot intervals).

Lake M0222

Other Names:

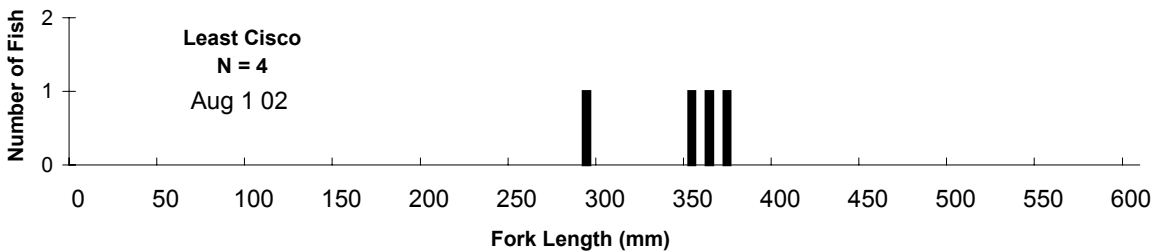
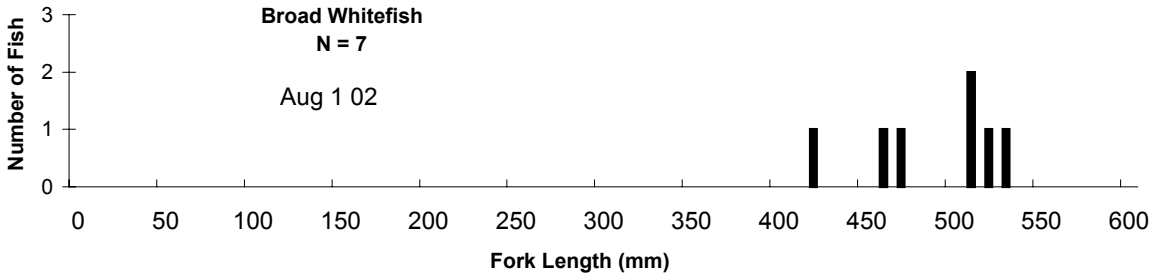
Location: 70° 44' 22.5"N 154° 38' 55.9"W
USGS Quad Sheet: T16N R11W, Sec. 14
Habitat:
Area: 82.9 acres
Maximum Depth: 17.5 feet
Active Outlet:
Turbidity: 2.1 NTU
Spec. Conductance: 149.4 µS/cm
pH: 8.0
Calculated Volume: 98.89 million gallons
Permittable Volume: 2.62 million gallons
Potential Aggregate: 12.89 acres (water depth 4 ft or less)

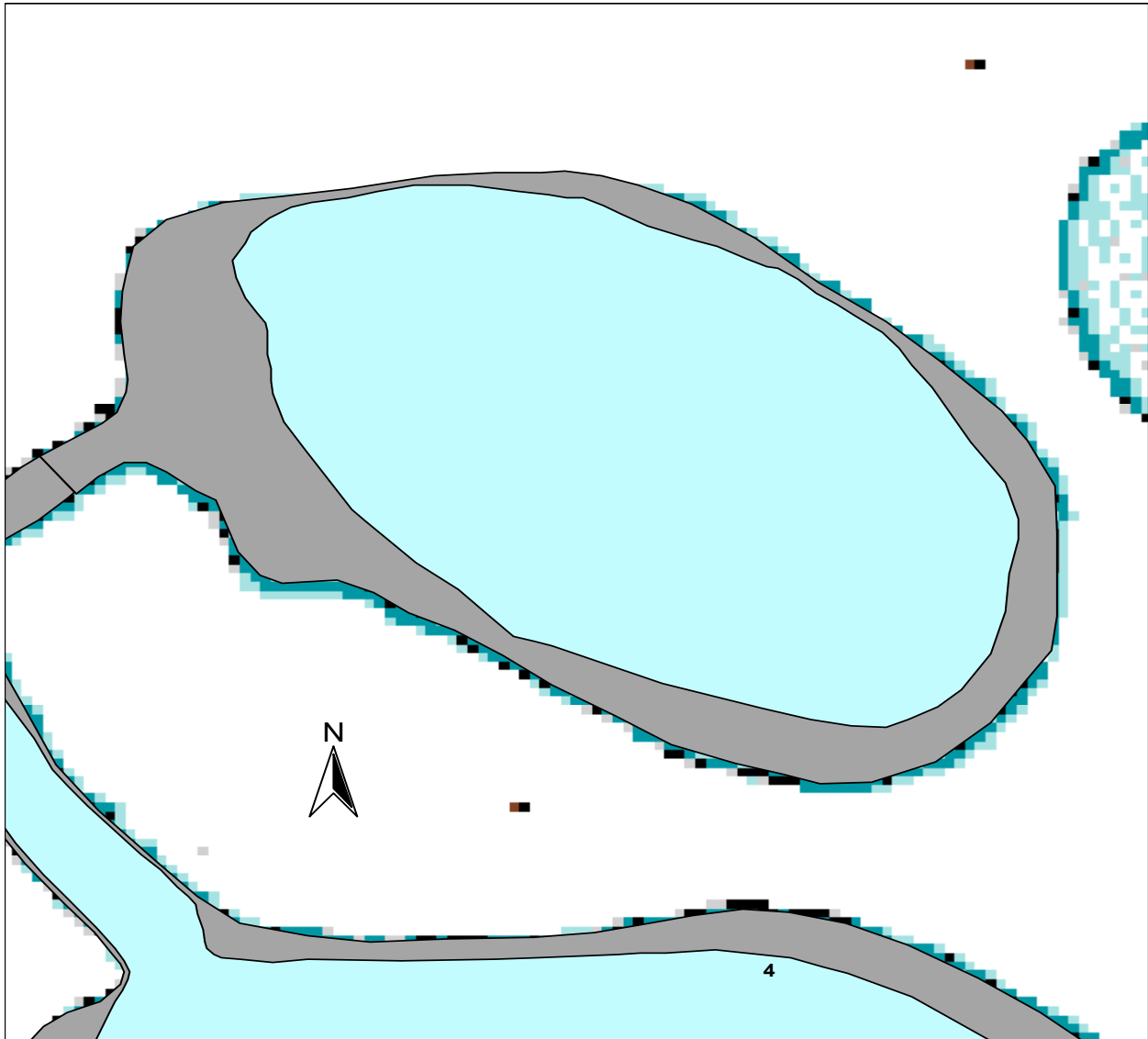
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	22.4	3.6	2.4	4.4	71		this study

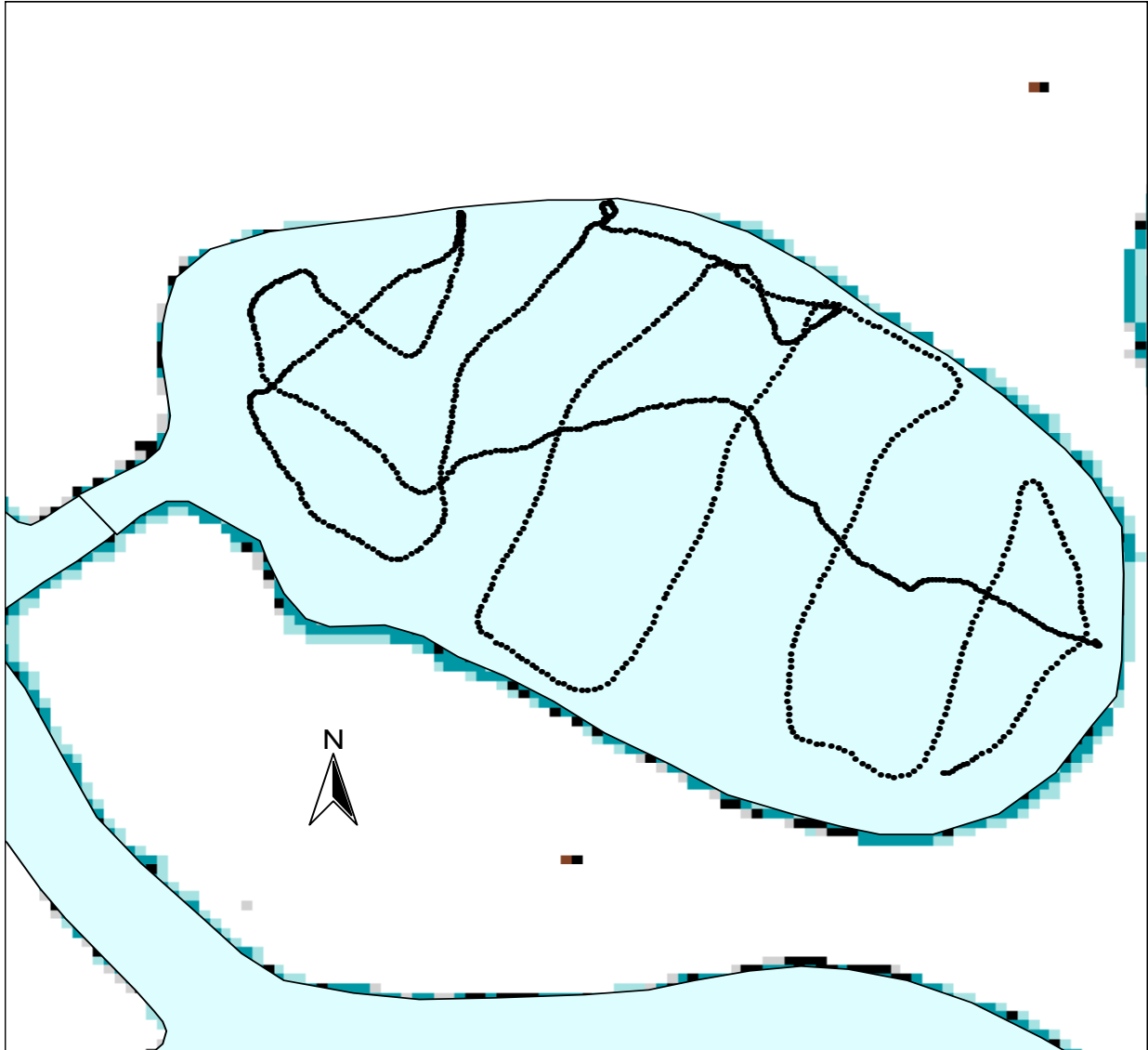
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Aug 1 02	2.5	Broad whitefish	7	425-530
			Least cisco	4	290-375

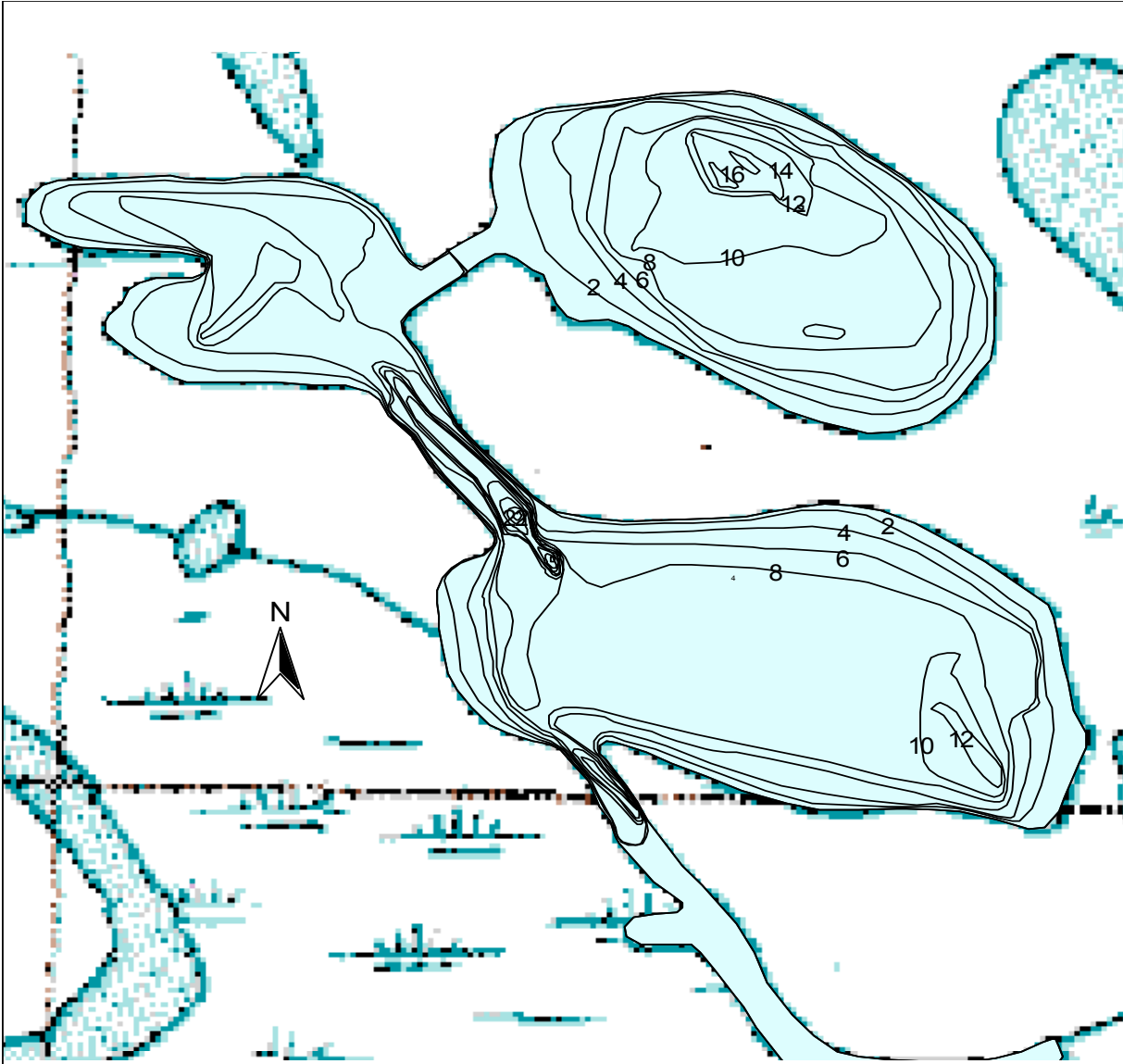




Regions of lake M0222 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on August 1, 2002.



Depth transects surveyed on lake M0222, August 1, 2002.



Depth contours based on transects surveyed on lake M0223, August 1, 2002 (contours in 2 foot intervals).

