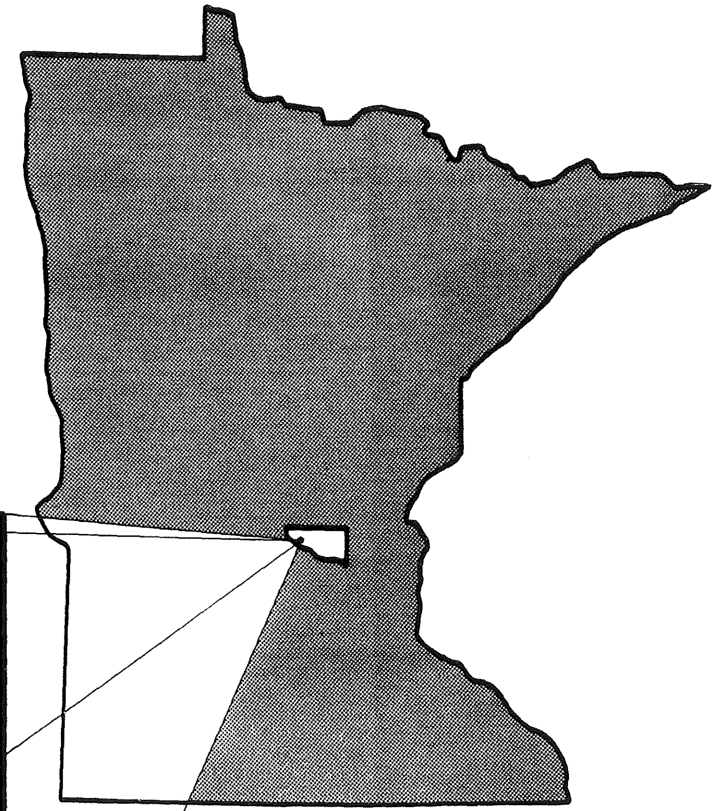
LONG LAKE CHAIN OF LAKES

(Sherburne County)

HIGH WATER INVESTIGATION MITIGATION STRATEGIES



BASIN GROUP:

(Long Lake, 71-159)
(Pickerel Lake, 71-158)
(Fish Lake, 71-150)
(Clear Lake, 71-153)
(Stickney Lake, 71-149)
(Unnamed, 71-329 W)
(Unnamed, 71-151)
(Unnamed, 71-152)
(Unnamed, 71-148)
(Unnamed, 71-155)
(Unnamed, 71-154)

April 1987

Revised 12/87

Minnesota
Department of Natural Resources
Division of Waters

HIGH WATER INVESTIGATION

AND

MITIGATION STRATEGIES

FOR

LONG LAKE CHAIN OF LAKES:

LONG LAKE	(71-159P)
PICKEREL LAKE	(71-168P)
FISH LAKE	(71-150P)
CLEAR LAKE	(71-153P)
STICKNEY LAKE	(71-149P)
UNNAMED BASINS	(71-329W)
	(71-151W)
	(71-152P)
	(71-148P)
	(71-155W)
	(71-154W)

SHERBURNE COUNTY

Minnesota Department of Natural Resources

Division of Waters

April 1987

Through an agreement between the Department of Natural Resources and the United States' Federal Emergency Management Agency (FEMA), a study was conducted to determine mitigation strategies for high water problem lakes. The work that provides the basis for this publication was supported by funding under a cooperative agreement with the Federal Emergency Management Agency. The substance and findings of that work are dedicated to the public. The author and publisher are solely responsible for the accuracy of the statements and interpretations contained in this publication. Such interpretations do not necessarily reflect the views of the Federal Government.

ACKNOWLEDGEMENT

This report was prepared under a Hazard Mitigation Assistance Grant from the Federal Emergency Management Agency with matching funds from the Department of Natural Resources, Division of Waters. This report would not have been possible without the special assistance of the Sherburne County Assessor's Office.

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INTRODUCTION

The Long Lake Chain of Lakes is located in western Sherburne County, Minnesota, approximately 70 miles northwest of the Twin Cities metropolitan area and about 7 miles southeast of the City of St. Cloud. Most of its area is within Sections 3, 4, 10, 11, and 12 of Township 34 North, Range 30W (Plate 1).

There are over 50 landlocked lakes within glaciated terrain in Minnesota that are currently experiencing high water level problems. These lakes have no active natural outlets for surface water outflow and are susceptible to large natural water level fluctuations. The duration of these fluctuations is usually on the order of years and is dependent on long-term climatic trends. These lakes typically have small watershed-to-lake area ratios, usually less than 5 to 1.

The Long Lake Chain of Lakes is situated in Pleistocine to Holocene terrace deposits of sand and gravel. During the early 1980's, the water surface elevations began to rise in the Lake Chain and by the fall of 1986, Long and Pickeral Lakes were 1.59' above their respective Ordinary High Water Levels (OHW) of elevation 982.4', NGVD, 1929[(1)], which resulted in the flooding of several structures. The remaining Basins in the Lake Chain have risen to varying degrees above their OHW's, but no buildings have been impacted as of the date of this report.

This report is intended as a resource document to assist landowners and the local unit of government in terms of long range planning, developing flood loss reduction or mitigation strategies and in obtaining assistance in dealing with high water level problem lakes. In addition, this report will include background data on the watershed setting, geology, soils, climatology, fish and wildlife, water quality, historic water levels, and land use and existing development.

The report which follows is divided into 4 parts: Summary and Conclusions, Part 1, Part 2 and Appendices. Part 1, through the presentation and analysis of watershed, geologic, precipitation, water level and other data will, to the degree possible, identify the source of the problem and project future conditions. Part 2 will identify the impact of future increases in water levels and identify mitigation options and implementation strategies. The appendices will provide additional data to be used by landowners and local, state and federal officials.

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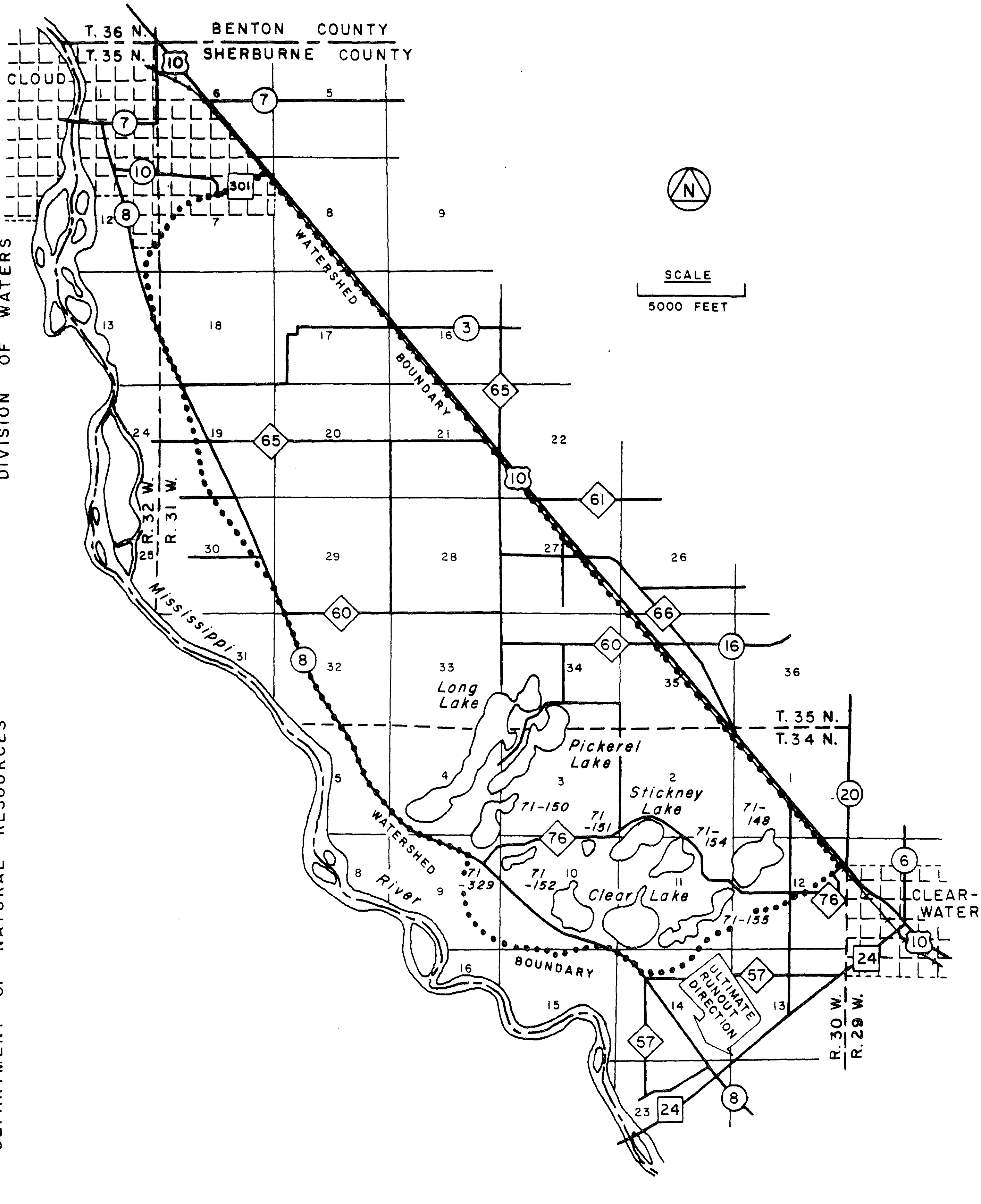
[1]National Geodetic Vertical Datum of 1929 is used for all elevations included in this report.

PLATE 1


T. 36 N.
T. 35 N.
BENTON COUNTY
SHERBURNE COUNTY
ST. CLOUD
SCALE
5000 FEET
N
WATERSHED BOUNDARY
Mississippi River
Long Lake
Pickerel Lake
Stickney Lake
Clear Lake
71-150
71-151
71-154
71-148
71-329
71-152
71-155
R. 32 W.
R. 31 W.
R. 30 W.
R. 29 W.
T. 35 N.
T. 34 N.
CLEAR-WATER
ULTIMATE RUNOUT DIRECTION

SUMMARY AND CONCLUSIONS/RECOMMENDATIONS

Water Level Data (See Part 1)

-In December of 1986, the Long Lake Chain of Lakes were individually at elevations anywhere from 2'-5' above their respective Ordinary High Water Levels. This Lake Chain reacts to both surface water runoff and ground water inflow.

-There is a correlation between the area's annual precipitation and water levels for the Long Lake Chain of Lakes. During the last 5-year period, there has been an excess of 30.38" of precipitation above normal annual precipitation. This has resulted in significant surface and ground water inflow and caused the current high water problem.

-This area in the past has experienced alternating wet and dry periods of varied duration. The current period may continue for several more years resulting in still higher water levels.

-If these water bodies were to rise to elevation 991.0', 22 structures would be flooded with 1986 assessed market values totalling $1,348,400. At this elevation, it is estimated that a minimum of $901,200 of actual damages would occur.

-Methodologies do not exist which can predict what the maximum elevation will be in the future for the Long Lake Chain of Lakes. The major factor on limiting potential increases in lake levels would be if these Lakes should reach their natural runout elevation which is at or near elevation 990.4'.

-Methodologies do exist which can calculate the probabilities of future water levels (i.e., both increases and decreases in water levels). There is a one-percent probability that the Long Lake Chain of Lakes will: 1) rise to elevation 984.5' by December 1, 1987; or 2) rise to elevation 987.3' by December 1, 1991. Conversely, there is a one-percent probability these Basins will: 1) fall below elevation 980.9' by December 1, 1987; or 2) fall below elevation 982.0' by December 31, 1991. There is a 50/50 chance that at the end of the next 5-year period these Basins will be at elevation 984.5'.

MITIGATION STRATEGIES (SEE PART II)

-The flood protection standards for new development in Sherburne County's current flood plain ordinance do not apply to the Long Lake Chain of Lakes' shoreline because a flood delineation is not currently shown for these Basins on the County's current flood plain zoning map. The County must properly regulate new development adjacent to each Basin's shoreline. The County can properly regulate new development with its existing state-approved shoreland regulations with two recommended revisions, as follows:

1) New development within the shoreland district of the Long Lake Chain of Lakes must be elevated, at a minimum, to an elevation 3' above the highest known water level of each respective Basin. It is recommended that the County adopt a flood protection elevation of 987.3' for all

Basins in the Lake Chain. This will provide an additional safety factor should these Basins equalize and continue to rise, considering the runout elevation is not reached until elevation 990.4';

2) For all new construction a provision should be added which requires an elevated road access to the minimum flood protection elevation established by the County.

-The County should develop a strategy to address the inundation of sewage treatment systems and wells, as well as the abandonment of flooded structures. The DNR will work with the County in formulating and implementing joint actions where appropriate.

-Flood insurance is available to all landowners and renters in the unincorporated area of Sherburne County. A structure and/or its contents can be insured. Landowners or renters adjacent to the Long Lake Chain of Lakes should explore purchasing flood insurance, especially those located within 3.5' of a Basin's current water surface elevation.

-Landowners can take emergency measures to protect existing development. The safest method is either relocating a structure to natural ground above the potential floodplain or elevating a structure at its existing site on fill to the recommended flood protection elevation. Emergency protection measures, such as filling, sandbagging, diking, etc., will require a permit from the County. A design professional should be contacted in advance to insure the flood protection measure will function properly.

-State and federal cost-sharing programs may be available to assist landowners and/or local governmental bodies in dealing with a high water problem. These programs include Corp of Engineers' flood control authorities, Small Cities Development Block Grant Program, Section 1362 of the Federal Flood Disaster Protection Act of 1973 and the State's Flood Loss Reduction Program. Local interests should explore these programs and the requirements for an acceptable local sponsor to submit the application.

-Comprehensive basinwide solutions to high water problems are best implemented when a local entity or interest group takes the lead role. The legislature has established special taxing procedures and quasi-governmental authorities (e.g., lake improvement districts/watershed districts) which can be used to deal with high water type problems. Landowners and local governmental bodies should: 1) define their respective roles in dealing with the existing high water problem; and 2) if necessary, use the special taxing procedures and/or quasi-governmental authorities to implement feasible basinwide solutions.

The report which follows goes into greater detail on the issues of water level data and mitigation measures (including additional recommendations). Part II also presents in detail state permitting requirements for future actions which would affect the lake basin proper. The reader is encouraged to read the remainder of this report. The Department of Natural Resources will assist local interests in the degree possible in implementing future flood loss reduction measures.

PART 1
LONG LAKE CHAIN AREA

GEOLOGIC SETTING

The Long Lake Chain of Lakes is situated in Pleistocene to Holocene terrace deposits of sand and gravel. These deposits are remnants of the former channel and flood plain of the Mississippi River. The Lake Chain is above the level of the present Mississippi River flood plain, and is below the level of nearby moraines and outwash surfaces. The sand and gravel deposits are 40-60 feet thick in the area of these Basins, and are underlain by gray silty till (Plate 2). The total thickness of glacial drift is around 100 feet. The drift is underlain by Pre-Cambrian igneous and metamorphic rocks.

SOILS

All the Basins in the Long Lake Chain of Lakes are surrounded almost entirely by sand and sandy soils, with varying degrees of finer materials in the top 2 feet. Small areas of marsh and peat soils are the only exception.

HYDROGEOLOGIC SETTING

The deposits in which these lakes are situated are hydrologically part of the Anoka sandplain aquifer which covers much of Sherburne, Isanti, and Anoka Counties. The Chain of Lakes is a reflection of the water table within the aquifer. They are hydrologically connected to the aquifer and are part of the ground water flow system. These Lakes are southwest of a ground water divide between the Mississippi and Elk Rivers (Plate 3). In the area of the Lake Chain, the direction of ground water flow is generally to the south-southwest towards the Mississippi River. In the vicinity of Basins 71-148P, 71-154W, and 71-155W, the ground water flow direction is more to the south and southeast (Plate 3). These Lakes are ground water flow-through lakes, with ground water inflow occurring along the north (or northeast) shores, and ground water outflow occurring along the south (or southwest) shores. Minipiezometer measurements along the shores of Long Lake, Pickerel Lake, and Fish Lake taken in August, 1986 have directly measured the gradient of this ground water inflow and outflow. On the north shores of Long and Pickerel Lakes, ground water inflow was occurring under a gradient of 0.09. On the south ends of Long and Fish Lakes, the outflow gradient was 0.16. Rough calculations of ground water inflow and outflow for the north and south ends of Long Lake based on fall of 1986 watershed conditions and the measured gradients indicate that the amounts may be 1-2 million cubic feet of water per day or 11.6 to 23.1 cubic feet of water per second (cfs), respectively.

The water table elevation in the surficial aquifer in the area of the Lake Chain has risen approximately 6 feet in the last 10 years as can be seen in the hydrograph from well #71013 (Plate 4). The lake levels in this Lake Chain have risen accordingly. Lowering the lake levels via an outlet will increase the ground water inflow and reduce the ground water outflow. This should be taken into account in the design of any outlet structure.

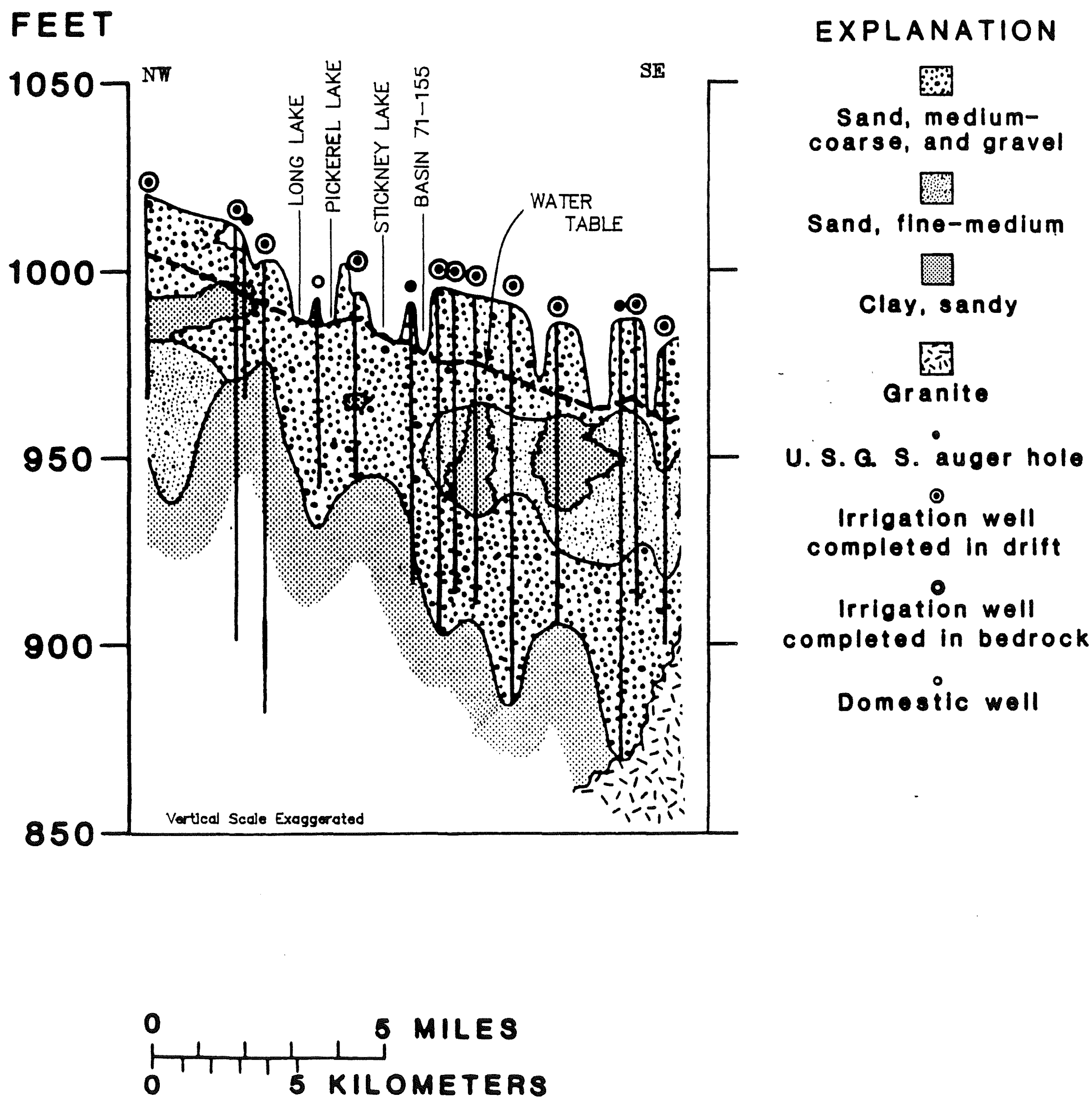


PLATE 2 : CROSS SECTION OF DRIFT DEPOSITS
(Modified from Lindholm, 1980)

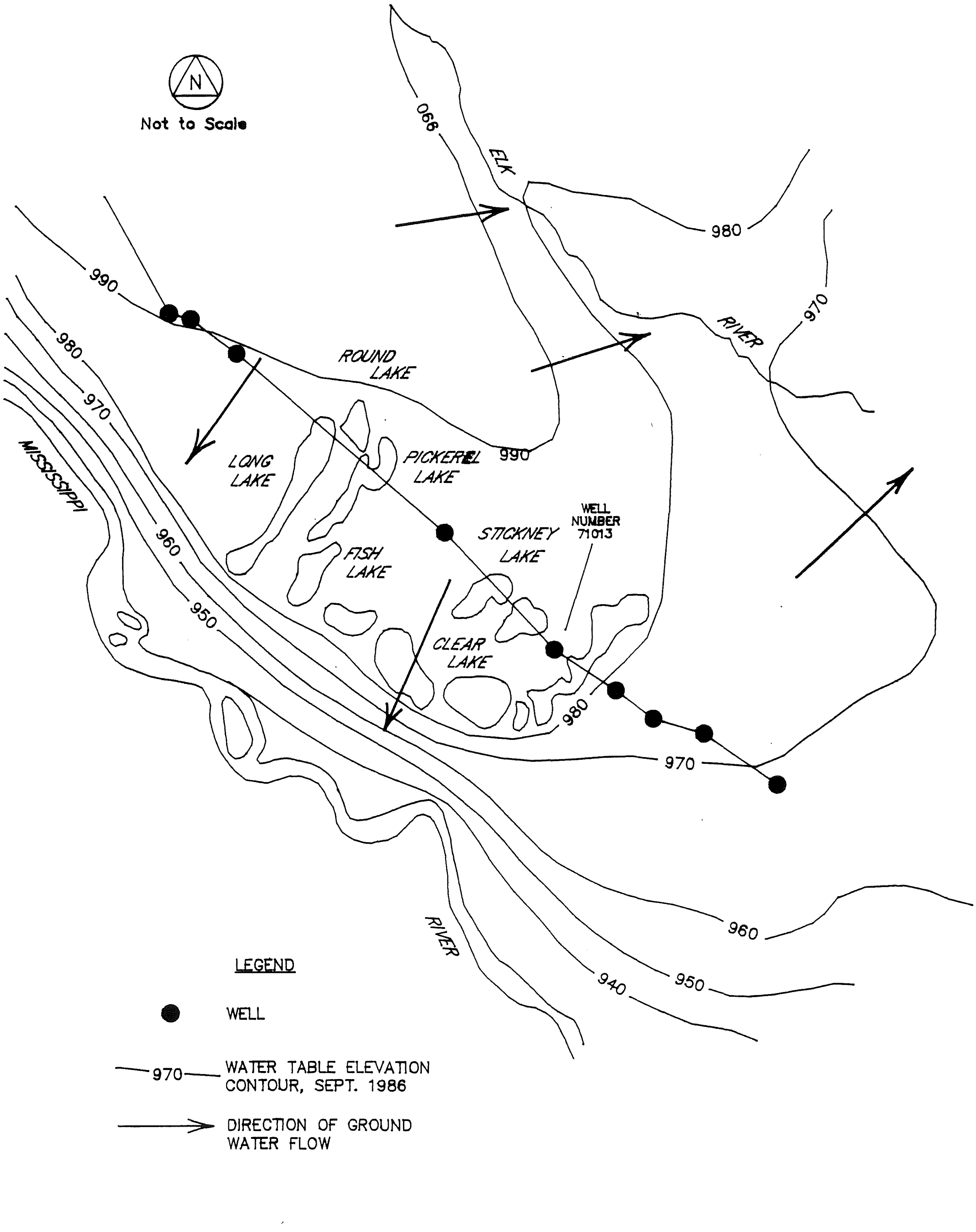
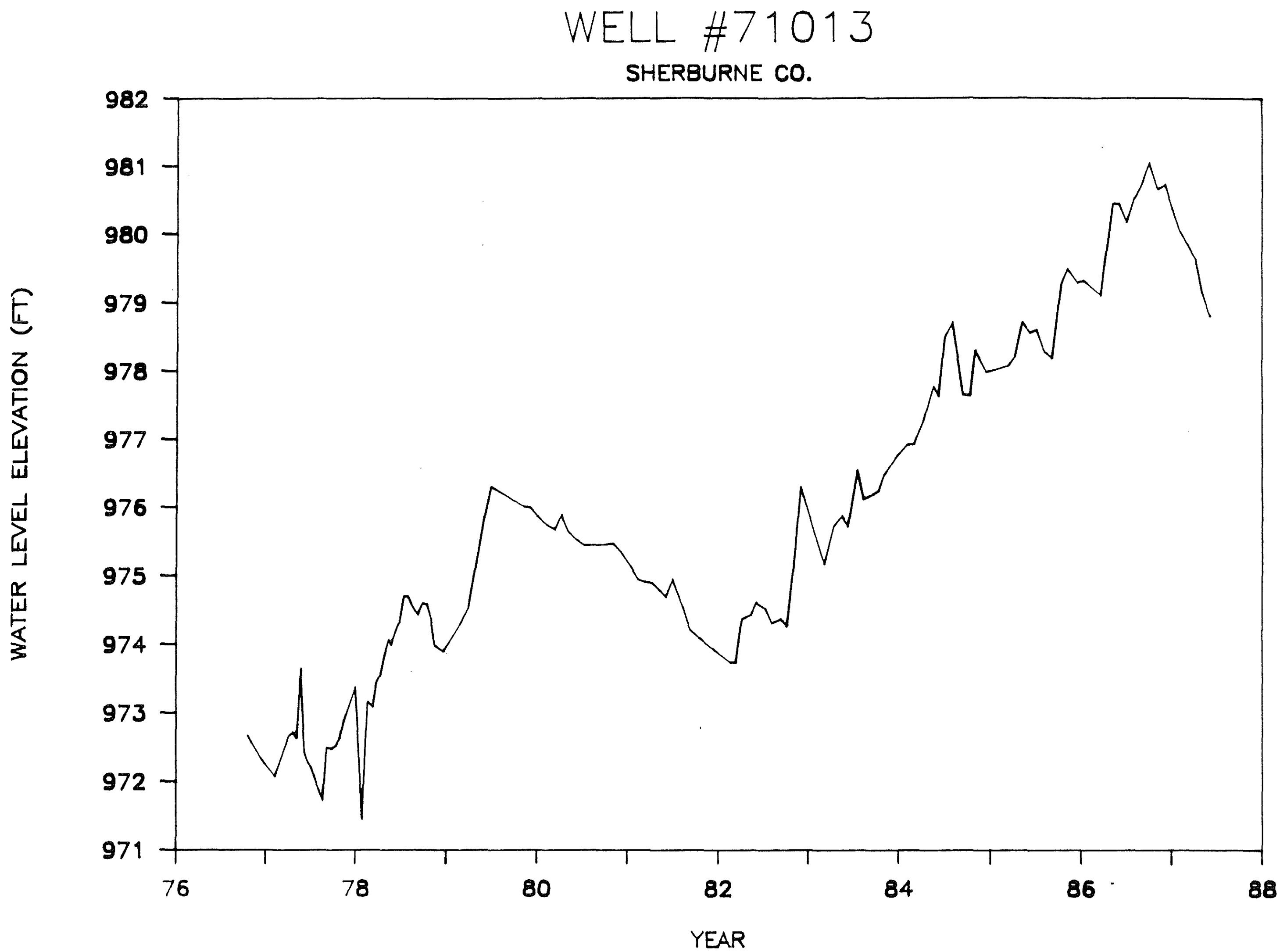