Lake M0223

Other Names:

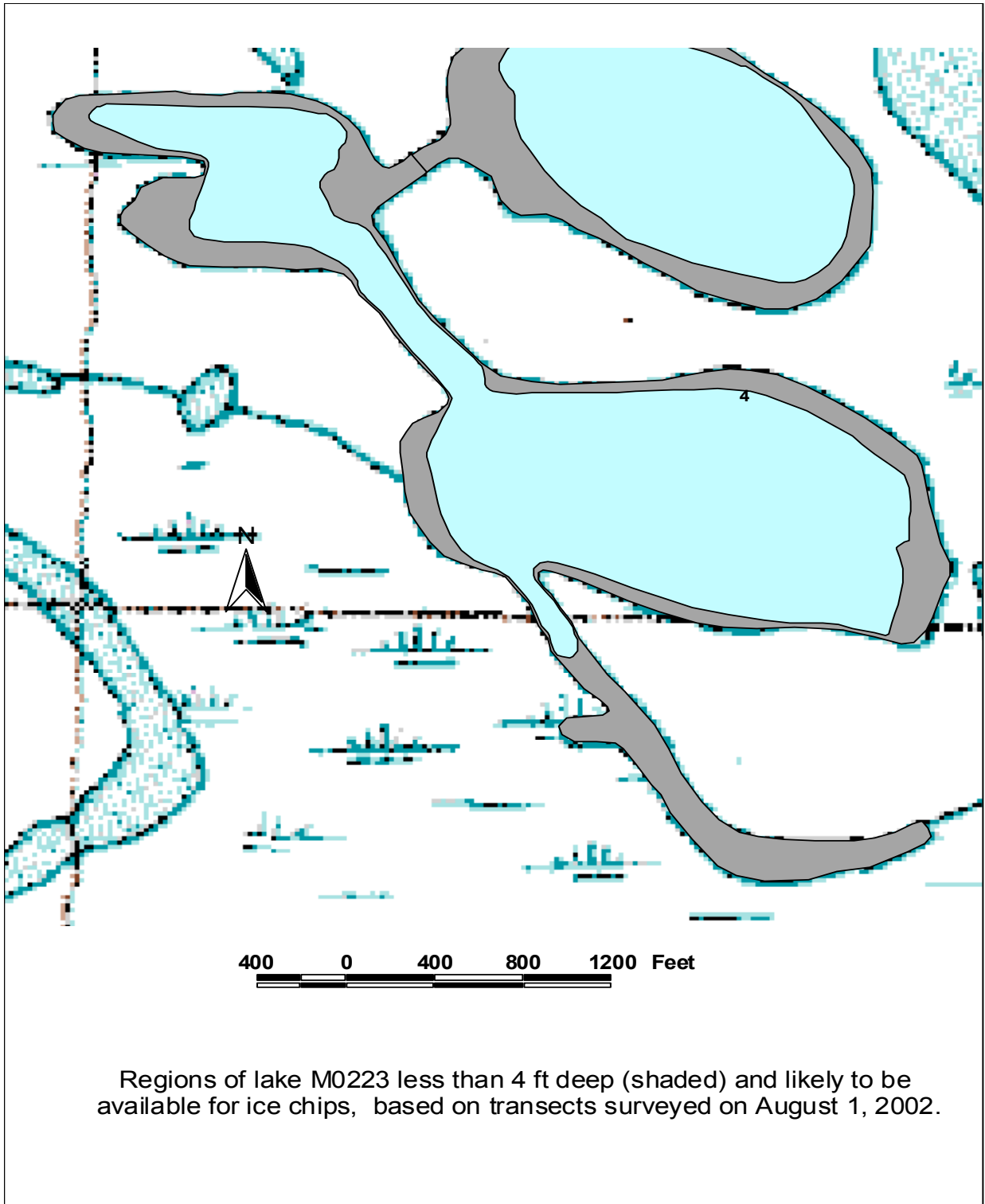
Location: 70° 44' 4.8"N 154° 38' 49.6"W
USGS Quad Sheet: T16N R11W, Sec. 14
Habitat:
Area: 171.2 acres
Maximum Depth: 23.5 feet
Active Outlet:
Turbidity: 1.7 NTU
Spec. Conductance: 151.4 μ S/cm
pH: 8.0
Calculated Volume: 183.55 million gallons
Permittable Volume: 3.79 million gallons
Potential Aggregate: 30.61 acres (water depth 4 ft or less)

Water Quality:

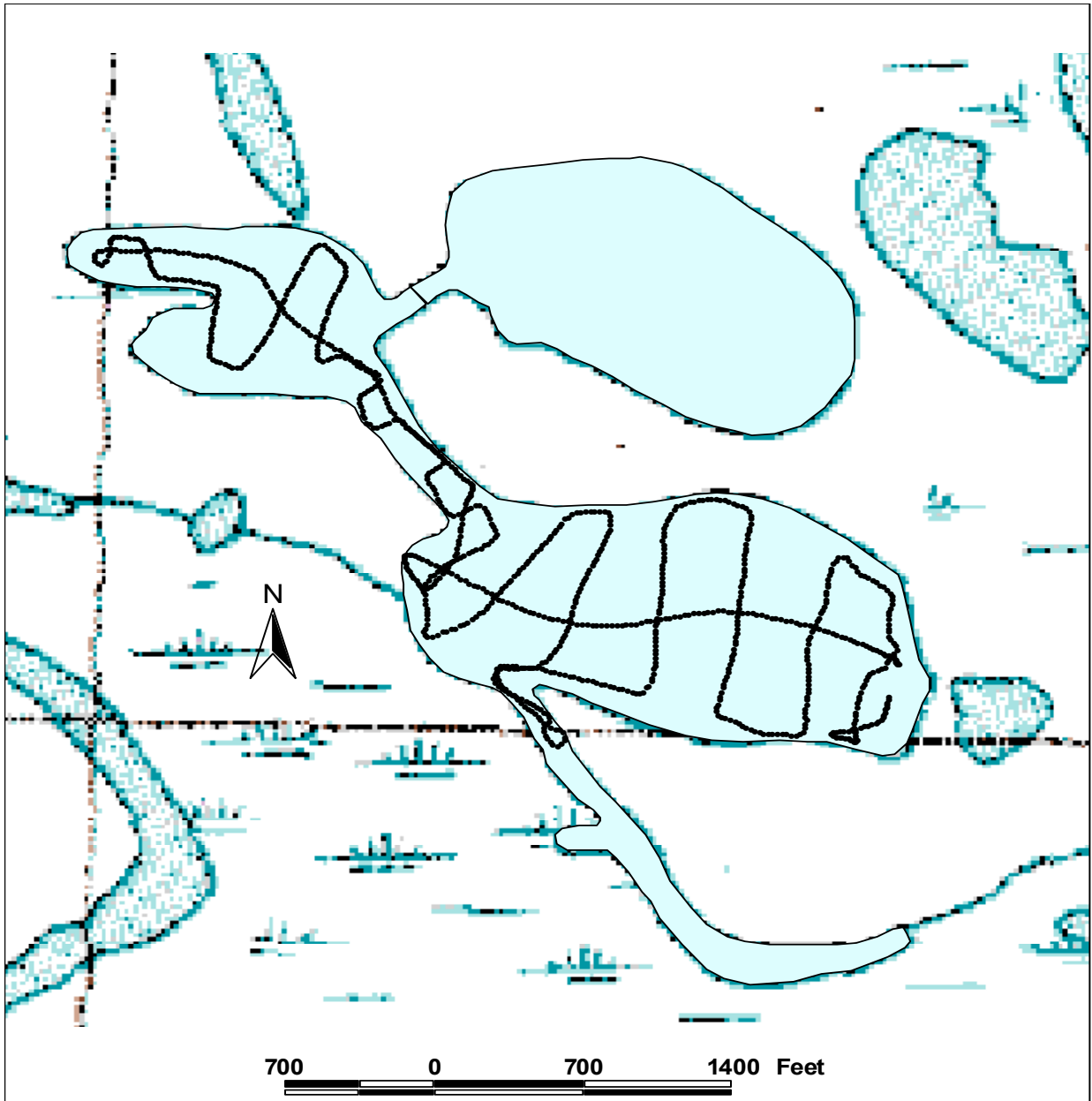
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	22.8	3.6	2.5	4.6	72		this study

Catch Record:

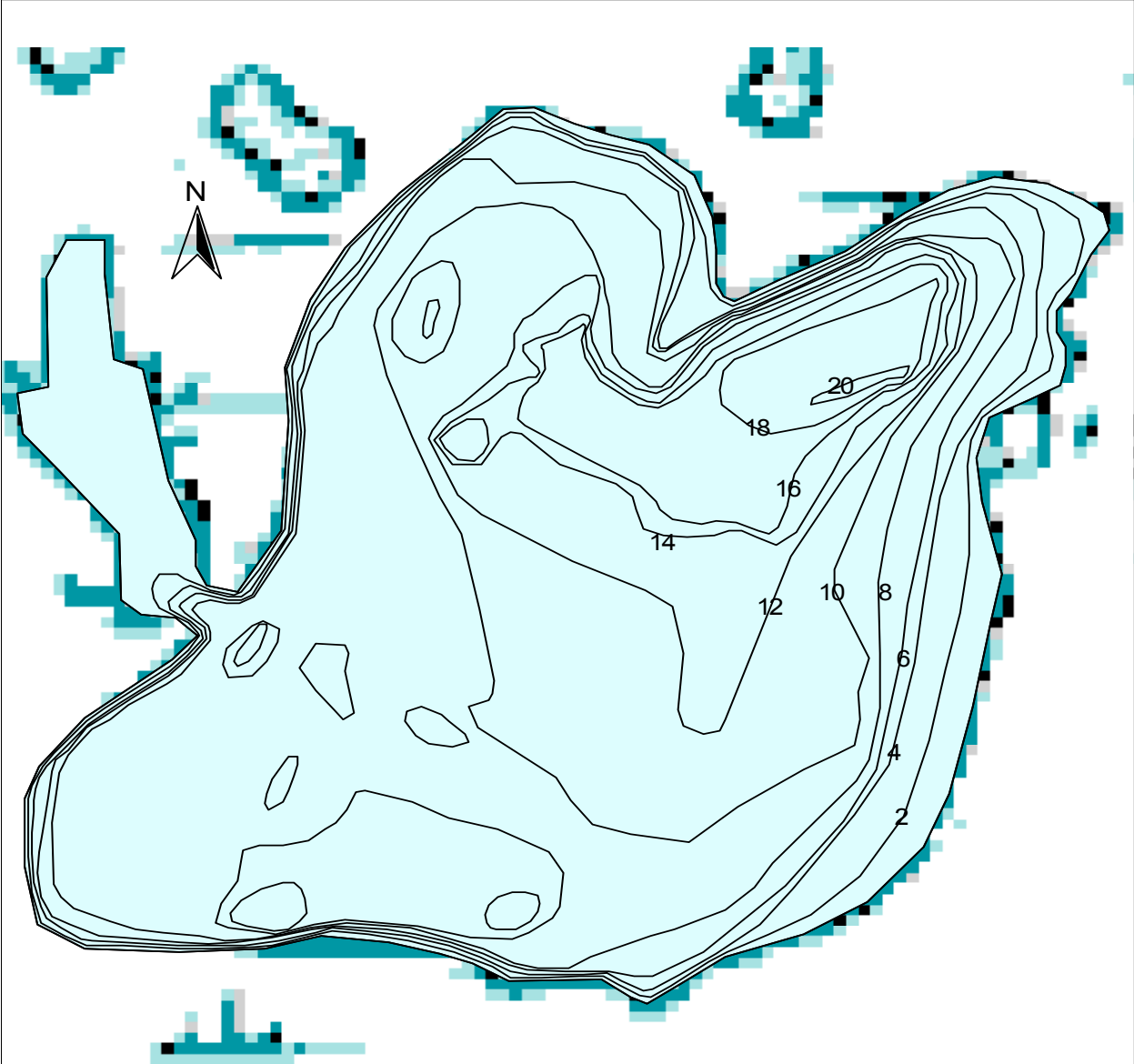
Gear	Date	Effort (hours)	Species	Number Caught
not sampled, connected to M0222				



Regions of lake M0223 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on August 1, 2002.



Depth transects surveyed on lake M0223, August 1, 2002.



200 0 200 400 600 Feet

Depth contours based on transects surveyed on lake M0224, August 2, 2002 (contours in 2 foot intervals).

Lake M0224

Other Names:

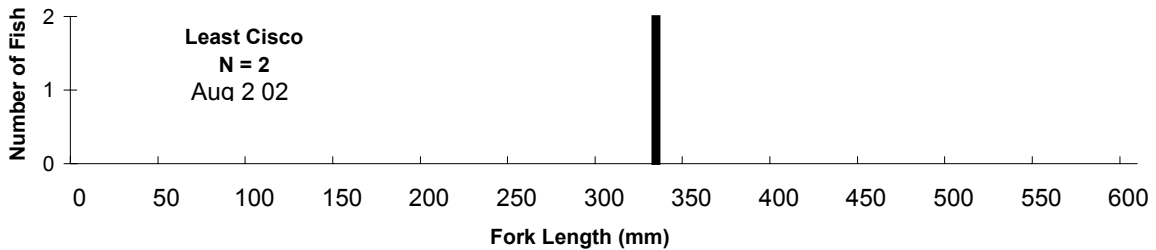
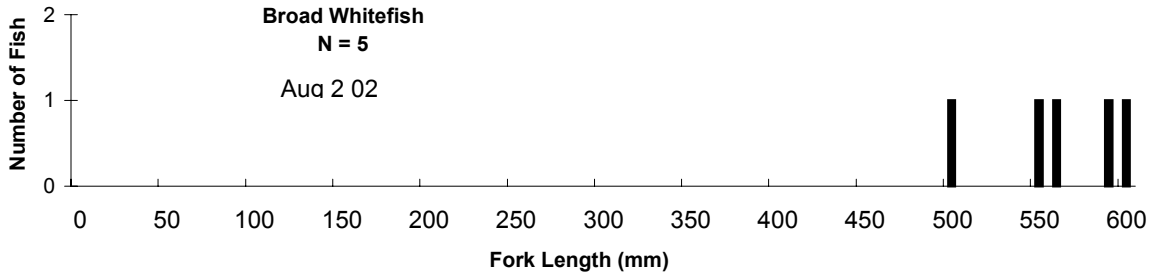
Location: 70° 40' 53.8"N 154° 31' 45.6"W
USGS Quad Sheet: T15N R10W, Sec. 5
Habitat:
Area: 99.5 acres
Maximum Depth: 20.8 feet
Active Outlet:
Turbidity: 1.0 NTU
Spec. Conductance: 184.9 µS/cm
pH: 8.0
Calculated Volume: 156.24 million gallons
Permittable Volume: 6.64 million gallons
Potential Aggregate: 8.02 acres (water depth 4 ft or less)