PLATE 3 : WATER TABLE CONFIGURATION AND DIRECTION OF GROUND WATER FLOW IN LONG LAKE CHAIN AREA

PLATE 4



WELL #71013
SHERBURNE CO.
982
981
980
979
978
977
976
975
974
973
972
971
WATER LEVEL ELEVATION (FT)
76
78
80
82
84
86
88
YEAR

WATERSHED

The total watershed area for the Long Lake Chain is approximately 11,516 acres or 18 square miles (Plate 1 on Page ii). The watershed of 11,516 acres minus the water surface area of these eleven Basins of about 1,000 acres equals 10,516 acres or a total watershed area to lake area ratio of 10.5:1. However, a closer examination of the total watershed area reveals that there are about 5,900 acres of other depressed areas or subwatersheds (mostly in the northwest one-half of the watershed) which also store runoff water and recharge the groundwater but would not contribute surface flow to the Long Lake Chain. These subwatersheds reduce the amount of total effective watershed to about 4,616 acres and, therefore, the effective watershed to lake area ratio is about 4.6 to 1.

This effective watershed to lake area ratio of about 4.6 to 1 is generally adequate to maintain normal surface water levels for the Long Lake Chain of Lakes during periods of normal precipitation. During periods of below normal precipitation lake levels would probably drop in elevation and during periods of above normal precipitation it would be expected to see a rise in elevation. Since the area has been experiencing periods of above normal precipitation it is not surprising to see a rise in water levels.

It should be noted however that the sandy soils within the watershed would further reduce the surface water runoff by allowing most of the water to infiltrate into the soil and become ground water which flows generally south southwest towards the Mississippi River. Also, as lake levels rise to above a basin's bottom seal, the water around the lake infiltrates the sandy soils quite rapidly which results in lowering the surface water levels more quickly if followed by normal or below normal precipitation periods.

From the available data, it appears that a closed basin group such as this is experiencing increasing water levels due primarily to above normal precipitation which results in increased surface water runoff together with increased net ground water flow into the Basins.

This Lake Chain has no natural outlet as indicated by an outlet stream or drainageway. From field survey results existing roads presently control outflow from all basins in the Long Lake Chain of Lakes. Basin water levels would have to exceed elevation 990.4' before these roadways would be overtopped and flow would be southwest in the direction of the Mississippi River (See Plate 1 on Page ii). If culverts were placed through these roadways at a low enough elevation to allow natural ground to control the outflow, it would occur when water levels exceed elevation 982.9'.

WATER QUALITY

Water quality information is available for only three lakes in this Lake Chain - these being Long Lake, Pickerel Lake and Clear Lake:

LONG LAKE

Water quality information on Long Lake is located in files of the Minnesota Department of Natural Resources (lake surveys in 1958, 1975, and 1983) and the Minnesota Pollution Control Agency (1981 water quality survey). Long Lake's water quality is representative of the water quality of the lakes in the area.

Long Lake can be described as a relatively clear, moderately nutrient rich, hardwater lake. A healthy variety of aquatic vegetation provides abundant cover for fish and maintains oxygen concentrations in the zone of active photosynthesis.

Water clarity has increased because the balance of biomass production has changed in Long Lake; whereas primary productivity was distributed between algae in the water column and aquatic weeds in 1958 (Secchi disc depth only 4.5 feet and plant rooting depth limited to 8 feet), it is now concentrated in aquatic weeds (1975 and 1983 surveys show only occasional algal colonies, the Secchi disc depth has increased to approximately 11 feet and plants can grow to a depth of about 20 feet). The changes may be caused by the increase in lake level, the associated additional volumes of water of low nutrient content entering the lake, and the resultant decrease in available phosphorus in the open water. Because phosphorus is still available from the lake bottom for rooted plants, they outcompete the algae for the nutrient pool.

PICKEREL LAKE

Water quality information on Pickerel Lake is located in the files of the Minnesota Department of Natural Resources (lake surveys in 1959, 1975, and 1980) and in the files of the Minnesota Pollution Control Agency (1973 and 1981 water quality surveys). Pickerel Lake's water quality has been typical of the lakes in the area.

Pickerel Lake can be described as a relatively clear, moderately nutrient rich, hardwater lake. A healthy variety of aquatic vegetation provides cover for fish and maintains oxygen concentrations in the water column above the thermocline. Pickerel Lake is shallow (median depth 4 feet, 87% littoral area), and there is oxygen demand from the sediments and thus the lake is susceptible to winter-kill.

Water clarity measurements at intervals during the summer of 1973 reveal fluctuations in Secchi disc depths which are typical of moderately nutrient-rich lakes: spring and fall highs (up to 14 feet) and mid-summer lows (2.5 feet). From surveys which detail the extent of weed growth, it can be inferred that water clarity has been increasing. This is most likely due to greater volumes of water of low nutrient content entering Pickerel Lake.

CLEAR LAKE

Water quality information on Clear Lake is located in the files of the Minnesota Department of Natural Resources (lake surveys in 1939, 1946, 1954 and 1978). Clear Lake's water quality has been exceptional compared with the water quality of the lakes in the area.

Clear Lake can be described as a relatively clear, moderately nutrient rich, hardwater lake. A healthy variety of aquatic vegetation provides cover for fish and maintains oxygen concentrations in the water column. There is relatively little oxygen demand from the sediments and the lake is less susceptible to winter-kill than many of the surrounding lakes. The lake bottom is sandy.

Water clarity has decreased since 1946 (bottom visible in 20 feet of water) to Secchi disc depths of about 9 feet in 1978. In times of lower water levels this lake received almost all of its water as nutrient-poor groundwater. High water table gradients in the vicinity of the lake caused ground water "flushing" of the lake, which served to keep nutrient concentrations low. As overland connections to other lakes are made in periods of high water, and as land use on the watershed impacts the lake, nutrient loading will become similar to that of the surrounding lakes and water quality will likely become more representative of typical lakes in the area.

FISH AND WILDLIFE

The Minnesota Department of Natural Resources' Fisheries Lake Survey Reports classify the three game fish lakes (Long, Pickerel and Clear) of this Lake Chain in ecological and management terms are Centrarchid (Bass/Panfish). The remaining basins experience winter kills and are not considered game fish lakes by the Department.

The non-game fish lakes do however receive fish from the game fish lakes by way of physical connections due to the overall higher water levels within the Basin Group. Also, in 1984, walleye were experimentally stocked in Stickney Lake and unnamed basins 148 and 155 but may not have been successful in surviving the 1985-1986 winter kill. A new fish survey will have to be conducted in order to conclude whether or not a fishable walleye population has been achieved.

The fish population of the Basin Group consists primarily of northerns, sunfish, largemouth bass, crappies, perch, white suckers, black bullheads, golden shiners, fathead minnows and possibly some walleyes.

The Department of Natural Resources' files do not contain wildlife information pertaining to this Basin Group. However, observations by the area wildlife manager indicate that the Basin Group is used extensively by waterfowl as a staging and nesting area from early spring to late fall. Trumpeter swans are present during the spring, summer and fall months and may be utilizing this basin group for nesting as well as feeding purposes. Herons, egrets, rails, wrens, terns and other wetland bird species are also observed within the area. In addition, mink, muskrat, beaver, raccoon, deer, fox and some pheasants continuously use the area for habitat.

Generally speaking, shallow water lakes are more productive in wildlife terms. Shallow water provides more feeding and nesting habitats for a wide range of wildlife. A situation that maximizes the shallow water environment is generally beneficial.

PRECIPITATION

The State Climatology Office reports that the average number of annual rain days for the St. Cloud area is 111. It actually rained 110 days in the St. Cloud area during 1986, which is normal. However, the area experienced more rain days in the higher 3 precipitation categories listed below which accounted for above normal total precipitation in 1986.

MEAN RAIN DAYS	MEAN PRECIPITATION CATEGORIES IN INCHES*	1986 ACTUAL RAIN DAYS
50	0.1 - 0.49	68
15	0.5 - 0.99	20
5	1.0 and above	7

*Trace amounts of precipitations less than .1" are not included.

St. Cloud Area

Long Range Normal Annual Precipitation Average (1893-1986) = 26.84"
Normal Annual Precipitation (current trends) 1951-1980 = 27.72" (Plates 5 and 6)
Actual Annual Precipitation:

1982-1986

1982 = 30.46"
1983 = 36.18"
1984 = 33.20"
1985 = 34.41"
1986 = 34.73"

5-year period, yearly average precipitation = 33.79"/yr.

Excess above normal precipitation for 5-year period = 30.38"

1977-1986

1977 = 35.59"
1978 = 27.91"
1979 = 31.18"
1980 = 26.34"
1981 = 23.00"
1982 = 30.46"
1983 = 36.18"
1984 = 33.20"
1985 = 34.41"
1986 = 34.73"

10-year period, yearly average precipitation = 31.30"/yr.

Excess above normal precipitation for 10-year period = 35.80"

A more in-depth of climatological data is contained in Appendix C.

PLATE 5

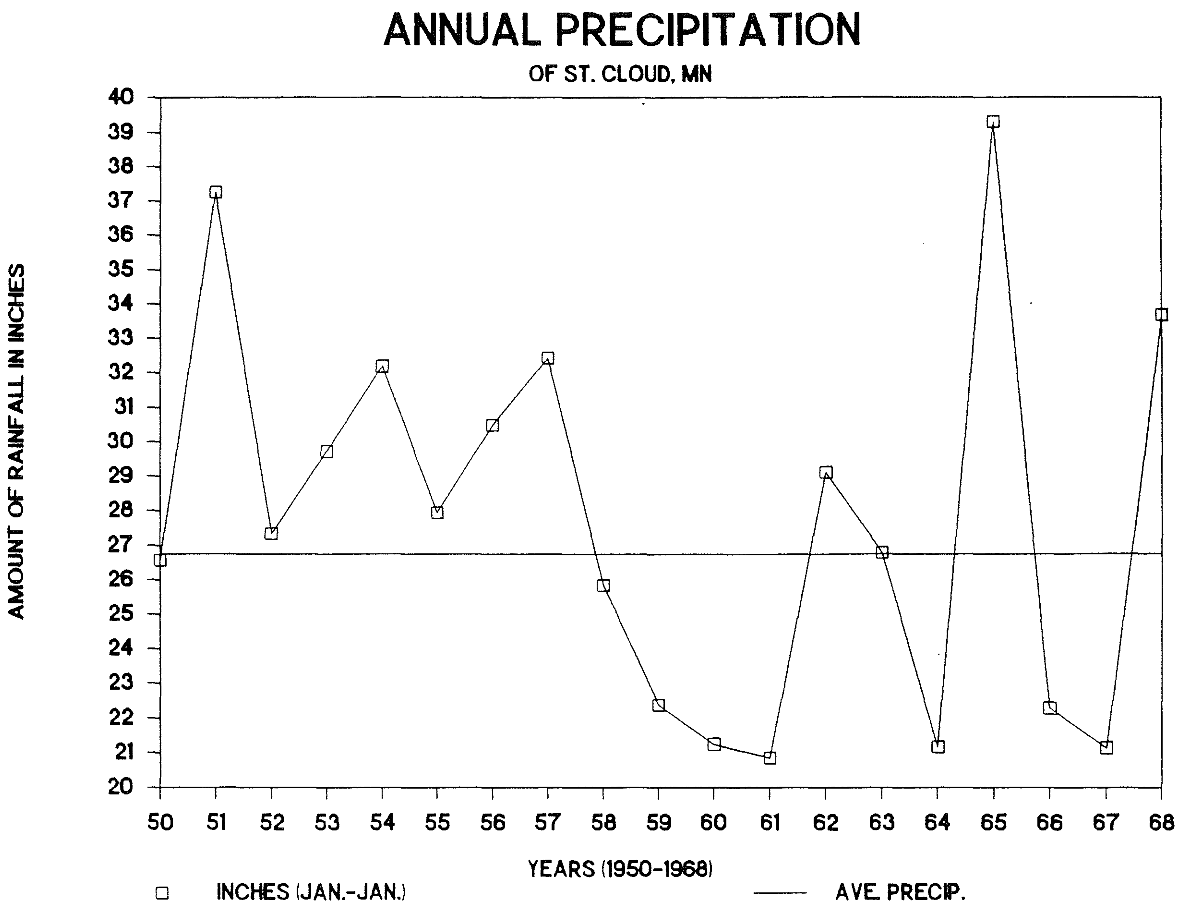
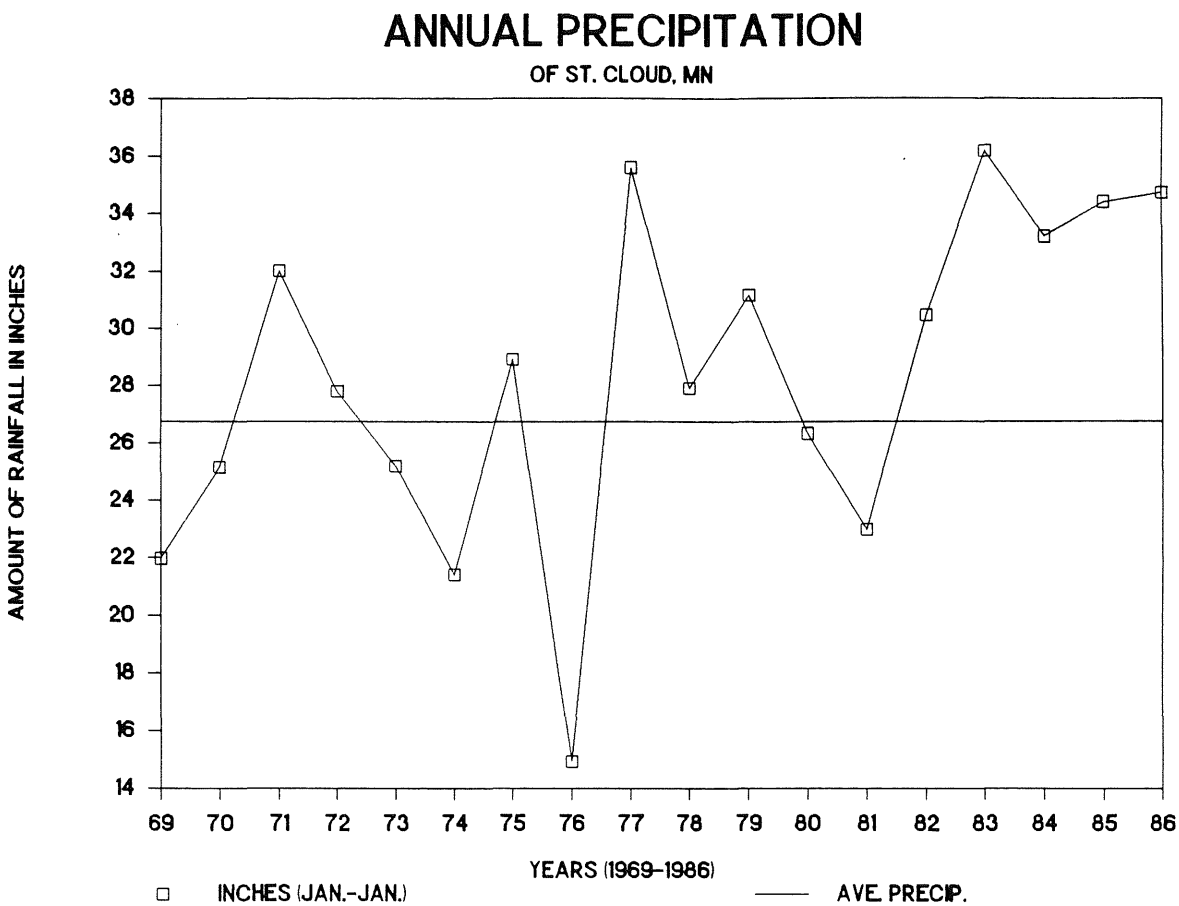

ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68
YEARS (1950-1968)
INCHES (JAN.-JAN.)
AVE. PRECIP.

PLATE 6


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
38
36
34
32
30
28
26
24
22
20
18
16
14
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS (1969-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.

WATER LEVEL HISTORY

The Department of Natural Resources' lake files contain a limited but fairly reliable number of water surface elevations for the Long Lake Chain of Lakes dating from 1951 to March 27, 1987 (refer to Table 1). The available precipitation and lake level data indicate a correlation between the area's annual precipitation and water levels. From 1982 through 1986, the St. Cloud area has received an additional 30.38 inches of precipitation over the normal annual precipitation of 27.72 inches (an additional 6.06 inches per year on the average).

The OHW levels for this Lake Chain (Table 1) range from elevation 977.9' for Basin 155W to 982.4' for Long and Pickerel Lakes. On October 24, 1985, the water surface elevations for Long and Pickerel Lakes were 983.81' or 1.41 feet above their Ordinary High Water levels; however, no water level data are available at this time for the other Basins in the Lake Chain. The remaining Basins apparently were above their respective Ordinary High Water levels as well, due to the fact that the entire Basin Group was physically connected to some degree through water exchange via culverts, overflows and channels as well as ground water interaction. By the fall of 1986, Long and Pickerel Lakes were at elevation 983.99', Fish Lake was at elevation 983.56', and Basin 71-329W was at elevation 983.43'. At this elevation (983.43') Basin 71-329W was not physically connected to the remainder of the Basins to the southeast, however these southeastern Basins (the lower group of Basins) were interacting with each other through physical connections.

By January, February and March, 1987, field survey results indicate a further lowering of the surface water elevations. The drop in elevations would be expected due to low fall, winter and early spring precipitation as well as some of the lake water infiltrating into the soil as groundwater which flows to the south southwest in the direction of the Mississippi River and to the southeast in the direction of the Elk River (Plate 3).

It should be noted that the precipitation patterns in this area are characterized by alternating wet and dry periods of varied duration (Plates 7 and 8). These long-term precipitation variations could continue into the future and the water surface elevations will respond accordingly. Because above normal periods of precipitation of longer duration than the current period have occurred in the past, the current period may continue for several more years resulting in continued increasing lake levels.

Table 1

Long Lake (71-159P)
(OHW = 982.4')

Date	Water Level	Source
1951	978.00'	USGS Quadrangle Map
5/29/57	979.30'	G&F Sounding Map
1974	**985.00'	USGS Quadrangle Map
12/5/83	983.11'	DOW Field Survey
4/16/84	983.40'	Measured by Area Hydrologist
6/12/84	984.21'[1]	Measured by Area Hydrologist
2/27/85	983.10'	Measured by Area Hydrologist
6/14/85	983.15'	Measured by Area Hydrologist
10/24/85	983.81'	Estimated by Area Hydrologist
7/24/86	983.90'	Measured by Area Hydrologist
9/10/86	983.57'	DOW Field Survey
9/22/86	983.95'	DOW Field Survey
9/23/86	983.99'	DOW Field Survey

Pickerel Lake (71-158P)
(OHW = 982.4')

Date	Water Level	Source
1951	*979.00'	USGS Quadrangle Map
1974	**985.00'	USGS Quadrangle Map
12/5/83	983.11'	DOW Field Survey
6/12/84	984.21'[1]	Measured by Area Hydrologist
10/24/85	983.81'	Estimated by Area Hydrologist
9/10/86	983.57'	DOW Field Survey
9/22/86	983.95'	DOW Field Survey
9/23/86	983.99'	DOW Field Survey

Fish (71-150W)
(OHW = 979.2')

Date	Water Level	Source
1951	974.00'	USGS Quadrangle Map
1974	979.00'	USGS Quadrangle Map
12/5/83	979.49'	DOW Field Survey
12/7/83	979.47'	DOW Field Survey
9/4/86	983.56'	DOW Field Survey
9/9/86	983.45'	DOW Field Survey
9/10/86	983.56'	DOW Field Survey
12/31/86	983.61'[1]	DOW Field Survey
1/7/87	983.58'	DOW Field Survey
527/87	982.41'	DOW Field Survey

[1]Highest recorded water level.

Unnamed (71-329W)
(OHW = 978.8')

Date	Water Level	Source
1974	979.00'	Estimated from USGS 7.5' Quadrangle Map
9/9/86	983.43'	DOW Field Survey
12/31/86	983.61'[1]	DOW Field Survey

Unnamed (71-152P)
(OHW = 978.0')

Date	Water Level	Source
1974	979.00'	USGS Quadrangle Map
9/4/86	981.58'	DOW Field Survey
9/9/86	981.47'	DOW Field Survey
9/10/86	981.62'	DOW Field Survey
12/31/86	981.64'[1]	DOW Field Survey
1/7/87	981.63'	DOW Field Survey
2/4/87	981.43'	DOW Field Survey
3/27/87	981.05'	DOW Field Survey

Clear (71-153P)
(OHW = 978.0')

Date	Water Level	Source
1974	976.00'	USGS Quadrangle Map
9/4/86	981.58'	DOW Field Survey
9/9/86	981.47'	DOW Field Survey
12/31/86	981.64'[1]	DOW Field Survey
1/7/87	981.63'	DOW Field Survey
2/4/87	981.43'	DOW Field Survey
3/27/87	981.05'	DOW Field Survey

Unnamed (71-155W)
(OHW = 977.9')

Date	Water Level	Source
1951	975.00'	USGS Quadrangle Map
1974	977.00'	USGS Quadrangle Map
9/4/86	981.58'	DOW Field Survey
9/9/86	981.47'	DOW Field Survey
12/31/86	981.64'[1]	DOW Field Survey
1/7/87	981.63'	DOW Field Survey
2/4/87	981.43'	DOW Field Survey
3/27/87	981.05'	DOW Field Survey

[1] Highest recorded water level.