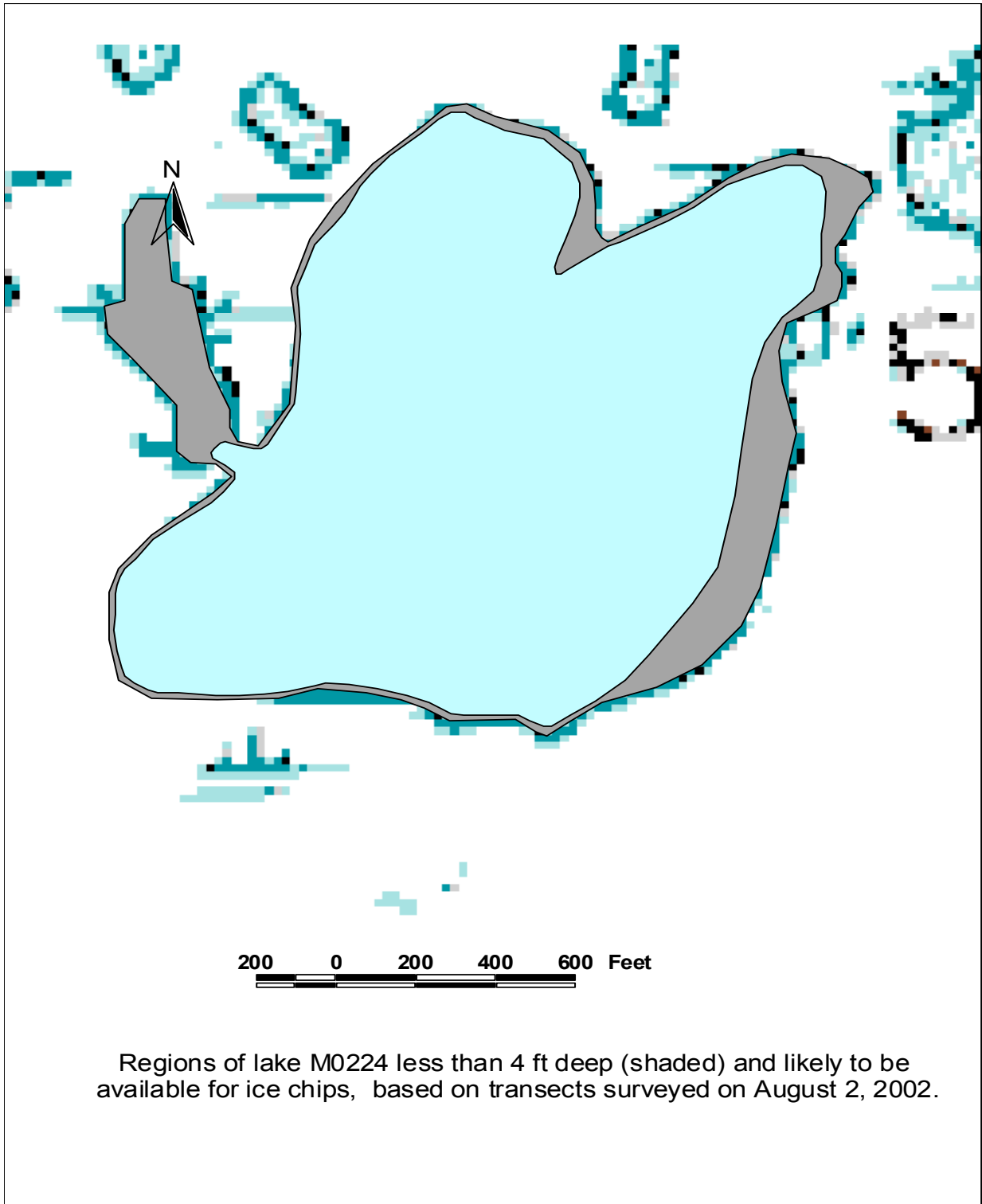
Water Quality:

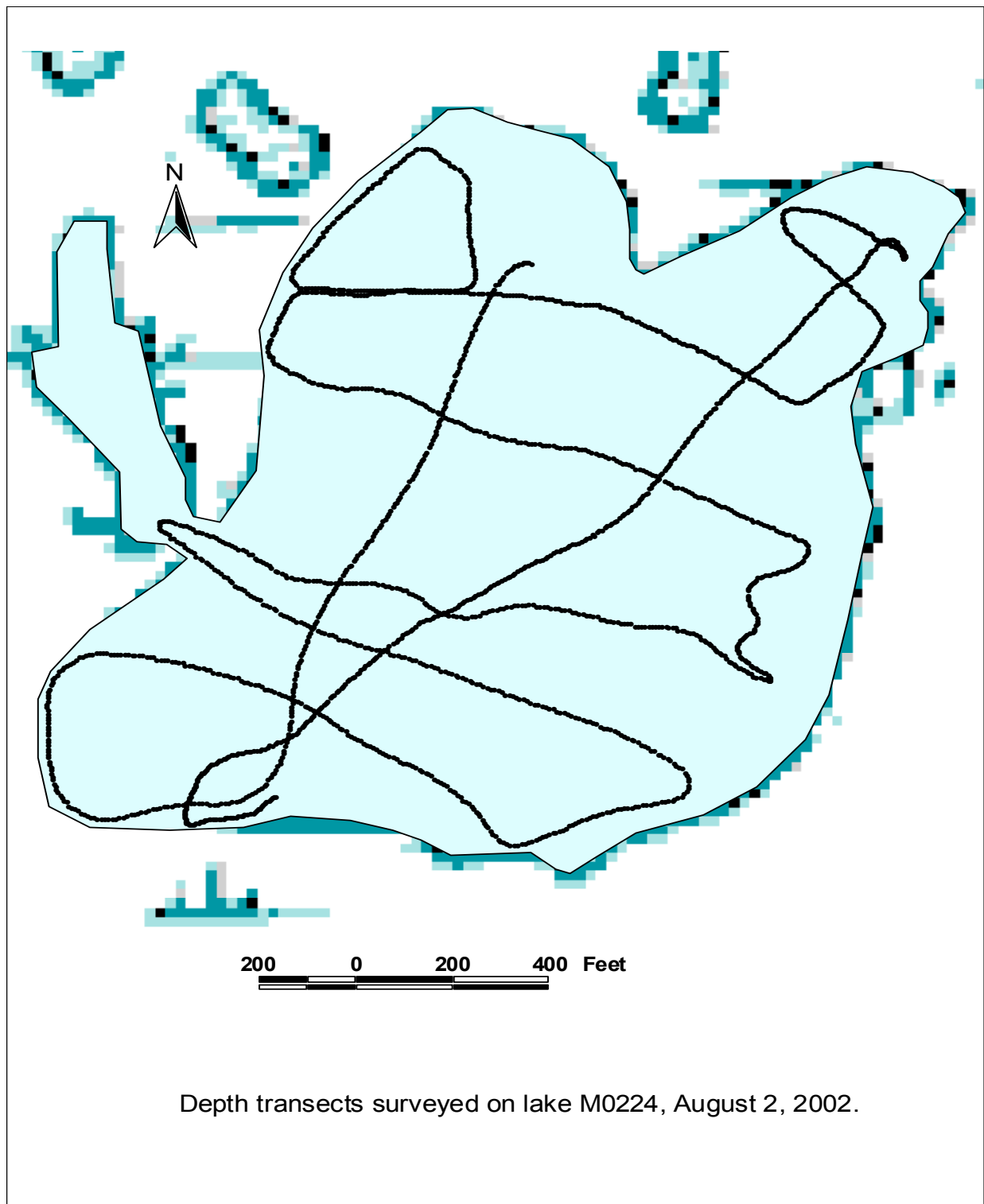
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	28.0	4.6	3.3	6.1	89	110	this study

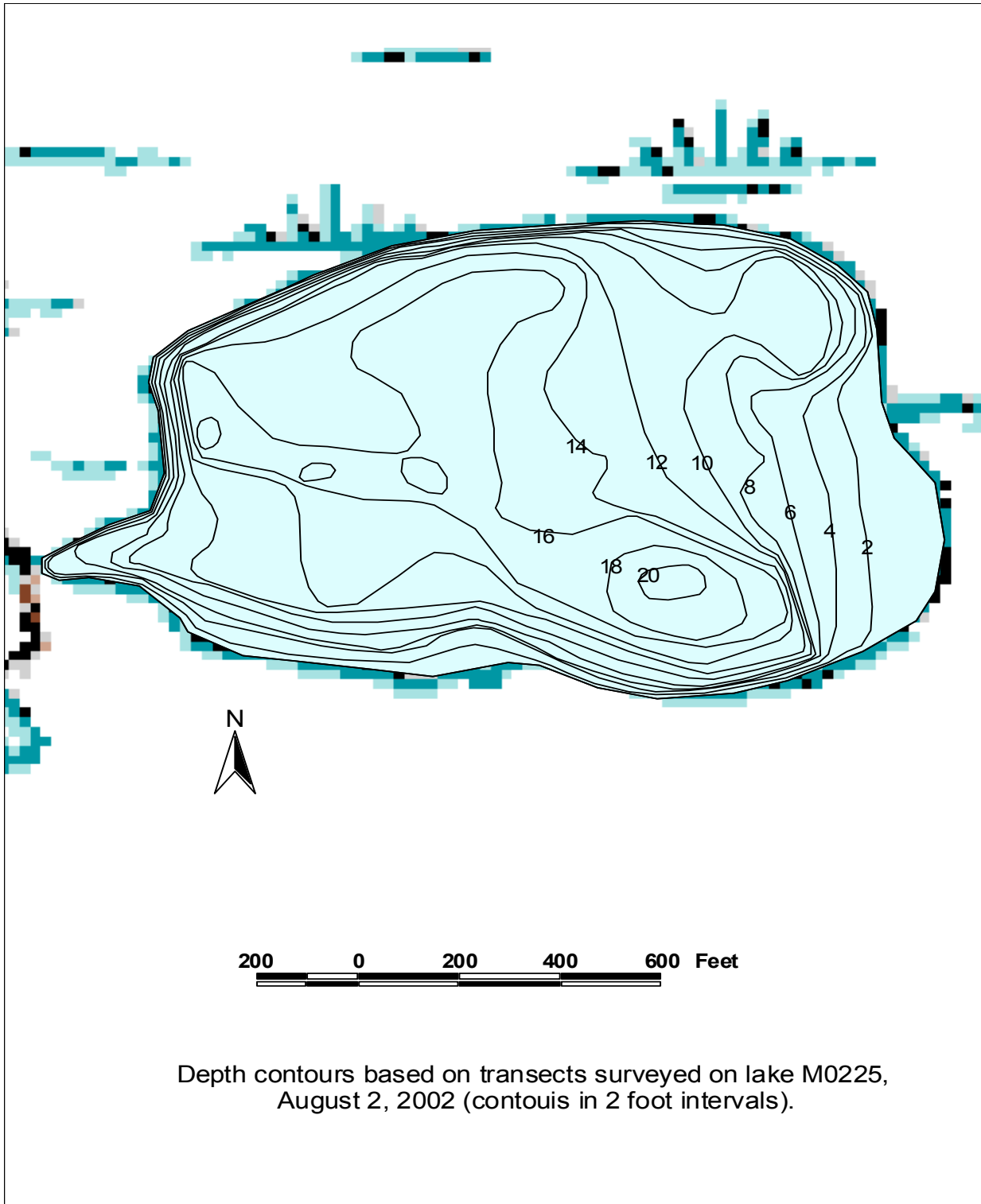
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Aug 2 02	2.2	Broad whitefish	5	505-600
			Least cisco	2	330-335









Lake M0225

Other Names:

Location: 70° 42' 45.1"N 154° 33' 7.5"W

USGS Quad Sheet: T16N R10W, Sec. 30

Habitat:

Area: 65.7 acres

Maximum Depth: 22.2 feet

Active Outlet:

Turbidity: 0.5 NTU

Spec. Conductance: 254.6 μ S/cm

pH: 8.2

Calculated Volume: 120.25 million gallons

Permittable Volume: 6.98 million gallons

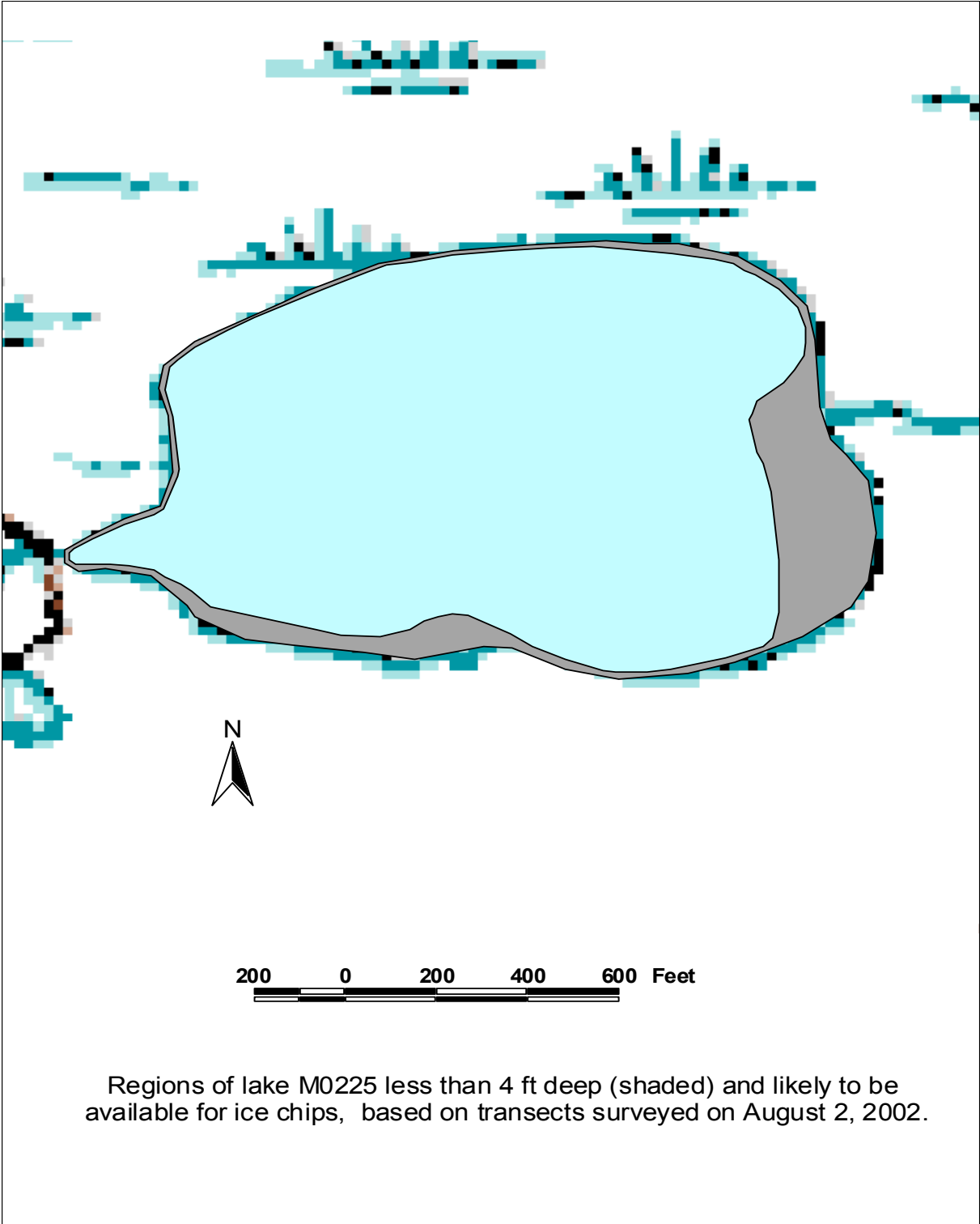
Potential Aggregate: 4.48 acres (water depth 4 ft or less)