Unnamed (71-151W)
(OHW Not Determined)

Date	Water Level	Source
1974	981.00'[1]	USGS Quadrangle Map

Stickney (71-149P)
(OHW = 980.2')

Date	Water Level	Source
1951	977.00'	USGS Quadrangle Map
1974	**982.00'	USGS Quadrangle Map
9/9/86	981.58'	DOW Field Survey
9/10/86	981.75'[1]	DOW Field Survey
12/31/86	981.72'	DOW Field Survey
2/4/87	981.62'	DOW Field Survey

Unnamed (71-148P)
(OHW = 978.4')

Date	Water Level	Source
1951	977.00'	USGS Quadrangle Map
1974	977.00'	USGS Quadrangle Map
9/9/86	981.52'	DOW Field Survey
12/31/86	981.65'[1]	DOW Field Survey
2/4/87	981.43'	DOW Field Survey

Unnamed (71-154W)
(OHW = 978.0')

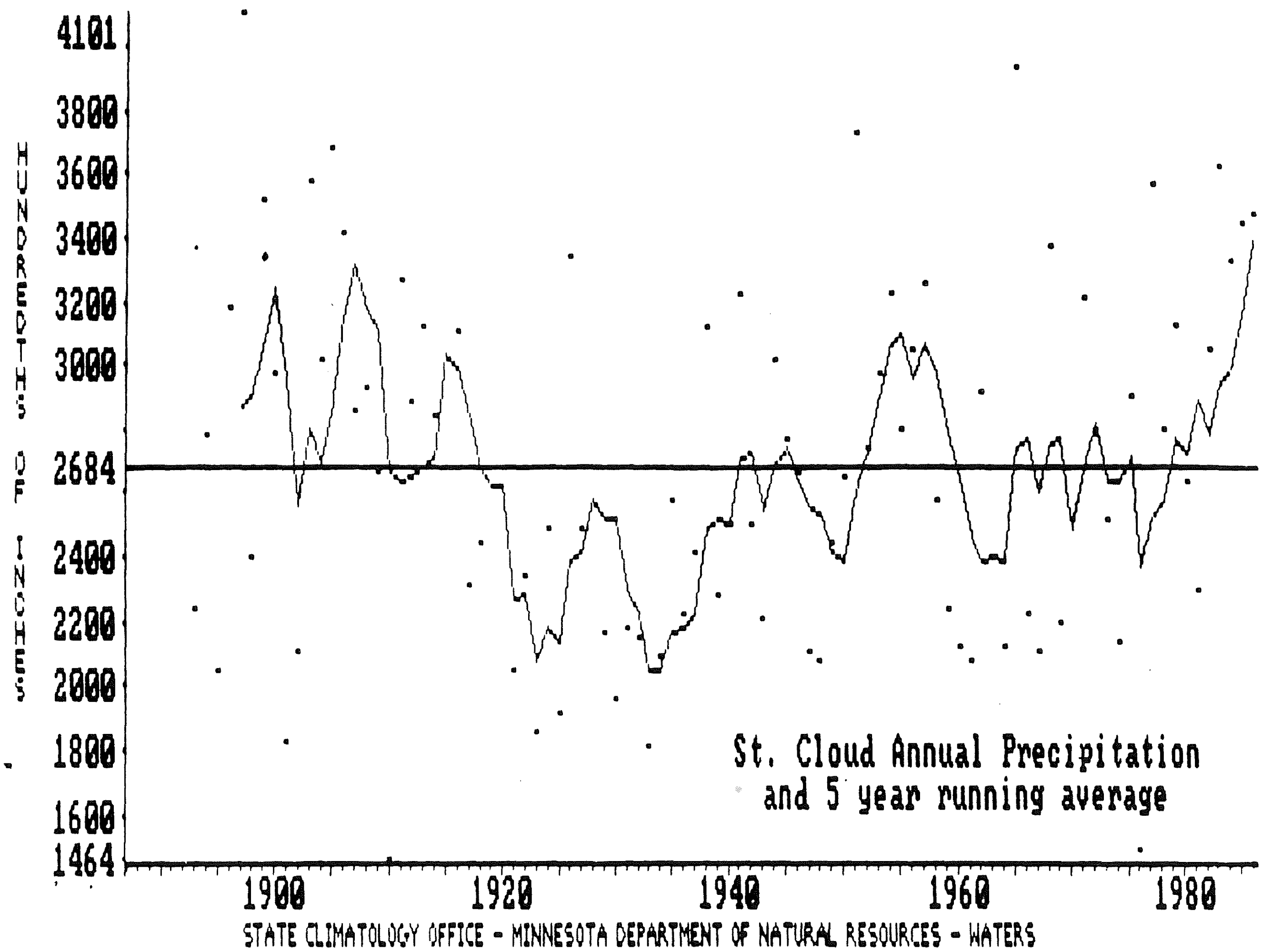
Date	Water Level	Source
1974	976.00'	USGS Quadrangle Map
9/4/86	981.58'	DOW Field Survey
9/9/86	981.47'	DOW Field Survey
12/31/86	981.64'[1]	DOW Field Survey
1/7/87	981.63'	DOW Field Survey
2/4/87	981.43'	DOW Field Survey

*The elevation of Pickerel Lake indicated on the 1951, 15 minute, USGS Quadrangle map is 989.0'. An examination of the elevations of the adjacent basins indicates an error and the elevation should probably be 979.0'.

**The USGS indicated photogrammetry methods were used for this USGS 7.5' Quadrangle Map to determine lake surface elevations. This method can be as much as half a contour (5') in error. These elevations do not appear logical (virtually impossible) and consequently were not used for interpretation purposes within this report.

[1] Highest recorded water level.

PLATE 7



4101
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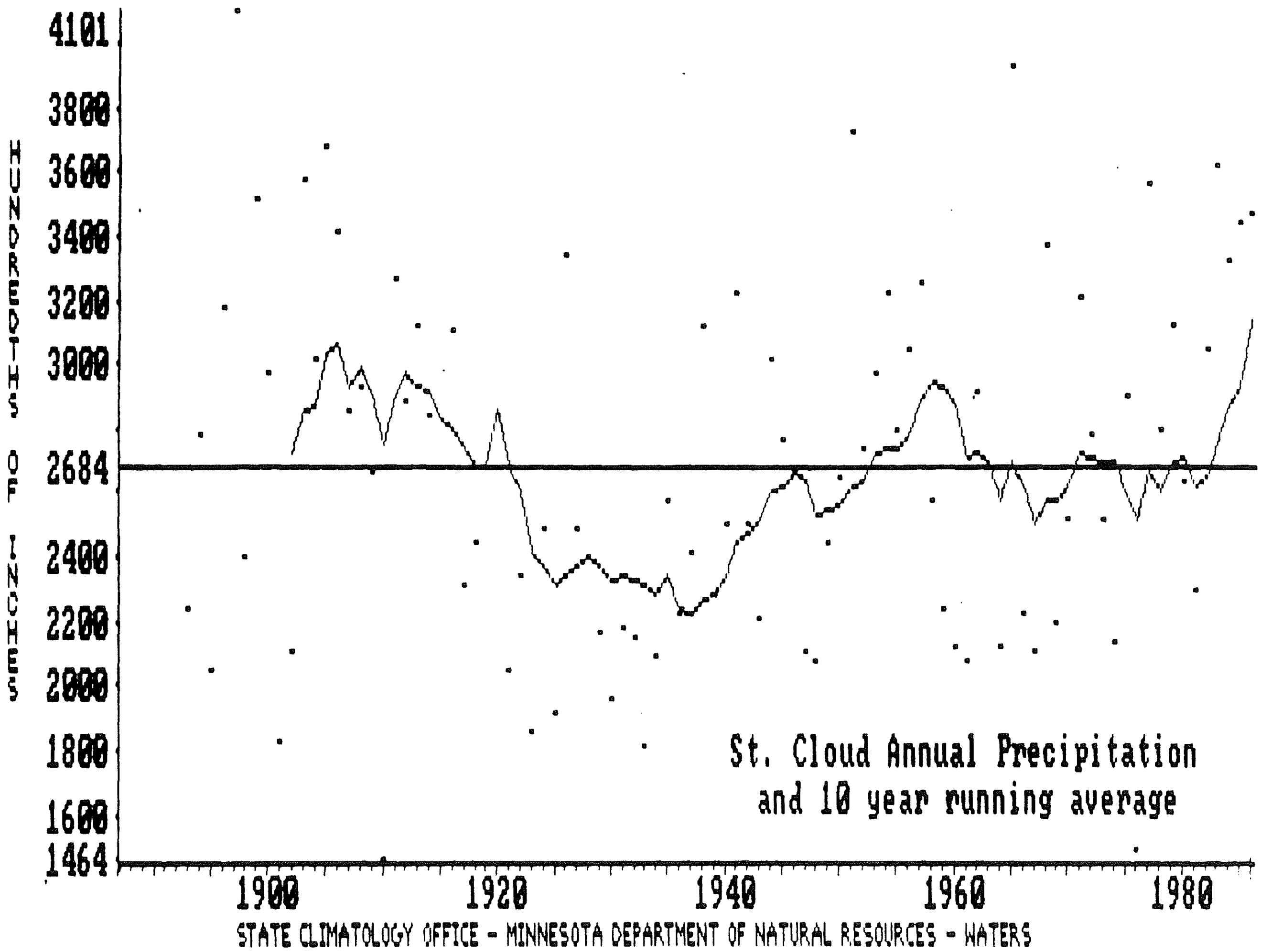
3400
3200
3000
2684
2400
2200
2000
1800
1600
1464
HUNDREDTHS OF INCHES
1900
1920
1940
1960
1980
St. Cloud Annual Precipitation and 5 year running average
STATE CLIMATOLOGY OFFICE - MINNESOTA DEPARTMENT OF NATURAL RESOURCES - WATERS

PLATE 8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St. Cloud Annual Precipitation
and 10 year running average
STATE CLIMATOLOGY OFFICE - MINNESOTA DEPARTMENT OF NATURAL RESOURCES - WATERS

ORDINARY HIGH WATER LEVEL (OHW)

The Ordinary High Water Levels[(1)] for the Long Lake Chain of Lakes have been determined by the Department of Natural Resources, Division of Waters in accordance with Minnesota Statute § 105.37, Subdivision 16. OHW data were obtained from field surveys completed on December 5, 1983 and January 7, 1987, and the subsequent analyses indicated the OHW's to be as follows:

Basin #	OHW
Long (159P)	982.4'
Pickerel (158P)	982.4'
Fish (150W)	979.2'
Clear (153P)	978.0'
Stickney (149P)	980.2'
329W	978.8'
151W	--
152P	978.0'
148P	978.4'
155W	977.9'
154W	978.0'

OHW General

Resource management and riparian rights pertaining to an inland lake are dependent upon identification and establishment of that lake's Ordinary High Water Level (OHW) elevation. The OHW is coordinated with the upper limit of the lake basin and defines the elevation (contour) on the lakeshore which delineates the boundary of public waters. Identification of the OHW comes from an examination of the bed and banks of a lake to ascertain the highest water level where the presence and action of water has been maintained for a sufficient length of time to leave recoverable evidence. The primary evidence used to identify the OHW of a lake consists of vegetational and physical features found on the banks of the lake.

Because trees are the most predominant and permanent expression of upland vegetation they are used as OHW indicators wherever suitable species and sites can be located. Particular attention must be given to the species of upland growth selected for consideration. In general, willow cottonwood and most ash are very water tolerant; maples and elms tolerant; and most birch intermediately tolerant and oak intolerant. The less tolerant trees make the best indicators but factors in addition to species also have to be considered such as age, the slope of ground, the effect of water and ice action on the shoreline and the physical condition and growing characteristics of the trees. Water dependent

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[1]According to Minnesota Statute 105.37, Subdivision 16, "Ordinary High Water Level" means the boundary of public waters and wetlands, and shall be an elevation delineating the highest water level which has been maintained for a sufficient period of time to leave evidence upon the landscape, commonly that point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial. For watercourses, the Ordinary High Water Level shall be the elevation of the top of the bank of the channel. For reservoirs and flowages the Ordinary High Water Level shall be the operating elevation of the normal summer pool.

vegetation such as cattails will follow lake levels as they rise and fall and therefore provide little evidence as to the lake's OHW, except in cases where more permanent vegetation does not exist.

Physical features searched for include soil characteristics, beachlines, beach ridges, scarp or escarpment (more prominent scarp can often be found in the form of the undercutting of banks and slopes), ice ridges, natural levees, berms, erosion, deposition, debris, washed exposed shoreline boulders, high water marks, movement of deposits as a result of wave action, top and toe of bank elevations as well as water levels. Caution is taken to be aware that many of the listed geomorphological features may take a long time to develop and also that several sets of these features may be found. That is, a lake likely will have more than one stage where the action of water has left recoverable evidence however only the stage coordinated with the upper limit of a basin are used to assist in identifying the OHW level. As an extreme example, water level stages resulting from the drought years of the 1930's certainly were the result of natural conditions extending over a number of years, but the resulting recoverable evidence is of no use in OHW determinations.

ANTICIPATED FUTURE LAKE LEVELS - PROBABILITIES

The problem facing landowners and government bodies for land-locked lakes is to respond to high water problems when there is no specific formula which tells us exactly when and how much a lake will go up or down. The Long Lake Chain of Lakes is essentially land-locked because the natural outflow to the southeast of Basin 71-155 is blocked by a series of roadways.

As previously described, levels fluctuate on the Long Lake Chain and are closely related to how much precipitation falls in this area. Precipitation patterns historically have varied significantly in this area and currently the pattern is on the upswing. No one can predict with certainty whether this will continue into the next six months, year, five-years, etc.

The probability of different scenarios of future water level conditions can be estimated from historical precipitation data and groundwater and lake level data. The DNR, Division of Waters has used a water budget computer model with a long-term series of monthly precipitation to determine probabilities of anticipated lake levels for the end of one and five year periods. Each end of period anticipated level was computed using the specific period or slice of historic precipitation (1 year or 5 years) and the known December 1, 1986 lake levels. By using all of the specific periods within the precipitation record, a series of anticipated lake levels is developed and then statistically analyzed to assign probabilities to the range of computed levels.