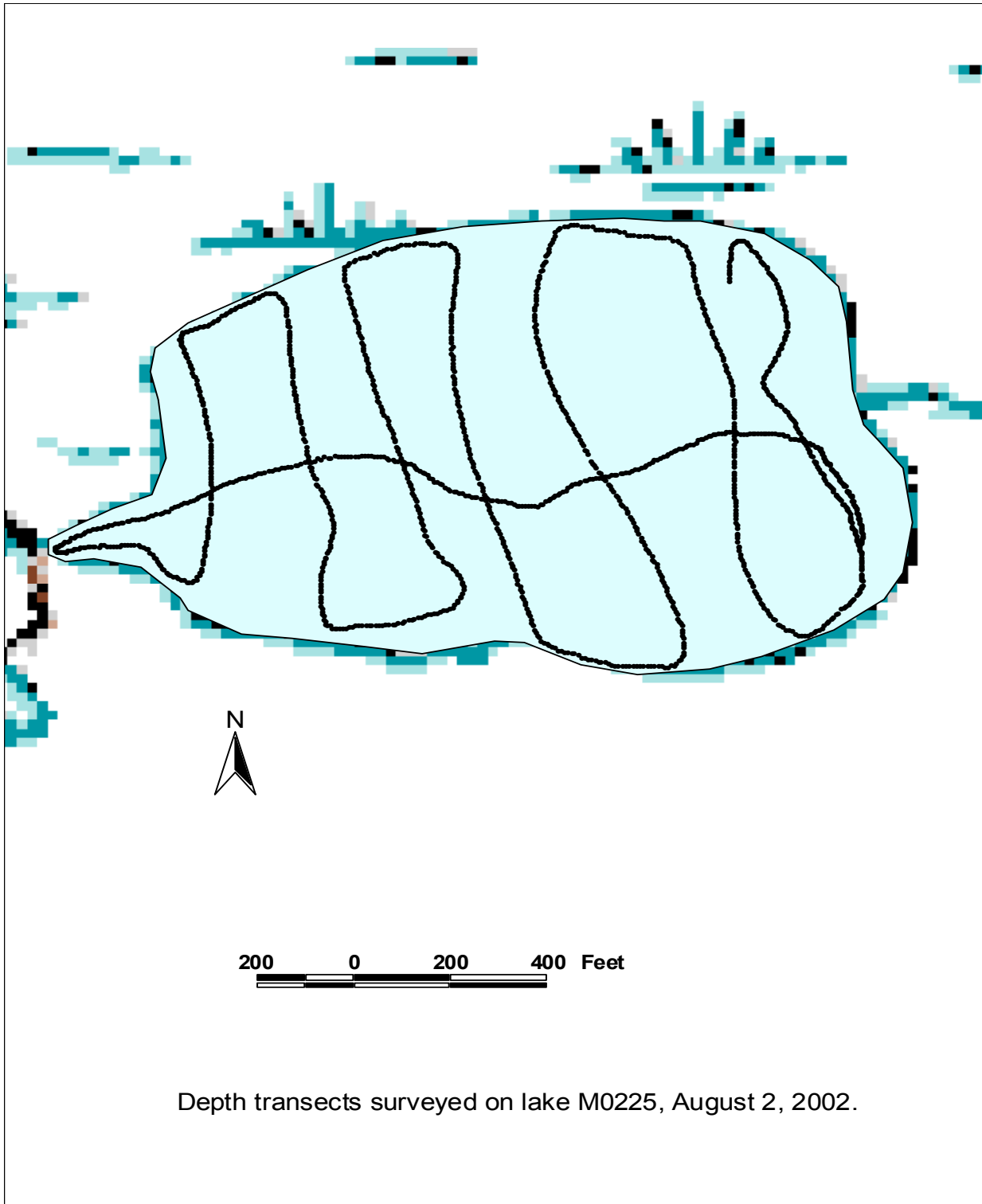
Water Quality:

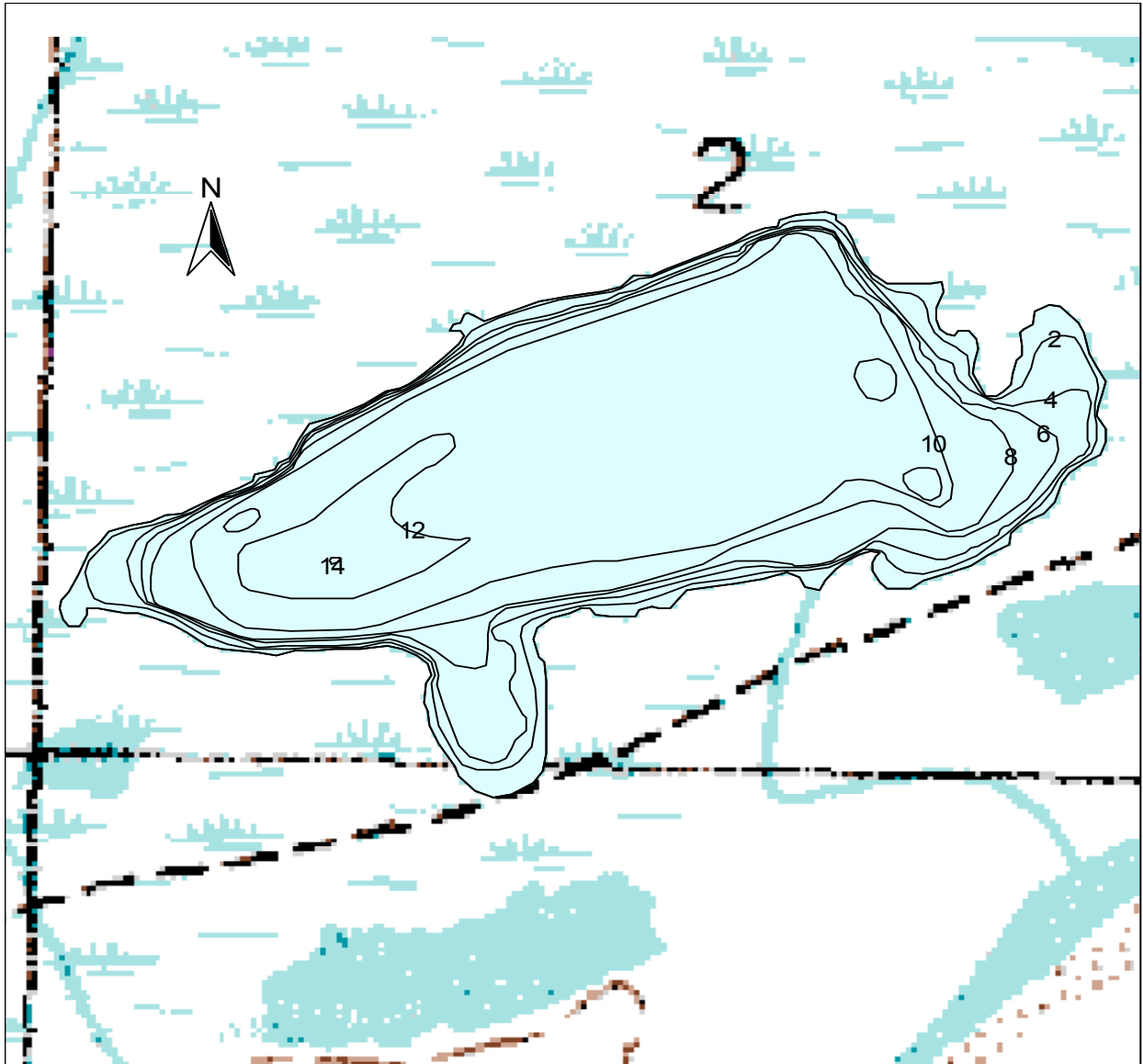
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	39.2	6.6	4.4	8.4	125	130	this study

Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
Gill Net	Aug 2 02	1.4	None	0







Depth contours based on transects surveyed on lake M0226, August 2, 2002 (contours in 2 foot intervals).

Lake M0226

Other Names:

Location: 70° 45' 56.7"N 154° 38' 57.8"W

USGS Quad Sheet: T16N R11W, Sec. 2

Habitat:

Area: 217.8 acres

Maximum Depth: 14.3 feet

Active Outlet:

Turbidity: 0.3 NTU

Spec. Conductance: 191.4 μ S/cm

pH: 7.9

Calculated Volume: 309.11 million gallons

Permittable Volume: 10.33 million gallons

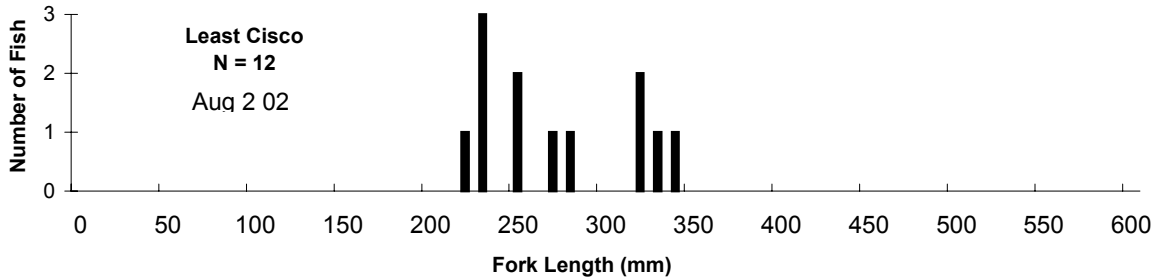
Potential Aggregate: 17.26 acres (water depth 4 ft or less)

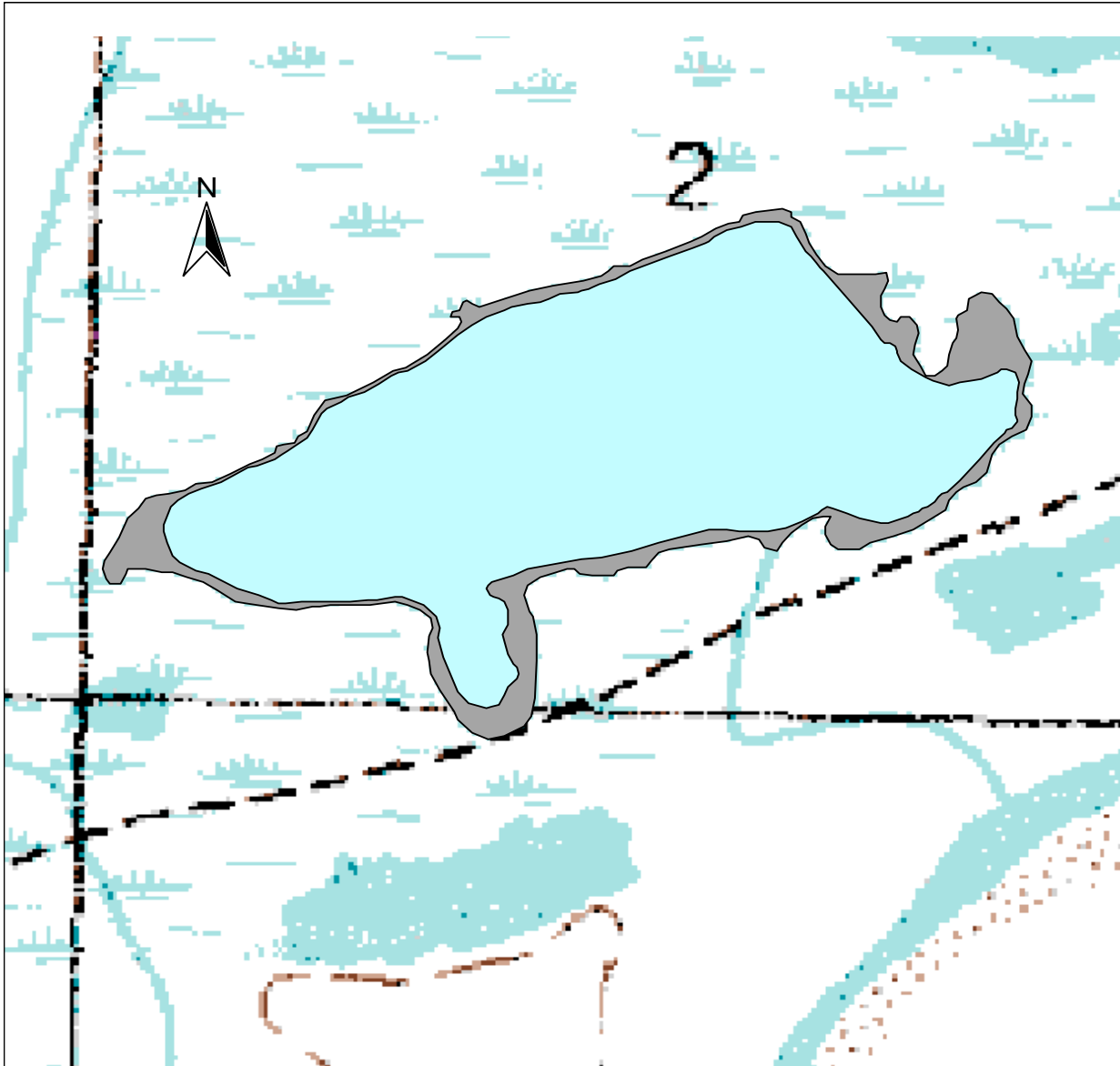
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	23.4	4.3	7.6	18.5	76	100	this study

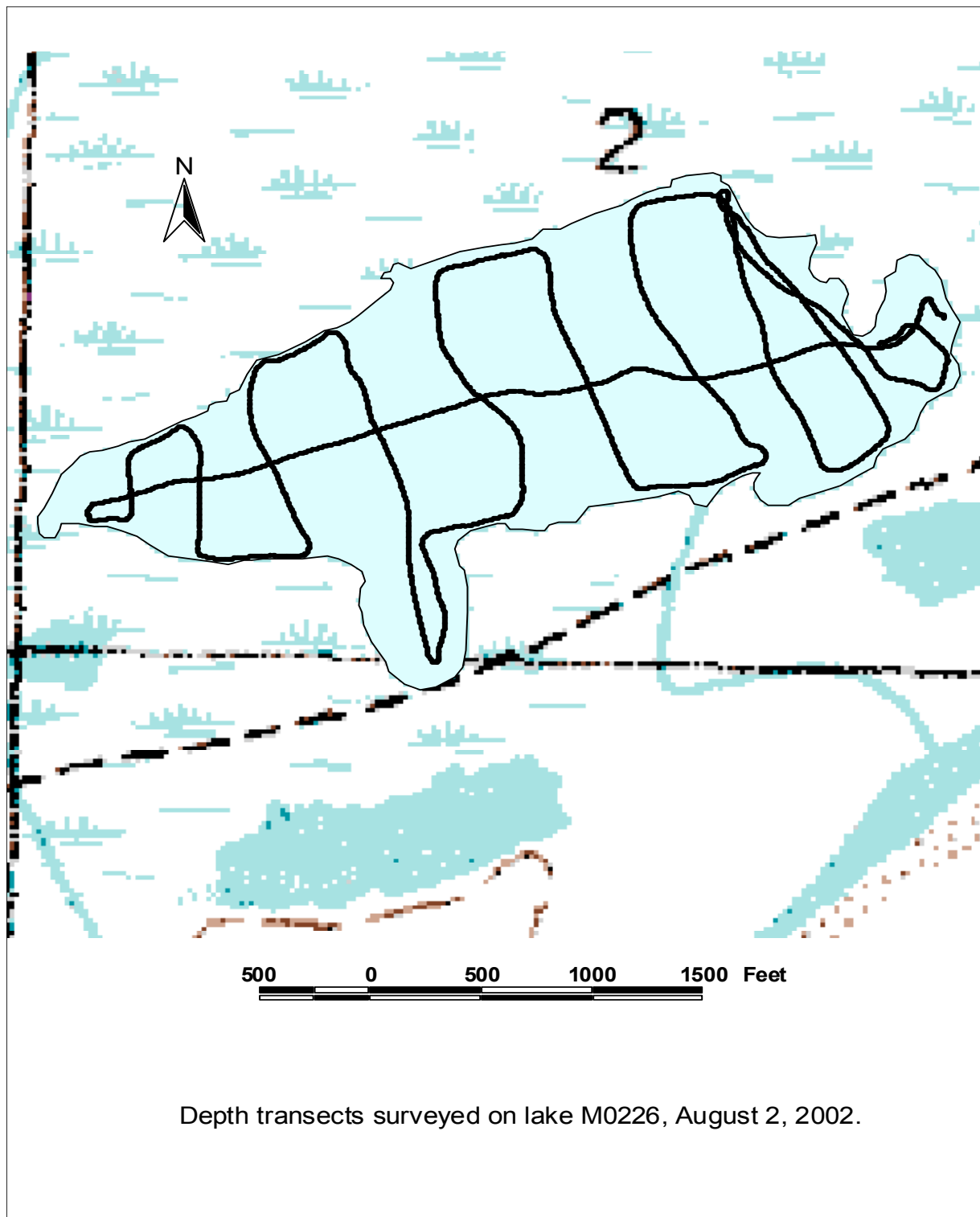
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Aug 2 02	2.7	Least cisco	12	222-342

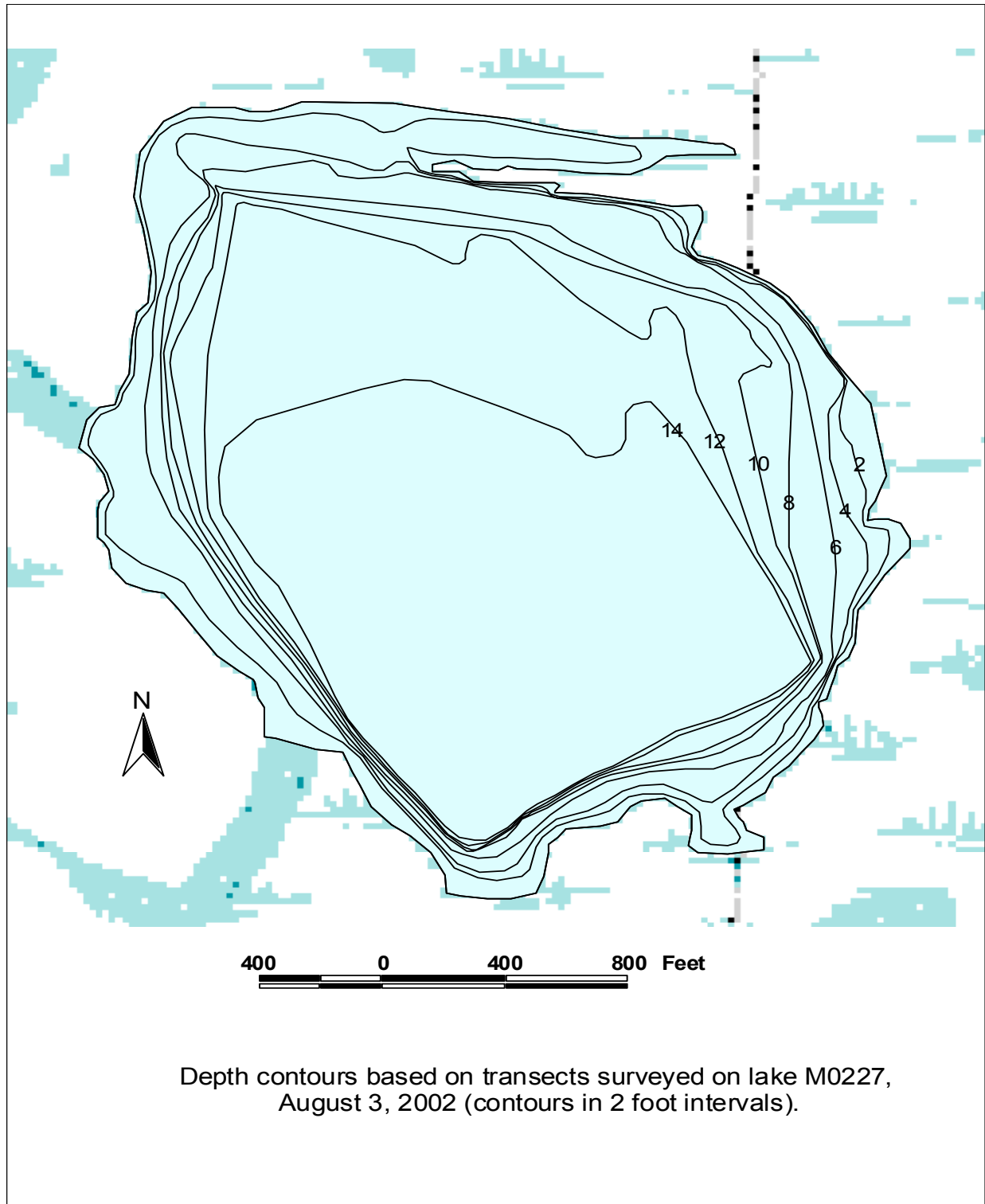




Regions of lake M0226 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on August 2, 2002.



Depth transects surveyed on lake M0226, August 2, 2002.



Lake M0227

Other Names:

Location: 70° 45' 18.2"N 154° 45' 49.9"W

USGS Quad Sheet: T16N R11W, Sec. 8

Habitat:

Area: 237.4 acres

Maximum Depth: 16.5 feet

Active Outlet:

Turbidity: 1.2 NTU

Spec. Conductance: 301.0 μ S/cm

pH: 8.3

Calculated Volume: 433.58 million gallons

Permittable Volume: 24.82 million gallons

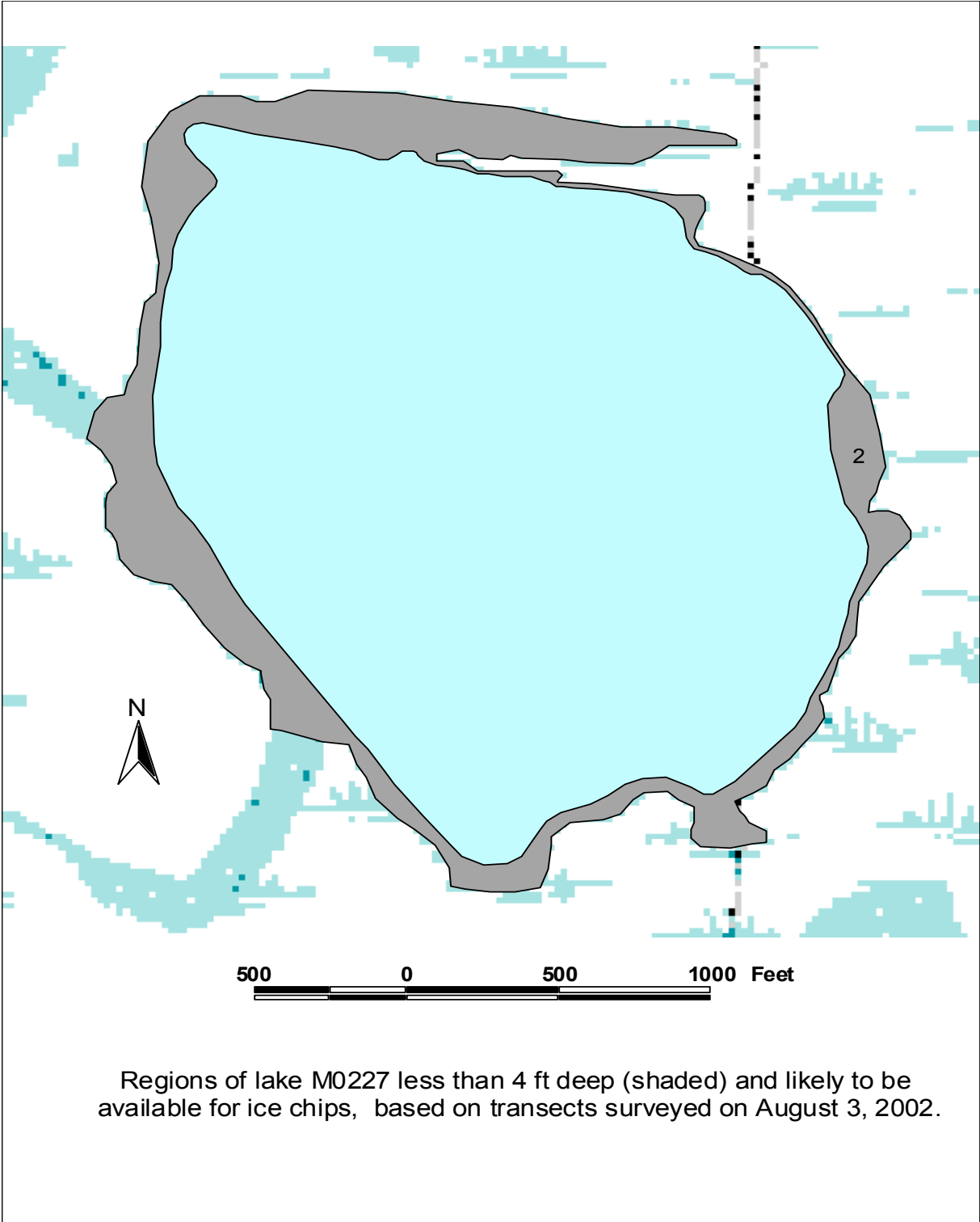
Potential Aggregate: 22.04 acres (water depth 4 ft or less)

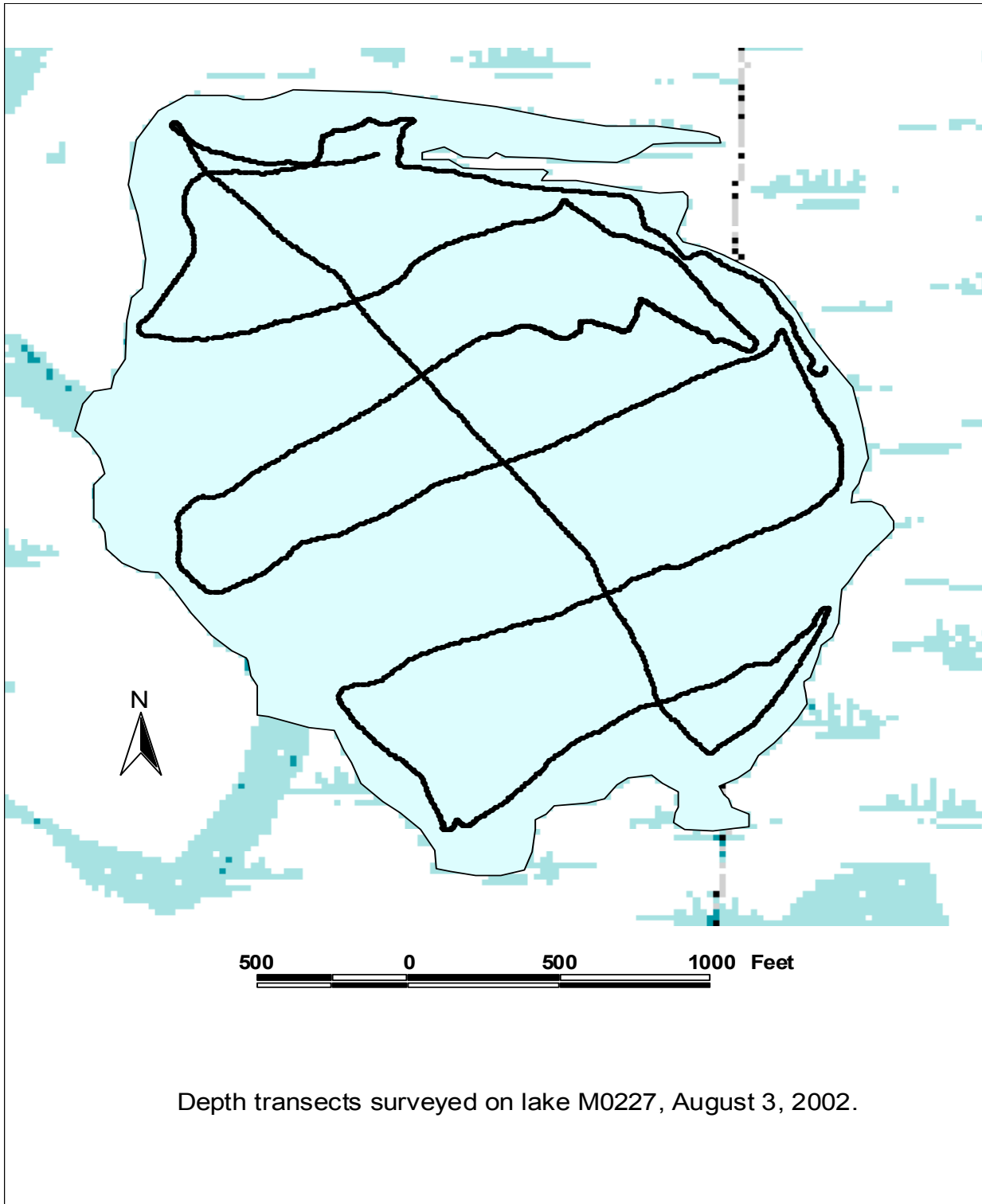
Water Quality:

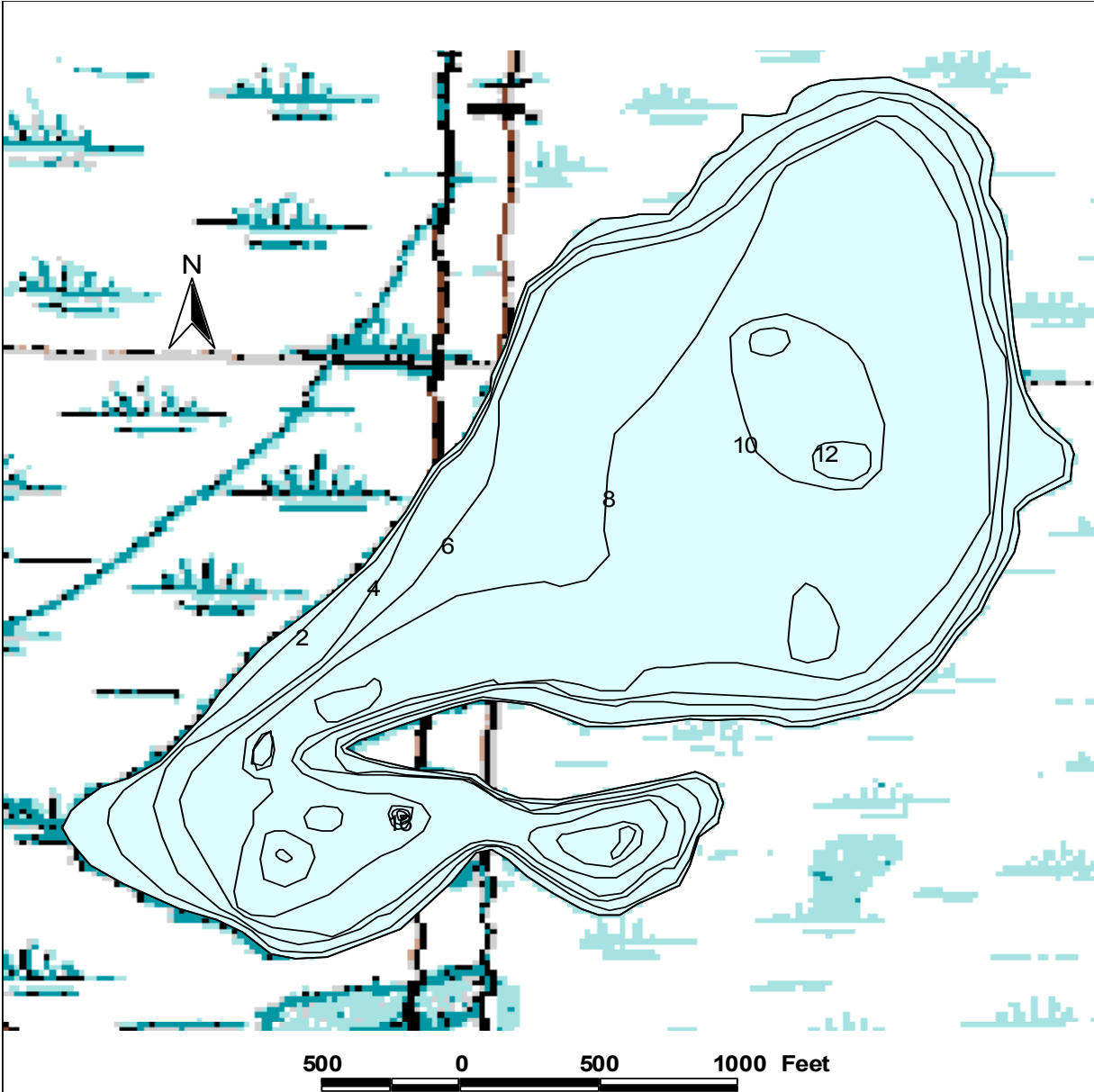
Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO ₃] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	43.1	7.3	9.2	23.7	137	160	this study

Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught
not sampled				







Depth contours based on transects surveyed on lake M0228, August 3, 2002 (contours in 2 foot intervals).

Lake M0228

Other Names:

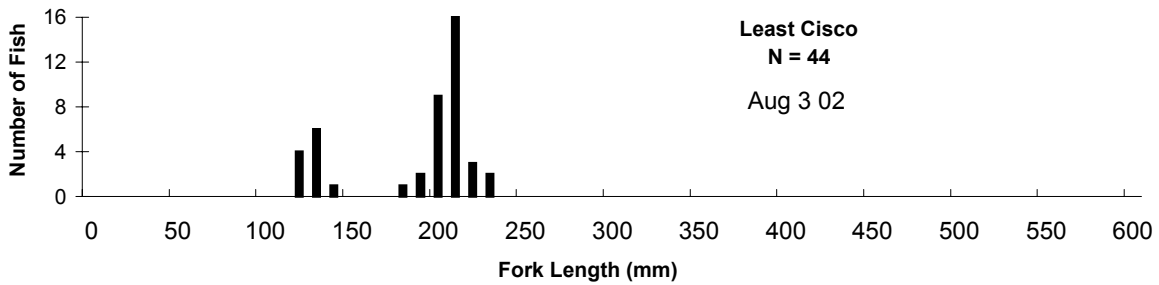
Location: 70° 45' 39.0"N 154° 47' 34.1"W
USGS Quad Sheet: T16N R11W, Sec. 5/7/8
Habitat:
Area: 274.5 acres
Maximum Depth: 16.7 feet
Active Outlet:
Turbidity: 2.3 NTU
Spec. Conductance: 303.1 µS/cm
pH: 8.3
Calculated Volume: 331.25 million gallons
Permittable Volume: 6.78 million gallons
Potential Aggregate: 22.99 acres (water depth 4 ft or less)

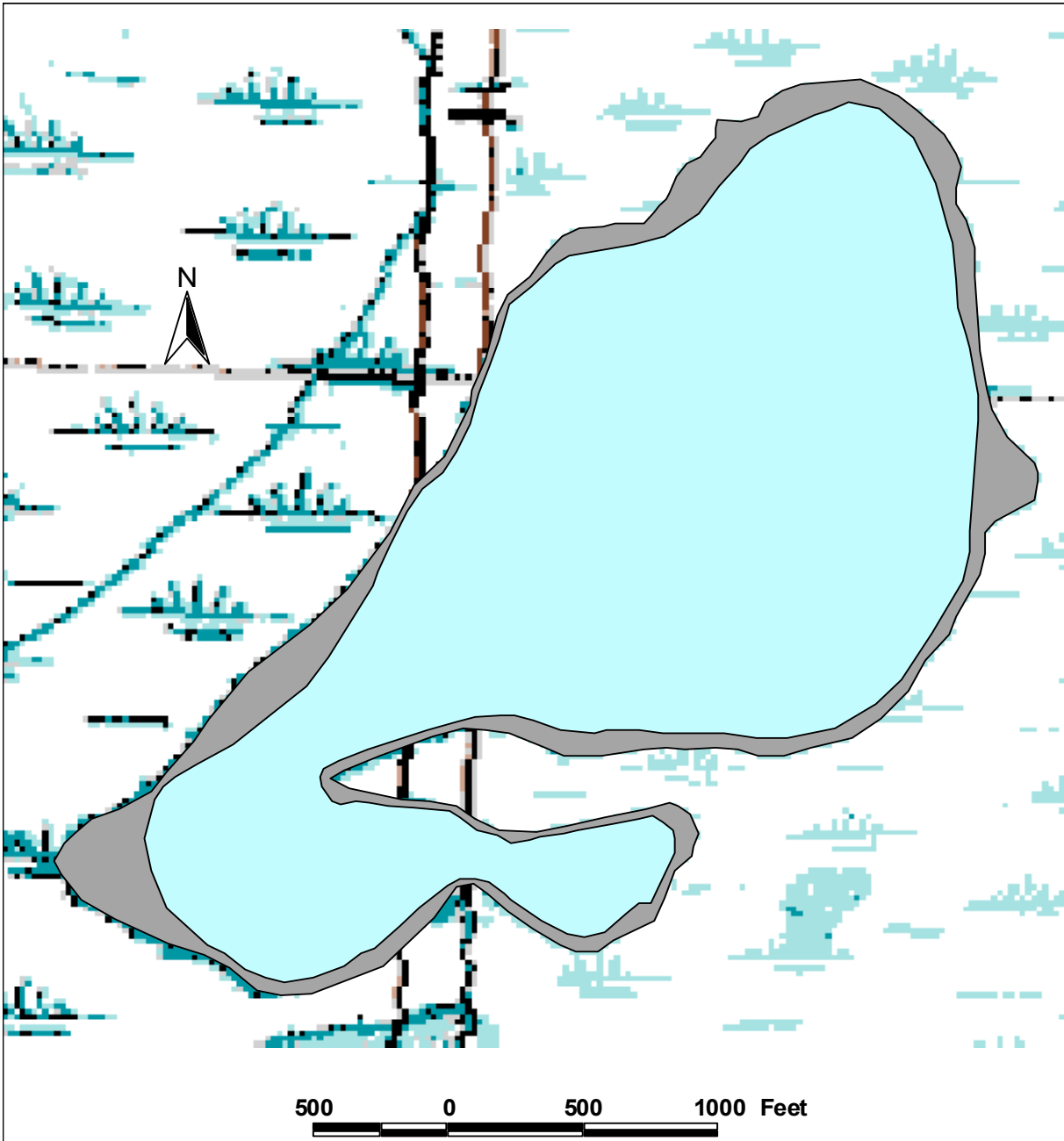
Water Quality:

Year of Test	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Total Hardness [CaCO3] (mg/l)	Total Dissolved Solids (mg/l)	Source
2002	44.9	6.6	9.5	23.2	139	150	this study

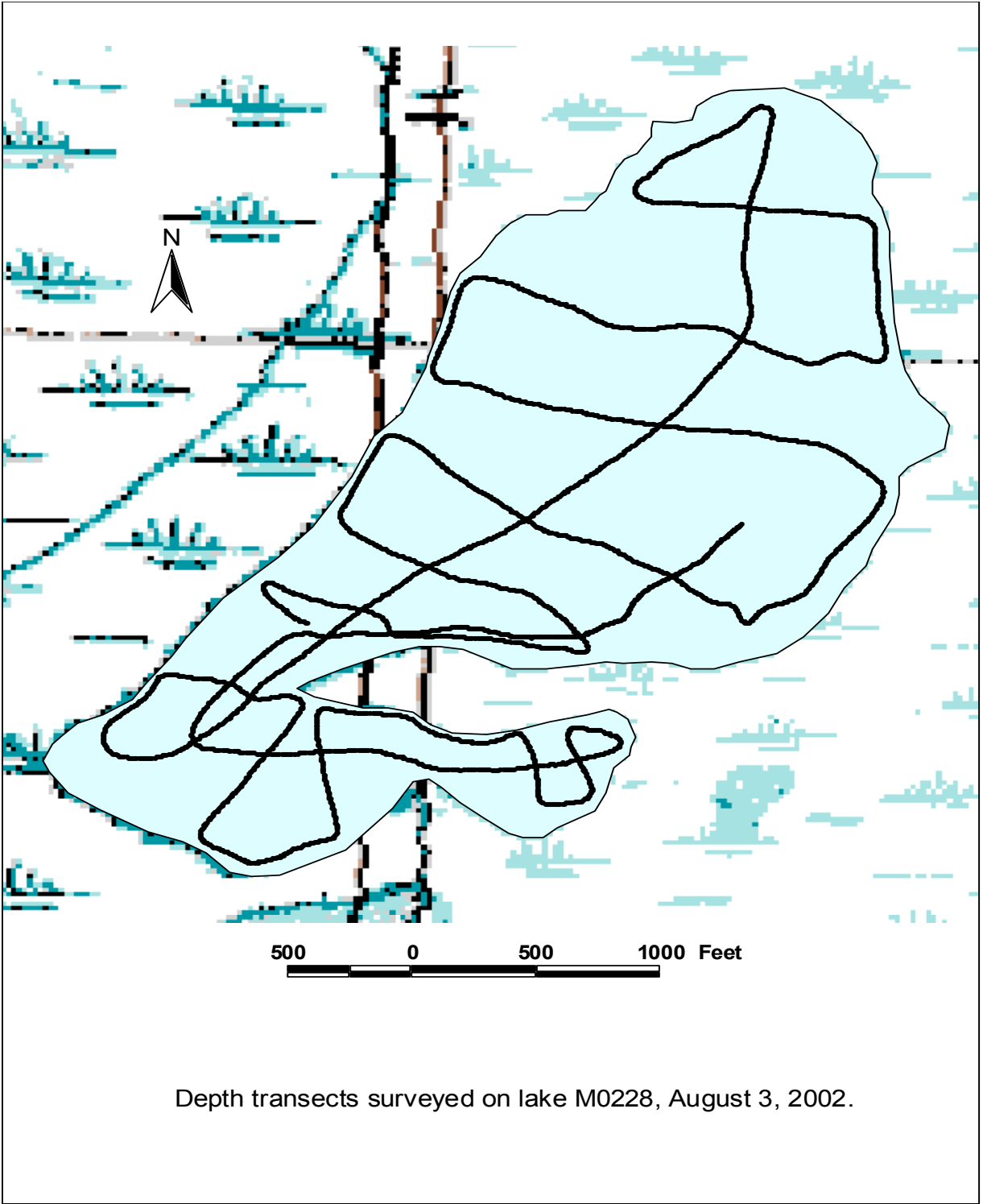
Catch Record:

Gear	Date	Effort (hours)	Species	Number Caught	Fork Length (mm)
Gill Net	Aug 3 02	3.2	Least cisco	44	122-234





Regions of lake M0228 less than 4 ft deep (shaded) and likely to be available for ice chips, based on transects surveyed on August 3, 2002.