The in-house water budget computer model "WATBUD" computes net monthly inflow and outflow volumes and storage routes them through the lake using the previous months lake level for initial conditions. The inflows consist of precipitation and runoff computed from precipitation using a constant coefficient. Outflows consist of evaporation and any discharge from an outlet. A constant monthly ground water seepage rate may be an inflow or outflow and together with the rainfall-runoff coefficient are used as calibration parameters to provide a balance water budget.

Because of the complex and dynamic hydraulics associated with these 11 interconnected Basins and the funding limitations for this report, several simplifying assumptions had to be made with respect to the modeling. In addition, coefficients for the Long Lake Chain WATBUD model were estimated by regionalizing calibrated coefficients from other models developed for Sherburne, Wright and Stearns Counties. This was due to insufficient historic lake level data on all 11 Basins. Therefore the modeling results reported below should be viewed with greater conservatism than if the hydraulics and water budget coefficients had been determined specifically for each basin addressed in this report.

Using an initial water surface elevation of 981.6', the modeling results indicate that there is a one-percent probability that the Long Lake Chain of Lakes would all rise above elevation 984.5' on December 1, 1987 and a one-percent probability the Lake Chain will exceed elevation 987.3' on December 31, 1991. These elevations are still 2-3 feet below the runout. It should be noted again that the upper four Basins (Long Lake, Fish Lake, Pickerel Lake and Basin #71-329) drain into the seven lower Basins. At some point, if sufficient inflow enters the seven lower Basins they will rise and equalize with the upper four Basins (and potentially to an elevation of 987.3' by December 31, 1991).

Conversely, probabilities exist which state the likelihood that these Basins may fall. There is a one-percent probability that one or more Basins may be below elevation 982.0' on December 31, 1991. The modeling results also suggest a 50-percent probability (a 50/50 chance) that one or more of these Basins will be at elevation 982.7' on December 1, 1987 and 984.5' in approximately 5-years.

The water budget modeling concerned itself with relatively long-term periods of total precipitation and did not attempt to determine the impacts of major short duration storm events which occur relatively quickly. A management plan for an area must consider the impact of these storm events because of their severe nature and there is little or no time to react to them.

The probability of lake level increases was also computed for the 24 hour and 10 day duration 100-year frequency storm events. Assuming the same initial condition water surface elevation of 981.6' for the lower 7-Basins, the 100-year, 24 hour duration event of 5.7 inches of precipitation would result in lake level increases of 1.7 feet to elevation 983.3' for the lower 7-Basins and the 100-year, 10 day runoff of 7.2 inches would result in a lake level increases of 3.2 feet to elevation 984.8' for all 11-Basins.

POTENTIAL STRUCTURAL DAMAGES

To determine the impact of potential continued increases in water levels, descriptive base data were collected for certain structures along the shoreline of the Long Lake Chain of Lakes. These base data were collected in September of 1986. While the potential maximum elevation of the Lake Chain is unknown, it was felt surveying structures below elevation 991.0' would identify those structures most immediately subject to flood damage.

The example below shows a generic fact sheet that was completed for each structure surveyed. The elevations provided are in Mean Sea Level Datum, 1929 Adjustment, and were determined from instrument surveys. Plate 9 on the following page shows the location of each structure surveyed. Appendix D contains the actual fact sheet for each structure surveyed with a numerical index to match the location map.

EXAMPLE

Structure number:	Doe, John
Name :	R.R. 1
Address: :	City, MN 55312
Legal Description:	Lake Subdivision N ½, Sec. 24, Twp. 122, R. 29 Lot 2
Floor Elevation:	990.0'
Ground Elevation:	987.5'
Basement:	Yes
Walkout:	Yes
Assessed Market Value	
Building Value:	$25,300.00
Land:	$15,200.00
Total Value:	$40,500.00
Flood Insurance:	Yes: Structure = $25,300.00 Contents = $10,000.00

STRUCTURE PHOTO PROVIDED

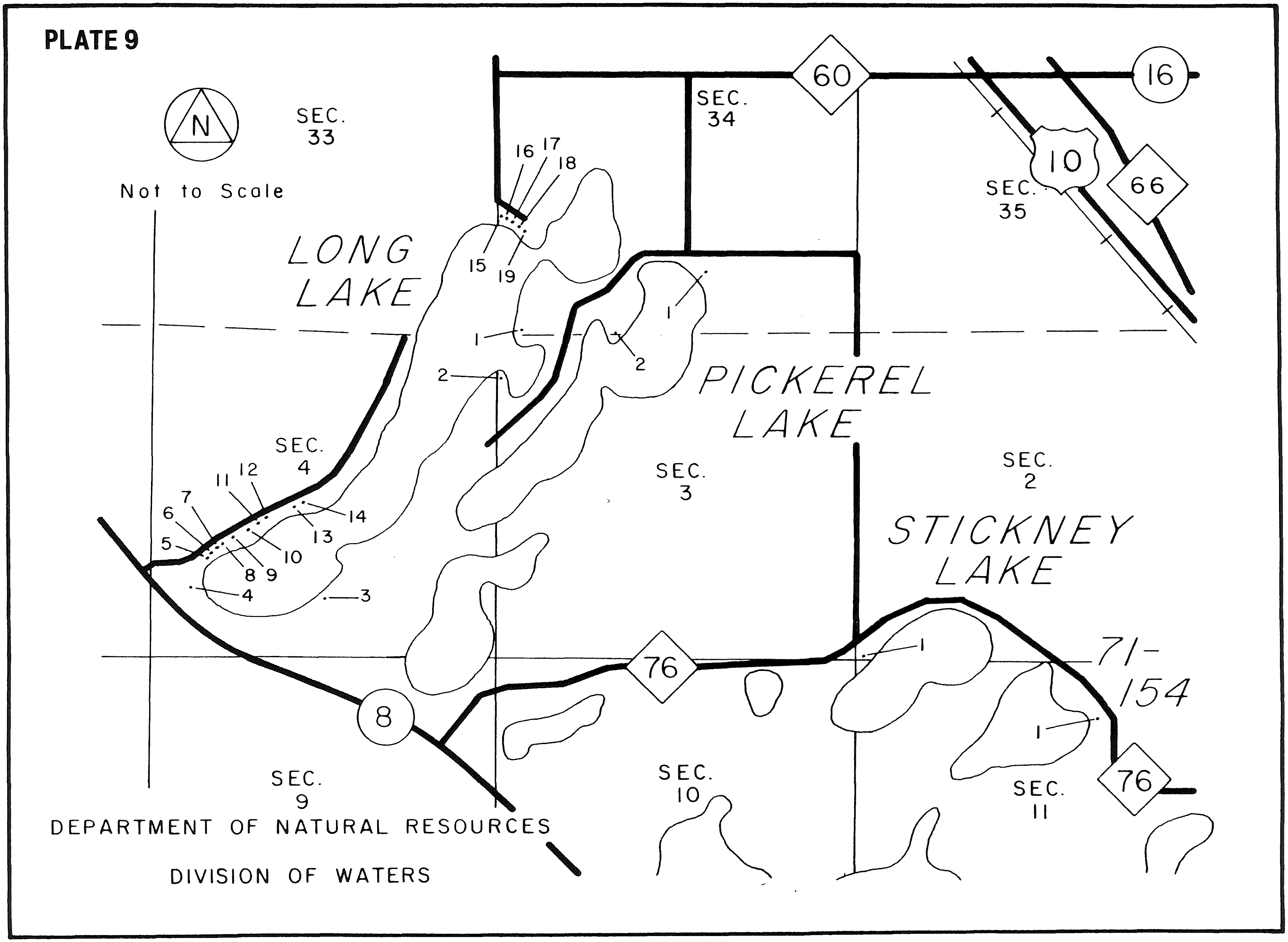
PLATE 9
N
Not to Scale
SEC. 33
SEC. 34
SEC. 35
SEC. 4
SEC. 3
SEC. 2
SEC. 9
SEC. 10
SEC. 11
LONG LAKE
PICKEREL LAKE
STICKNEY LAKE
60
16
10
66
76
8
71-154
1
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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS

Potential structural losses for the Long Lake Chain can be viewed from two different viewpoints:

> First - Once water enters a structure (e.g., in the walkout level) for an extended period of time (e.g., over a winter season), the structure has minimal or no monetary value. The rationale being the structure's habitability to the owner is seriously in question and, on the competitive real estate market, the structure would be most likely unsellable. In effect, the structure's useful and economic life has ended. The loss to the landowner would be the structure's fair market value prior to the water entering the structure. Table 2 tabulates the total assessed market values per incremental increase in water levels. The total loss for all newly damaged structures between elevations 984.0' and 991.0' would be $1,348,400.

> Second - The actual loss to the landowner could be viewed as the physical damage to the structure caused by the water. This assumption is premised upon the water receding at some future date and the landowner could fix the damage and re-occupy the structure. Table 2 tabulates the estimated actual damage to each structure by incremental 1' increase in lake levels. At elevation 991.0', an estimated $901,200 of structural damage would occur. The reader is cautioned that the damage figures are taken from generalized assumptions and are applicable for basinwide planning purposes only.

The decision making process to take corrective measures can include the analysis of the degree of risk exposure, the anticipated benefits or losses prevented and the cost of corrective measures. The data presented thus far should aid landowners and local officials in assessing the degree (probability) of risk exposure. Special reference should be given to the discussion on Anticipated Future Lake Levels on pages 23 and 24 and the site specific surveyed elevations found in Appendix D. Basinwide solutions to a given problem (e.g., a lake outlet) often-times are based upon the total dollars worth of anticipated benefits of losses prevented. Table 2 was provided to show the estimated losses which could occur should these Basins continue to rise.

Again, potential loss figures provided here were from generalized assumptions and the intent was to not provid exact projected damages for individual structures. Potential damages per individual structure would have to be determined after a site-specific investigation. Pages 36-39 in Part II do provide suggested site-specific protection measures and general construction guidelines which could be followed.

Table 2
Potential Increases in Flood Losses
By
Incremental Increases in Water Levels

	Structure Number as Shown on Location Map	Market Value of Building[2]	First Floor Level[3]	Walkout Level	Ground Level at Base of Crawlspace or Basement	Potential Damages/ Row Totals: Market Value	Potential Damages/ Row Totals: Actual Damages[4]	Potential Damages/ Cumulative Row Totals: Market Value	Potential Damages/ Cumulative Row Totals: Actual Damages[4]
Structures below elevation 983.99 presently flooded[1]	14	$ 1,200	983.4	N/A	N/A				
New damages between elevations 984.00 and 984.99	6	$ 8,000	984.4	N/A	N/A	$ 92,800	$ 7,500	$ 92,800	$ 7,500
	1 (Long)	$ 84,800	984.4	N/A	987.6				
New damages between elevations 985.00 and 985.99	7	$ 17,900	987.9	N/A	985.1				
	1 (71-154)	$ 93,300	992.1	985.1	N/A				
	1(Stickney)	barn	N/A	N/A	985.5				
	3	$ 27,700	985.5	N/A	N/A				
	17	$ 11,700	988.2	N/A	985.4	$227,200	$ 69,975	$320,000	$ 77,475
	19	$ 58,700	992.9	985.9	N/A				
	18	$ 17,900	987.3	N/A	985.8				
New damages between elevations 985.00 and 985.99	9	$ 61,200	986.1	N/A	N/A	$ 61,200	$144,800	$381,200	$222,275
New damages between elevations 987.00 and 987.99	8	$ 72,800	989.1	N/A	987.1				
	11	$ 70,000	994.4	987.4	N/A				
	12	$ 46,800	994.5	987.5	N/A	$518,100	$101,245	$899,300	$355,320
	5	$ 51,500	990.0	N/A	987.5				
	4	$ 18,000	990.2	N/A	987.2				
New damages between elevations 988.00 and 988.99	16	$ 43,200	988.0	N/A	N/A				
	10	$ 14,900	990.6	N/A	988.1				
	2	$130,700	995.1	988.1	N/A				
	13	$ 28,300	995.3	988.3	N/A	$310,600	$174,430	$1,209,900	$529,750
	1(Pickerel)	$ 56,700	995.7	N/A	988.7				
	15	$ 36,800	990.7	N/A	988.9				
New damages between elevations 989.00 and 989.99	No new structures at this elevation	N/A	N/A	N/A	N/A	N/A	$142,050	$1,209,900	$671,800
New damages between elevations 990.00 and 990.99	2(Pickerel)	$138,500	990.6	N/A	N/A	$138,500	$229,400	$1,348,400	$901,200

Note: The first floor level of structure #1 on Long Lake is the garage floor elevation. The ground level elevation is at the house.

[1] Basin #71-149 water surface elevation was 983.99' in September of 1986, which was the time the structure elevation data were collected.

[2] 1986 assessed market values were supplied by County Assessor.