ATTACHMENT A

Michael Baker, Jr. Data on Potential Water Source Lakes near Barrow

Table A-1. Summary for Lakes Sampled in September 2002 near Barrow

Lake Name	Latitude ⁽³⁾	Longitude ⁽³⁾	Township	Range	Section	Surface Area ⁽⁴⁾ [acres]	Maximum Depth [feet]	Estimated Total Lake Volume ⁽⁵⁾ [10 ⁶ gallons]	Estimated Under-Ice Volume ⁽⁵⁾ [10 ⁶ gallons]	Requested Water Volume ⁽⁶⁾ [10 ⁶ gallons]
	NAD 27									
MB0201	71.21825°	156.64011°	22N	18W	22,23,26,27,34,35	1,229	8.0	1,068	2.1	0.32
MB0202	71.21850°	156.59606°	22N	18W	23,24,25,26,35,36	501	8.0	436	0.9	0.14
MB0203	71.09167°	156.16361°	20N	16W	4,5,6,7,8,9,15,16, 17,18,19,20,21,22, 27,28,29,32,33,34	8,612	9.0	8,417	92.4	13.86
			21N	16W	32,33					
			19N	16W	3,4					
MB0204	71.10058°	156.25117°	20N	17W	2,11,12,13	266	6.0	173	0.8	0.40
MB0205	71.12294°	156.31667°	20N	17W	3	416	6.5	294	3.6	1.80
			21N	17W	35,36					
MB0206	71.18911°	156.47886°	21N	17W	5,6,7,8	445	5.0	242	0	0.00

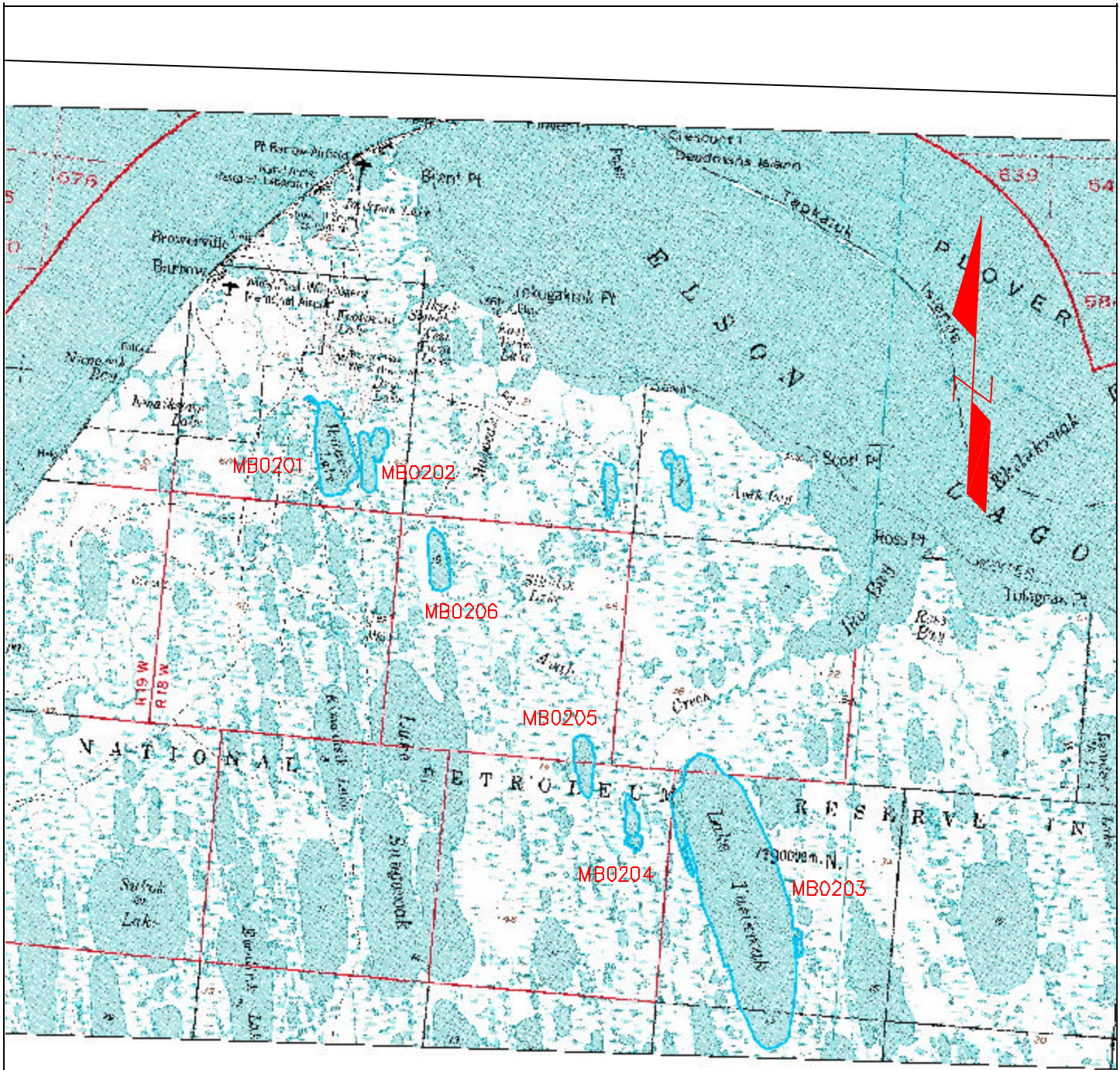
Total Requested Water Volume = 16.52

Notes:

1. Lakes were sampled between September 11 and 12, 2002.
2. Lakes were not sampled for fish. All lakes deeper than 5 feet are assumed to have fish present. Lakes that are between 5 and 7 feet deep, and are also unconnected to fish-bearing streams, are assumed to have only sticklebacks present.
3. Latitude is presented in decimal degrees, north latitude. Longitude is presented in decimal degrees, west longitude.
4. Surface areas estimated from United States Geological Survey mapping.
5. Total lake volumes were estimated using the Cone Method. Under-ice volumes were estimated using the Proportional Cone Method.
6. The requested water volume is based on 15% of the volume under 7 feet of ice for lakes deeper than 7 feet. For lakes between 5 and 7 feet deep, the requested volume is based on 50% of the volume under 5 feet of ice.

Table A-2. Water Chemistry Parameters for Lakes Sampled in September 2002 near Barrow.

Lake Name	Sampled Date	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (mS/cm)	pH	Turbidity (NTU)	Salinity (%)
MB0201	Sep 11 02	5.60	11.93	0.177	6.50	9.12	0.00
MB0202	Sep 11 02	4.80	12.45	0.181	6.98	9.00	0.00
MB0203	Sep 11 02	6.00	12.15	0.378	7.94	27.60	0.01
MB0204	Sep 11 02	5.50	12.61	0.192	6.98	5.98	0.00
MB0205	Sep 12 02	5.80	13.81	0.178	6.25	8.77	0.00
MB0206	Sep 12 02	5.30	14.01	0.387	6.27	10.50	0.01



GRAPHIC SCALE



(IN FEET)
1 inch = 20000'

ConocoPhillips

Baker

Michael Baker Jr., Inc.

TITLE:

SITE MAP
LAKE VOLUME AND LOCATION

COMMENT: 9/17/02

A-4

FILE NAME:

25288

SCALE:

1"=20,000'

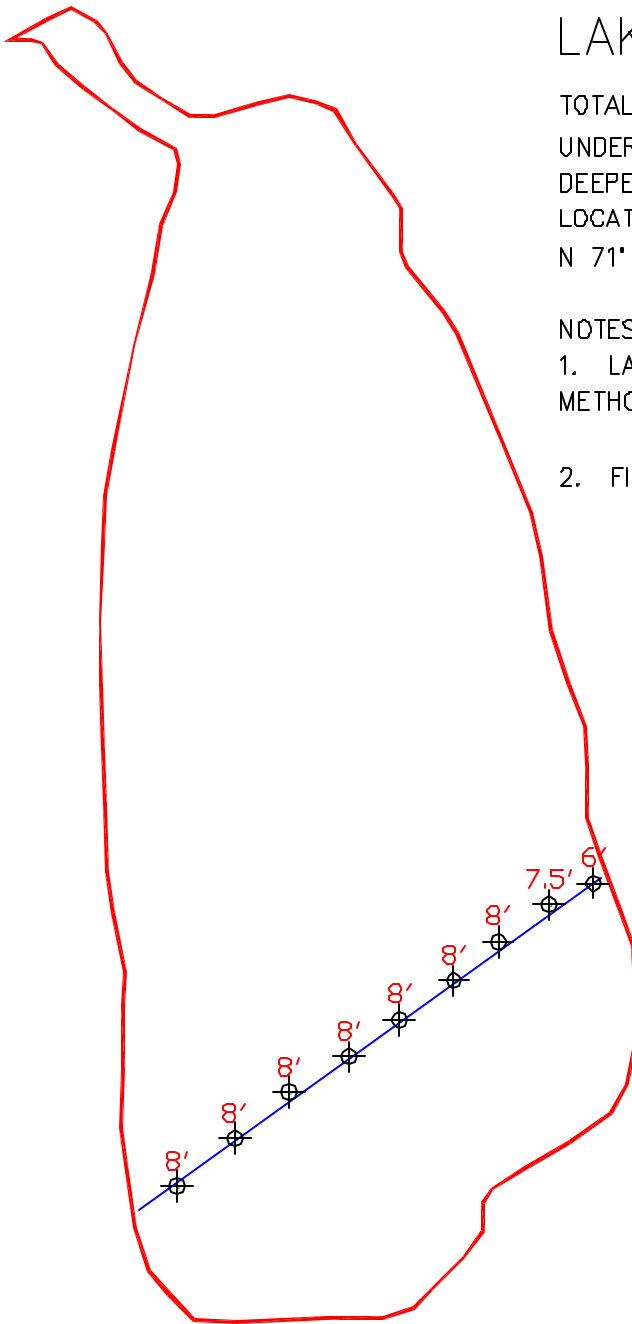
OVERVIEW

LAKE MB0201

TOTAL LAKE VOLUME= 1,100,000,000 GAL
 UNDER ICE LAKE VOLUME= 2,100,000 GAL
 DEEPEST RECORDED WATER DEPTH= 8.0 FT
 LOCATION OF DEEPEST RECORDED DEPTH=
 N 71° 13' 5.7" W 156° 38' 24.4"

NOTES:

1. LAKE VOLUMES WERE DERIVED USING THE CONE METHOD, AND A DESIGN ICE THICKNESS OF 7 FEET.
2. FIELD SURVEY CONDUCTED ON 9/11/02.



LEGEND

— LAKE TRANSECT

⊕ LAKE DEPTH

GRAPHIC SCALE



(IN FEET)
 1 inch = 2000ft.



Michael Baker Jr., Inc.

TITLE: LAKE MB0201
 LAKE VOLUME AND LOCATION

COMMENT: 9/17/02

A-5 □

FILE NAME: 25288

SCALE: 1"=2000'

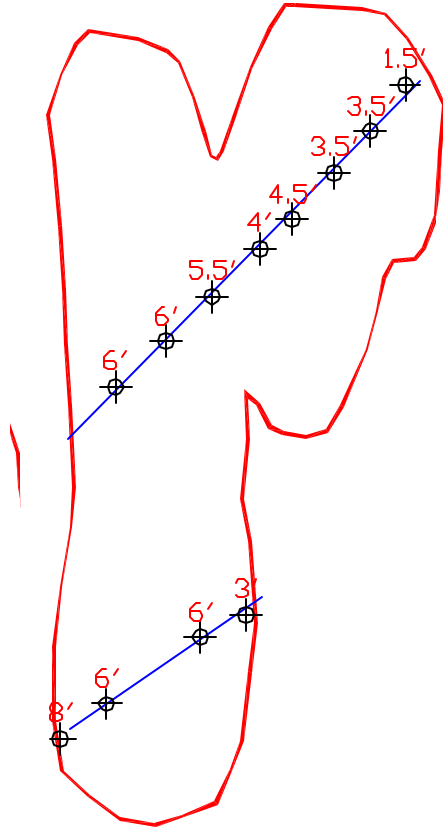
MB0201

LAKE MBO202

TOTAL LAKE VOLUME= 440,000,000 GAL
 UNDER ICE LAKE VOLUME= 840,000 GAL
 DEEPEST RECORDED WATER DEPTH= 8.0 FT
 LOCATION OF DEEPEST RECORDED DEPTH=
 N 71° 13' 6.6" W 156° 35' 45.8"

NOTES:

1. LAKE VOLUMES WERE DERIVED USING THE CONE METHOD, AND A DESIGN ICE THICKNESS OF 7 FEET.
2. FIELD SURVEY CONDUCTED ON 9/11/02.



LEGEND

— LAKE TRANSECT

⊕ LAKE DEPTH

GRAPHIC SCALE



(IN FEET)
 1 inch = 2000ft.



Michael Baker Jr., Inc.

TITLE: LAKE MBO202
LAKE VOLUME AND LOCATION

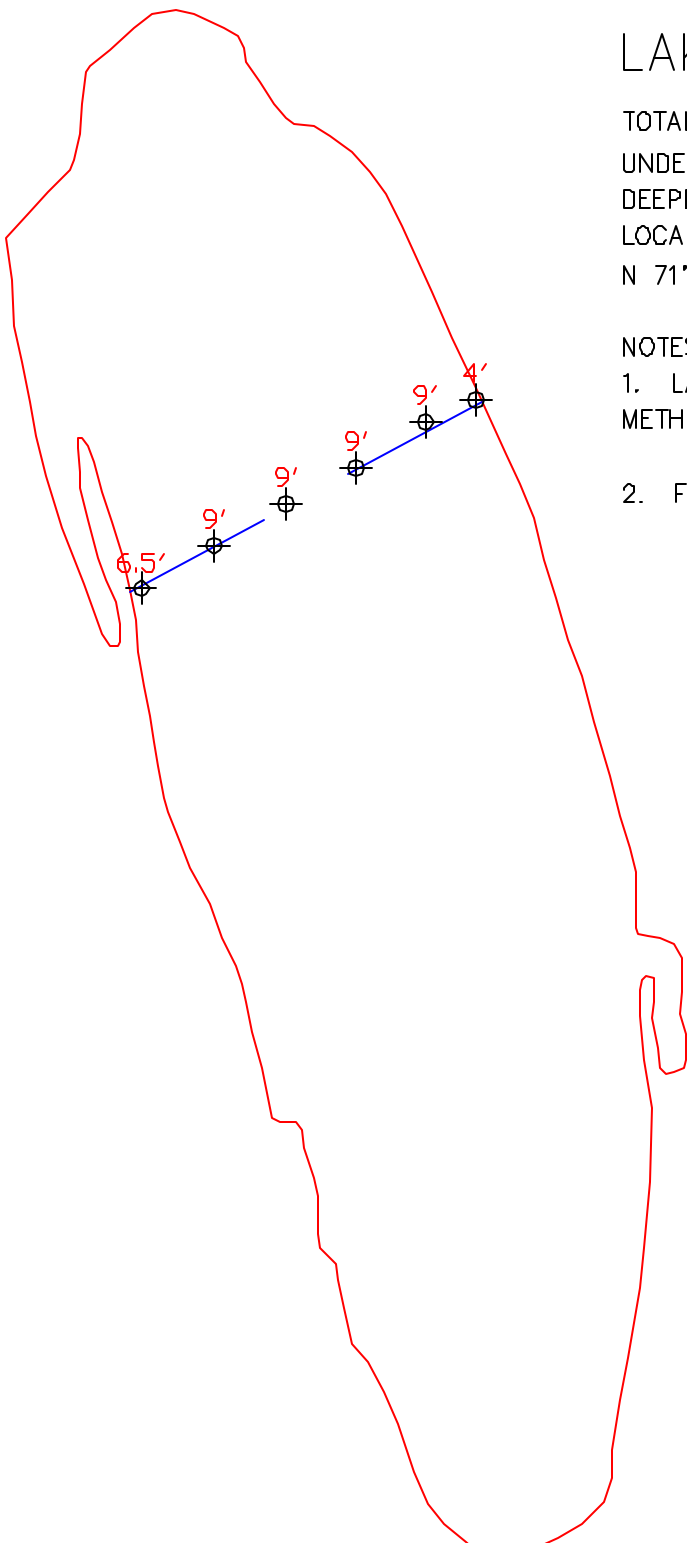
COMMENT: 9/17/02	A-6□	FILE NAME: 25288	SCALE: 1"=2000'	MB0202
----------------------------------------------------	------	----------------------------------------------------	---------------------------------------------------	------------------------------------------

LAKE MB0203

TOTAL LAKE VOLUME= 8,400,000,000 GAL
 UNDER ICE LAKE VOLUME= 92,000,000 GAL
 DEEPEST RECORDED WATER DEPTH= 9.0 FT
 LOCATION OF DEEPEST RECORDED DEPTH=
 N 71° 5' 30.0" W 156' 9' 49.0"

NOTES:

1. LAKE VOLUMES WERE DERIVED USING THE CONE METHOD, AND A DESIGN ICE THICKNESS OF 7 FEET.
2. FIELD SURVEY CONDUCTED ON 9/11/02.