[3] The first floor elevation of all walkout structures was estimated by adding 7' to the walkout floor elevation.

[4] A) Estimated damaged for walkouts followed the recommendations of the National Flood Insurance Program's Loss Adjustment Staff by: 1) assuming 20% damages when flood water was up to 1' in depth in a structure; 2) assuming an additional 55% damage when the flood water was greater than 1' in depth but less than the floor level of the main habitable floor; and 3) assuming total damage, or an additional 25% damage, when water reaches the main habitable floor.

B) Estimated damage for crawlspace/basements followed the recommendations of the National Flood Insurance Program's Loss Adjustment Staff by: 1) assuming 25% damages when flood water was up to 1' in depth in a structure; and 2) assuming total damage, or an additional 75% damage, when water reaches the main habitable floor.

C) The figures provided do not include the additional costs for removal and disposal of flooded/abandoned structures, providing replacement water supply and waste treatment systems or abandonment of flooded wells according to health department standards.

The reader should be cautioned these figures do not include any allowance for contents damage because of the uncertainty of whether contents would be removed prior to damage to the structure. If an adjustment is to be made for contents damage, the author recommends a 20% adjustment to each figure provided.

[5] Twenty-five percent additional damages will occur when water enters any structure with a second level above elevation 990.99'. The first structure where this would occur is #1 (Basin 71-154) at elevation 992.1'. See column "First Floor Level".

PART II

FLOOD HAZARD MITIGATION - INTRODUCTION

A broad definition of flood hazard mitigation is those actions taken by individuals and governmental bodies to prevent future flood losses. Prevention of future losses can pertain to existing structures already at risk as well as future development which, if built improperly, will be subject to flood damage. Individual strategies by the landowner should also consider properly insuring oneself against financial, catastropic loss.

Part II will emphasize those structural and nonstructural hazard mitigation actions which will prevent future losses. These actions will generally include flood insurance, local government land use regulations, lake level control structures (especially state permit requirements) and site-specific flood protection techniques (i.e., flood proofing). There will also be a discussion of: 1) potential non local cost-sharing programs to assist in constructing hazard mitigation measures; and 2) institutional frameworks for implementing these measures.

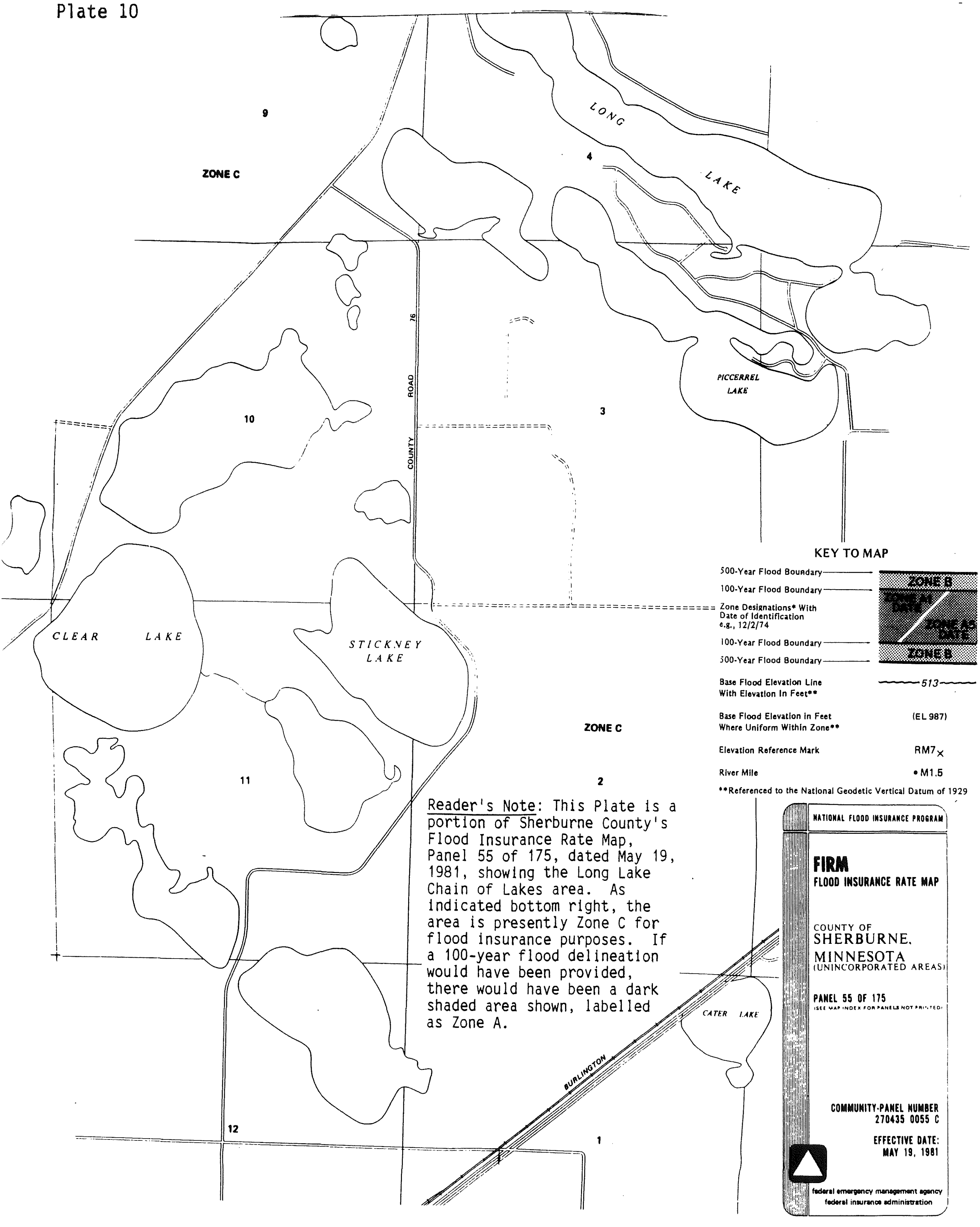
FLOOD INSURANCE

Landowners adjacent to the Long Lake Chain of Lakes can purchase flood insurance through Sherburne County's eligibility in the National Flood Insurance Program (NFIP). Actually, all property owners and renters in the unincorporated areas of in Sherburne County can purchase flood insurance regardless of whether or not the property is located in an identified flood hazard area. This latter point must be stressed because a review of Sherburne County's Flood Insurance Rate Map (Plate 10) shows a flood hazard delineation has not been provided for this Lake Chain. The County's Flood Insurance Study is under revision but at present there has been no discussion within the Federal Emergency Management Agency to add a flood delineation for the Long Lake Chain of Lakes. The significance of a lack of a flood hazard delineation will be discussed in greater detail on Pages 34-36 for the discussion on local government land use regulations.

Obviously, the decision to purchase flood insurance will be based primarily on the probability that a structure and/or its contents will be flooded. The decision making process must also take into consideration the provisions of the standard flood insurance policy which identifies amongst other things:

- When losses are covered (i.e., a general condition of flooding exists);
- Items covered and not covered;
- Removal of a flood damaged structure from a site;
- A "loss in progress" (5-day waiting period); and
- Special loss adjustment procedures for continuous lake flooding.

Plate 10



Reader's Note: This Plate is a portion of Sherburne County's Flood Insurance Rate Map, Panel 55 of 175, dated May 19, 1981, showing the Long Lake Chain of Lakes area. As indicated bottom right, the area is presently Zone C for flood insurance purposes. If a 100-year flood delineation would have been provided, there would have been a dark shaded area shown, labelled as Zone A.

Table 3 identifies the amount of flood insurance coverage available via the NFIP. Sherburne County has been in the Regular Program since March 1, 1979 so, for residential structures, $185,000 of coverage is available for a structure and $60,000 for contents. Questions pertaining to flood insurance premiums (i.e., costs) should be referred to the NFIP toll-free at 1-800-638-6620. It should be noted that all areas not now mapped as having a flood delination on the Flood Insurance Rate Map are considered "Zone C" for flood insurance rating purposes. Zone C has the cheapest flood insurance premium costs. The reader is also cautioned that if contents coverage is desired it must be specifically requested.

Table 3

	Emergency Program	Regular Program	
	Total Amount Available Basic Coverage	Additional Limits	Total Coverage Available
Residential Buildings - Single Family	$35,000	$150,000	$185,000
Residential Contents	10,000	50,000	60,000
Other Residential Buildings	100,000	150,000	250,000
Small Business - Buildings	100,000	150,000	250,000
Small Business - Contents	100,000	200,000	300,000
Other Nonresidential Buildings	100,000	100,000	200,000
Other Nonresidential Contents	100,000	100,000	200,000

The most important factors in determining whether flood insurance will cover a loss are:

1) Is the water body experiencing a "general condition of flooding"? A general condition of flooding is defined in the standard flood insurance policy as:

-"A general and temporary condition of partial or complete inundation of normally dry land areas from:
  a. The overflow of inland or tidal waters;
  b. The unusual and rapid accumulation or runoff of surface waters from any source;
  c. Mudslides (i.e., mudflows) which are proximately caused by flood, as defined above and are akin to a river of liquid and flowing mud on the surface or normally dry land areas, as when earth carried by a current of water and deposited along the path of the current.

-The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding the cyclical levels which result in flood, as defined above.

-Sewer (drain) backup, which is covered only if it is caused by flood, as defined above."

2) Was an insured structure and/or its contents damaged by direct surface water contact during a general condition of flooding?

Land-locked lakes with no outlets do not react to high water like streams/rivers and waterbodies with outlets. The latter, generally go up and down fairly quickly (days or weeks) and there is little question that a general and temporary condition of flooding has occurred. Lakes such as the Long Lake Chain of Lakes can increase and decrease in elevation very slowly over a period of years. While the NFIP will judge each land-locked lake with a high water problem individually, a general condition of flooding has been determined to exist on the Long Lake Chain of Lakes.

It must be pointed out that a flood insurance policy only covers a structure and its contents. The Department of Natural Resource's experience with the NFIP claims adjustment process indicates that surface water must come into direct physical contact with an insured structure during a general condition of flooding before the loss will be eligible for reimbursement. Seepage losses due to water table fluctuations during a general condition of flooding will not be reimbursed. The following is a general description of items covered and not covered (specific questions on coverage should be referred to the above-noted NFIP toll-free number):

> A building and its contents may be insured. Almost every type of walled and roofed building that is principally above ground can be insured. In most cases, this includes mobile homes, but not travel trailers or converted buses. Gas and liquid storage tanks, wharves, piers, bulkhead, crops, shrubbery, land, livestock , roads, machinery or equipment in the open and motor vehicles are among the types of property which are not insurable.

There is a 5-day waiting period for a flood insurance policy to take effect. A loss which occurs during the 5-day waiting period after a policy has been taken out is considered a "loss in progress" and will not be covered by the NFIP. This is a critical factor. The reader may wish to refer back to the Part 1, pages 23 and 24 for the discussion on anticipated water surface elevations.

The discussion on anticipated water surface elevations stresses two important facts. First, no one can predict a maximum water surface elevation for this Lake Chain. If these lakes should continue to rise, a dampening effect would occur as they reach their runout elevation (at an elevation of approximately 990.4'). If the cause of the flooding is due to long-term, above normal precipitation, then the assumption would be as these lakes rise slowly (e.g., 1-2' per year) a landowner would have sufficient advance warning to purchase flood insurance and meet the 5-day waiting period before a loss occurs.

The second important factor to consider is that this Lake Chain can react quickly to high intensity rainfall events (i.e., the 100-year 24 hour and 100-year, 10-day rainfall events). These high intensity rainfall events do occur randomly over time with little or no advance warning to the landowner. If these rainfall events were to occur, there would likely be insufficient time for a landowner to purchase a flood insurance policy and meet the 5-day waiting period.

The previous section on anticipated lake levels indicates that for the 100-year, 10-day rainfall event (at assumed starting water surface elevations of 981.6' and 984.0' for the lower and upper Basin groups, respectively), the Basins would equalize at elevation 984.6'. If the starting water surface elevations were higher than 981.6' and 984.0' just prior to onset of a 100-year, 10-day rainfall event, which is possible, then the resultant 100-year flood elevation would be higher than elevation 981.6'. Landowners should refer to Appendix D which provides actual lowest floor elevations for adjacent shoreland development for comparison. It is the Department of Natural Resources' recommendation that, at a minimum, any landowner with a structure within 2'-3' of a Basin's current water surface elevation should strongly consider purchasing flood insurance.

The NFIP has recently adopted special provisions to deal with continuous lake flooding situations. These provisions are provided below for the reader's information.