LEGEND

— LAKE TRANSECT

⊕ LAKE DEPTH

GRAPHIC SCALE



(IN FEET)
 1 inch = 5000ft.



Michael Baker Jr., Inc.

TITLE: LAKE MB0203
 LAKE VOLUME AND LOCATION

COMMENT: 9/17/02

A-7□

FILE NAME: 25288

SCALE: 1"=5000'

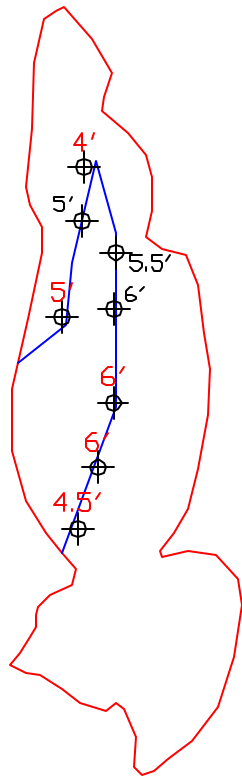
MB0203

LAKE MB0204

TOTAL LAKE VOLUME= 170,000,000 GAL
 UNDER ICE LAKE VOLUME= 0 GAL
 DEEPEST RECORDED WATER DEPTH= 6.0 FT
 LOCATION OF DEEPEST RECORDED DEPTH=
 N 71° 6' 2.1" W 156' 15' 4.2"

NOTES:

- LAKE VOLUMES WERE DERIVED USING THE CONE METHOD, AND A DESIGN ICE THICKNESS OF 7 FEET.
- FIELD SURVEY CONDUCTED ON 9/11/02.



LEGEND

— LAKE TRANSECT

⊕ LAKE DEPTH

GRAPHIC SCALE



(IN FEET)
 1 inch = 2000ft.



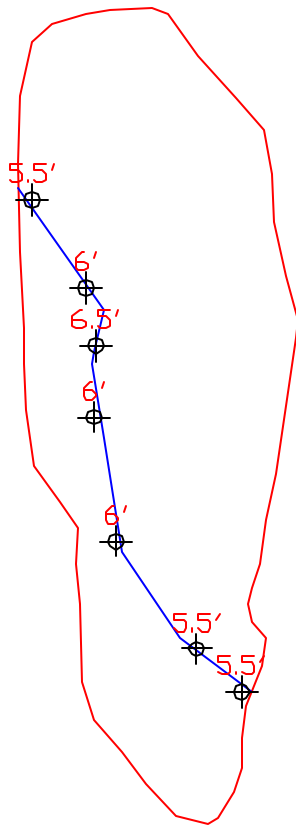
Baker	Michael Baker Jr., Inc.	TITLE: LAKE MB0204 LAKE VOLUME AND LOCATION		
COMMENT: 9/17/02	A-8	FILE NAME: 25288	SCALE: 1"=2000'	MB0204

LAKE MB0205

TOTAL LAKE VOLUME= 290,000,000 GAL
 UNDER ICE LAKE VOLUME= 0 GAL
 DEEPEST RECORDED WATER DEPTH= 6.5 FT
 LOCATION OF DEEPEST RECORDED DEPTH=
 N 71° 7' 22.6" W 156° 19' 00.0"

NOTES:

1. LAKE VOLUMES WERE DERIVED USING THE CONE METHOD, AND A DESIGN ICE THICKNESS OF 7 FEET.
2. FIELD SURVEY CONDUCTED ON 9/12/02.



LEGEND

— LAKE TRANSECT

⊕ LAKE DEPTH

GRAPHIC SCALE



(IN FEET)
 1 inch = 2000ft.



Baker	Michael Baker Jr., Inc.	TITLE: LAKE MB0205 LAKE VOLUME AND LOCATION		
COMMENT: 9/17/02	A-9□	FILE NAME: 25288	SCALE: 1"=2000'	MB0205

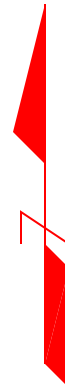
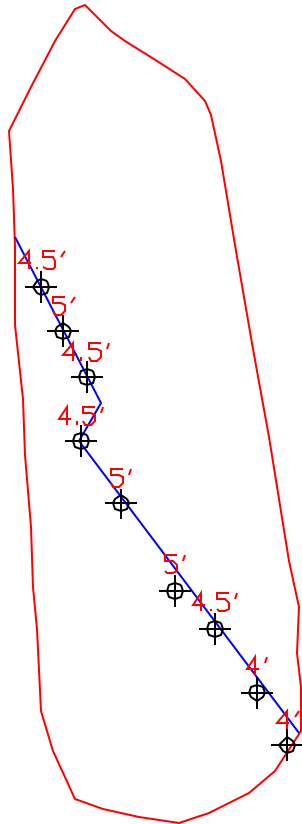
LAKE MB0206

TOTAL LAKE VOLUME= 240,000,000 GAL
 UNDER ICE LAKE VOLUME= 0 GAL
 DEEPEST RECORDED WATER DEPTH= 5.0 FT
 LOCATION OF DEEPEST RECORDED DEPTH=
 N 71° 11' 29.1" W 156' 30' 3.7"

NOTES:

1. LAKE VOLUMES WERE DERIVED USING THE CONE METHOD, AND A DESIGN ICE THICKNESS OF 7 FEET.

2. FIELD SURVEY CONDUCTED ON 9/12/02.



LEGEND

— LAKE TRANSECT

⊕ LAKE DEPTH

GRAPHIC SCALE



(IN FEET)
 1 inch = 2000ft.



Baker	Michael Baker Jr., Inc.	TITLE: LAKE MB0206 LAKE VOLUME AND LOCATION		
COMMENT: 9/17/02	A-10□	FILE NAME: 25288	SCALE: 1"=2000'	MB0206

ATTACHMENT B

Teshkepuk Lake as a Potential Water Source

August 29, 2002

Caryn Rea
Phillips Alaska, Inc.
P.O. Box 100360
Anchorage, AK 99510-0360

Dear Caryn:

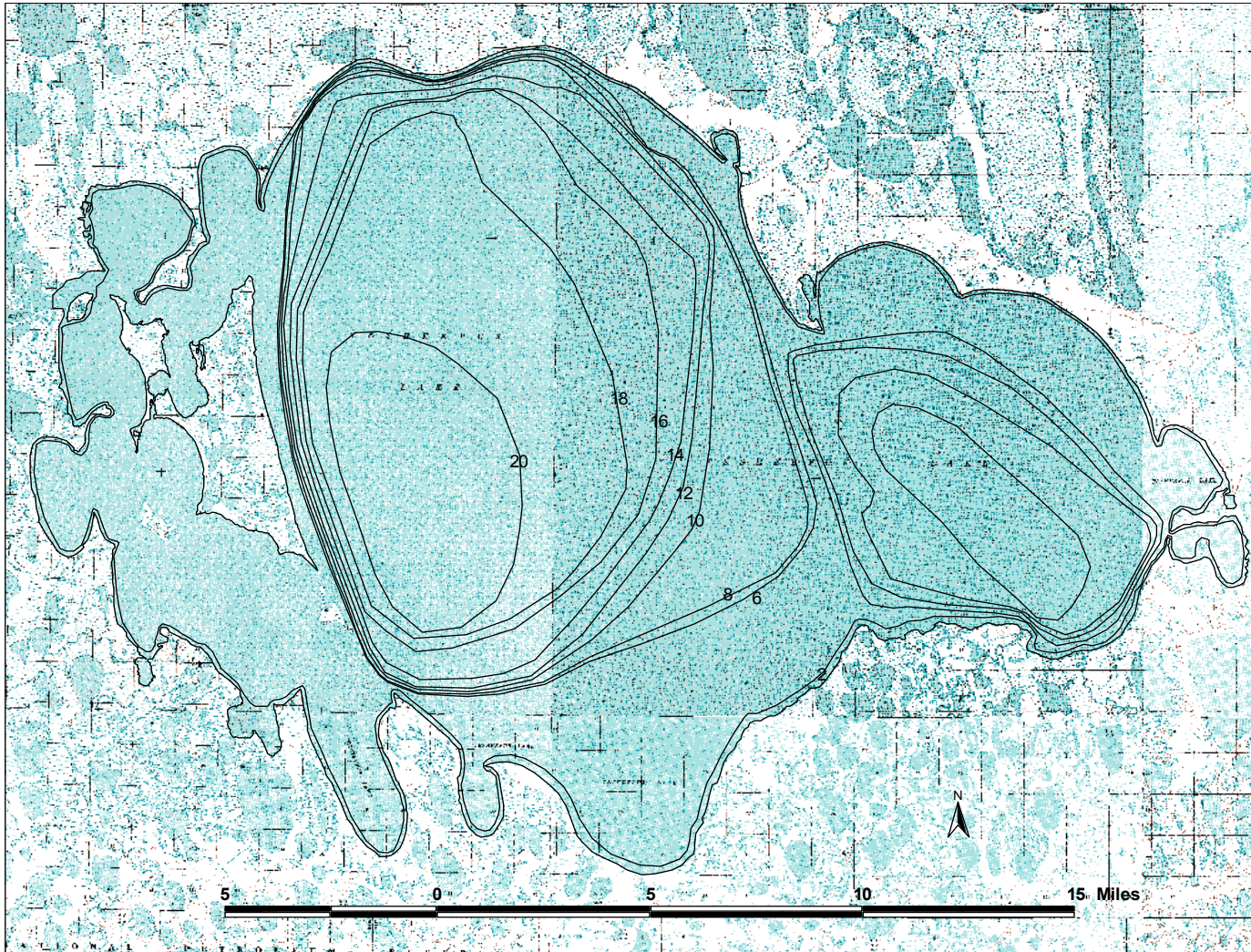
The volume of water available for use from the western basin of Teshekpuk Lake is estimated to be 37,243 million gallons. I arrived at this estimate based on depth information contained in Philo et al. (1993). This report lists the locations of 151 depth measurements. I mapped the depth locations in Arcview and fit 2 ft depth contours by hand around the depth intervals in the western basin only because there is a shallow sill that separates the western and eastern basin. I then used the formula for the volume of truncated cones to estimate the volume of each 2 foot contour interval. The total volume of the western basin is estimated at 248,289 million gallons. Applying the criteria for a fish-bearing lake (15% of the volume greater than 7 ft deep) provides the above estimate of available water. Figures of the depth locations and resulting contours are attached.

Sincerely,

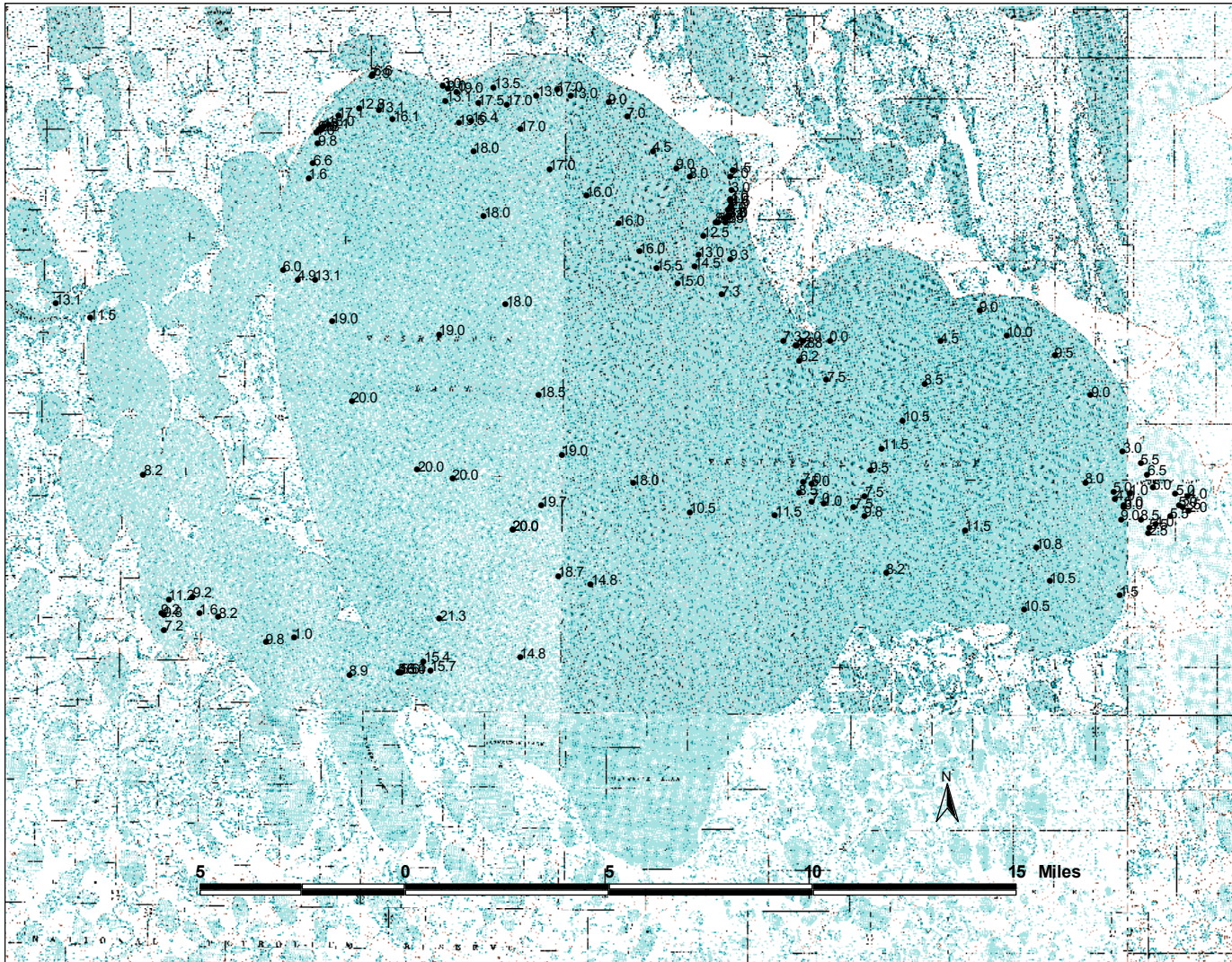
Lawrence L. Moulton
MJM Research

Reference:

Philo, L.M., J.C. George and L.L. Moulton. 1993. The occurrence and description of anadromous and freshwater fish in Teshekpuk Lake, Alaska 1990-1992. Department of Wildlife Management, North Slope Borough. Barrow, AK. 96p.



Depth contours used to estimate water volumes in the western basin of Teshekpuk Lake (depths in feet).



Depths measured in Teshekpuk Lake, 1990-1992 (data from Philo et al. 1993, depths in feet).