> W. Continuous Lake Flooding: Where the insured building has been flooded continuously for 90 days or more by rising lake waters and it appears that a continuation of this flooding will result in damage reimbursable under this policy to the insured building of the building policy limits plus the deductible, the Insurer will pay the Insured the building policy limits without waiting for the further damage to occur if the Insured signs a release agreeing (i) to make no further claim under this policy, (ii) not to seek renewal of this policy, and (iii) not to apply for any flood insurance under the National Flood Insurance Act of 1968, as amended, for property at the property location of the insured building. If the policy term ends before the insured building has been flooded continuously for 90 days, the provisions of this paragraph W still apply so long as the first building damage reimbursable under this policy from the continuous flooding occurred before the end of the policy term.

It should also be noted that the DNR has had discussions with the NFIP about whether a flood insurance policy will reimburse a landowner for the cost of removing a damaged structure from a site. Under most situations the answer is yes. A determining factor is that the cost of removal, in combination with the reimbursement for all covered losses, does not exceed the limits of structural coverage. If a landowner is considering purchasing flood insurance, the issue of maintaining additional coverage for removal of a damaged structure should be kept in mind.

A discussion on basement coverage will be provided here because of the number of structures with "walkout" basements adjacent to this Lake Chain. In the early 1980's, the NFIP reduced coverage to basement areas to cover primarily damage only to the structural components (e.g., foundation walls, floors, etc.) and limited contents. There would no longer be coverage for some finishing materials on walls and floors and most contents. A basement was defined, though, as a space subgrade <u>on all four sides</u>. Therefore, a walkout basement is not subgrade on all four sides and does not meet the definition of a "basement". The coverage reductions do not apply to structures with walkout lower levels.

This section was intended to provide background information on the NFIP and information relevant to lake flooding situations. Specific questions should be referred to the NFIP. Flood insurance can be purchased through any licensed insurance agent or broker who can write property insurance in Minnesota. Landowners contemplating purchasing flood insurance should locate an insurance agent familiar with the NFIP.

LOCAL GOVERNMENT
LAND USE REGULATIONS

Proper enforcement of land use regulations for new development is the cornerstone of a hazard mitigation program. New development includes not only new construction but also modifications, additions to and repair of existing construction. Sherburne County, by virtue of its eligibility in the NFIP, must properly regulate new development in flood prone areas to insure continued eligibility in the NFIP for all citizens in the unincorporated area of the County.

As noted earlier, the current Flood Insurance Rate Map for Sherburne County does not show a flood delineation (i.e., Zone A) for the Long Lake Chain of Lakes. This means that: 1) technically, Sherburne County does not now have to apply the provisions of its flood plain ordinance to new development bordering this Lake Chain; and 2) the NFIP, while making flood insurance available to property owners, places no minimum development standards to be met by the County when regulating new development in this area.

The obvious question is what prudent course of action should Sherburne County take when regulating new development adjacent to the Long Lake Chain of Lakes? Sherburne County must continue to properly enforce its state-approved shoreland management regulations adopted pursuant to Minnesota Statute, Chapter 105. The basic regulatory components of the County's shoreland regulations relevant to flooding potential on a land-locked basin include:

- The County must specify a lowest floor or flood protection elevation. In the absence of an acceptable 100-year flood level, all new structures and additions/modifications/ substantial repairs of existing construction must be elevated with the lowest floor (including basement) to 3' above the highest known water level. The highest known water levels have varied for the upper and lower basin groups in this Lake Chain, as shown in Table 1 on pages 16-18. The minimum fllod protection elevation for each Basin in the Lake Chain can be established by adding 3' to the highest respective water level shown in Table 1.

- On-site water supply and sewage treatment systems must be designed so as not to be impaired/contaminated during times of flooding. These systems, at a minimum, must be designed to the flood protection level discussed immediately above.

- New subdivisions, prior to approval by the County, must be reviewed to insure the area is suitable for the proposed use including a consideration of the potential for flooding. Each newly created lot must have a building site and a location for on-site utilities at or above the flood protection elevation.

It is important to discuss whether a flood delineation should be added to the County's Flood Insurance Rate Map (FIRM). The issues are essentially three-fold:

1) A flood delineation would provide a notification to potential purchasers of existing property that the area is flood prone (and the potential magnitude of the flooding) and that the purchase of flood insurance may be advisable;

2) Flood insurance in a mapped Zone A (approximate 100-year flood plain) would then be mandatory for all federally insured, financed or regulated mortgages, grants, etc., thus protecting the investment of the public at large. Otherwise, a landowner may default on a mortgage if a non insured loss were to occur; and

3) Would the delineation of an approximate Zone A on the FIRM better facilitate the future regulation of new development adjacent to the Long Lake Chain of Lakes.

The latter of the above-noted three issues will be discussed first. It is the Department of Natural Resources' opinion that the County's current shoreland zoning and subdivision regulations can adequately regulate new development on the Lake Chain. As was discussed earlier, the County must, at a minimum, use a 3' separation from the highest known water level as a lowest floor regulatory elevation. For all new shoreland development an additional provision should be added to the shoreland ordinance which requires an elevated road access to the flood protection elevation.

The rationale for using 3' above the highest known water level as a regulatory elevation is that in the absence of any studies of projected high water levels (such as was done in the section on Anticipated Water Levels, pages 23-24), 3' above the highest known water level is reasonably safe for most basins (but not necessarily land-locked basins). Aside from the flood plain mapping/ordinance issue, the County must assess whether using this 3' separation factor under its current shoreland regulations is a proper long-term strategy for regulating new development.

The County must look to the long-term because the economic life of new residential construction can be on the order of many decades. With the documented cyclical nature of water levels and precipitation in this area, what might the maximum water level be in the next 60-80 year period? The answer to this question is unknown. What is known is that if new development is built to 3' above the highest known water level, and this level is exceeded during the life of the development, the ramifications will be severe because of the potential long duration of flooding. Considering the above, a proper course of action for the County would be to consider requiring under its shoreland regulations additional freeboard (or safety factor) above this 3' separation factor (and especially for the lower 7-Basins).

It is the Department of Natural Resources' recommendation that the County use elevation 987.3' as the minimum flood protection elevation for all Basins in this Lake Chain. This is the elevation established in the previous section on anticipated water levels for the 100-year or 1%, 5-year precipitation event using the WATBUD model. Using elevation 987.3' will provide more freeboard for 7 of the 11 Basins in the Lake Chain. This additional safety factor may be extremely beneficial considering the natural runout for the entire Basin group is above elevation 990.0'.

Adding a flood delineation on the County's FIRM would primarily act as a consumer awareness device for potential purchases of property and would also better protect the investment of federal dollars in mortgages, subsidized flood insurance, etc. The County has the authority to properly regulate new development with its current shoreland regulations, in the absence of a flood delineation and the jurisdiction of its flood plain ordinance. Adding a flood delineation on the FIRM would have to be premised on the selection of a flood elevation which best serves the public's interest. The decision will be left to the Federal Emergency Management Agency, with local input.

PROTECTING NEW/EXISTING STRUCTURES

As mentioned in the previous section on local land use regulations, new construction and additions, modifications to and repair of existing structures must be protected against potential flood damage. The minimum protection level pursuant to local shoreland regulations is 3' above the highest known water level. The Department of Natural Resources strongly encourages a local flood protection level of a minimum of 987.3' for all Basins in this Lake Chain.

The most prudent method of protecting new and existing development in a potentially long duration flooding event is to elevate the building site on properly compacted fill. The lowest floor (including crawl spaces, basements, and other enclosed areas), must not extend below the identified flood protection level, even if continuous fill is placed around the structure to the identified flood protection level. Standard flood proofing techniques for enclosed spaces below the flood protection level generally are not recommended in flood plains for land-locked Basins. This is due to the long duration of flooding and associated saturated soil conditions. Although flood proofing of spaces is generally not recommended when flooding is long-duration, more detailed information is available in the report "Flood Proofing Regulations" which has been adopted into the State Building Code.

Taking emergency action to protect existing development presents a particular problem to the landowner and the community. Because these activities require structural modifications to structures, grading/filling, alteration to shoreline vegetation, etc., a development permit will be required from the local unit of government. The County would review the proposal so as to insure neighboring properties are not affected and the lake resource protection standards are met (e.g., setbacks, flood protection, vegetation removal, etc.).

Plates 11 and 12 provide a number of potential emergency protection measures. The decision to employ any given measure will depend on the site-specific flooding situation. These emergency protection measures are presented here so as to inform the reader of the general design factors which must be considered. The reader is cautioned that an engineer or architect and the local building code official should be consulted prior to the design of emergency flood protection measures.

Except for the following two situations, a landowner may choose the protection level for <u>emergency protection measures</u>.

1) A structure has been damaged to 50-percent of its market value at the time of loss and the landowner wishes to repair the damage; or

2) The emergency protection measures would equal or exceed 50-percent of the structures market value.

For the two above situations, the structure, at a minimum, must be protected to the flood protection elevation established by the County.

The reader is requested to pay special attention to the discussion of levees and filling around structures on Plates 11 and 12 on the following pages. Levees are temporary measures and should not be considered as a permanent solution. In no case should a structure protected by a levee be used for human occupancy. This is especially true when the top of the levee is higher than 1-2' above the lowest floor level. A sudden collapse of the levee or overtopping can cause structural failure to the supporting walls, inundating the building with little warning and causing serious damage. All damageable items should be removed from potentially damaged areas and provisions should be made to allow water to enter the building (to equalize water pressure inside and out) should the levee fail.

Secondly, fill could be placed around an existing building to keep surface water away. It is likely that the fill material adjacent to the building will become saturated because of the potentially long duration of the high water and the porosity of the soil. Water pressure will likely build on the outside walls at an elevation equal to the lake level. Any attempt to keep the area inside the building dry by pumping will create differential pressures inside and outside of the building's walls. This could lead to wall and floor collapse and, in no case, should the building be used for human occupancy. A design professional should be consulted prior to pumping the inside of a structure to determine if the structure can tolerate differential pressures against its walls and floors. A safer alternative may be to fill the inside area of the building with granular material (a permanent loss of a lower level) or to allow water to enter into and equalize inside the lower level.

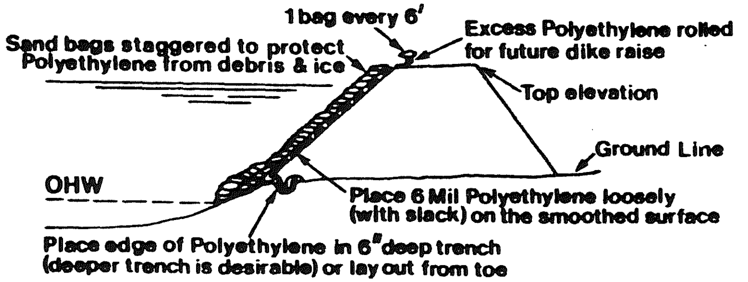
PLATE 11
FLOOD PROTECTION MEASURES

The following information is being presented to stress the importance of following prudent design and permit review procedures prior to installing emergency or permanent protection measures. Design guidelines assisted by a qualified professional are not only cost effective (e.g., the measure will work as designed and will not be over or under-designed), but protect the investment of the landowner. Community permit review will insure consistency with local land use controls which were designed to avoid haphazard, unregulated shoreline encroachment that will have adverse impacts on adjoining landowners, long term property values and the lake resource.

TYPE OF PROTECTION

GENERAL DESIGN CONSIDERATIONS

EARTHEN LEVEE



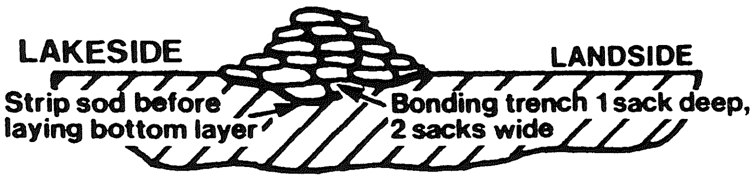
SECTION

These criteria are guidelines for construction of temporary levees. The criteria are not for permanent protection and not intended for long term exposure to high water.

- Site Preparation: Remove topsoil and vegetation on the foundation of the levee. This material can be stockpiled and used for cover of the levee.
- Construction Materials and Placement: The preferred material is clay as it is relatively impervious if compacted properly. The material should be placed in layers not exceeding 9 inches and compacted with four to six passes of a roller. Impervious material such as sand or sandy-clay can be used. This material requires a flatter side slope than clay. Place material in layers not more than 12 inches, and compact with not less than two passes of a roller.
- Side Slope (minimum):
  Clay - 1 vertical on 2½ horizontal
  Sand - 1 vertical on 3 horizontal (lakeward)
  1 vertical on 5 horizontal (landward)
- Top Width: Clay - 8 feet
  Sand - 10 feet
- Interior Drainage: Pumping will always be required for removal of seepage and rainfall behind the levee. The amount of pumping depends on the foundation soils, the levee material and the drainage area behind the levee.
- Slope Protection: Protection is needed on the lakeward side of the levee to prevent erosion from wave action. The preferred protection is a layer of rock riprap 12 inches in diameter with a filter underneath (filter cloth, poly sheeting). Protection of the toe of the levee and foundation is critical for areas of high wave action. A second method of protection is reinforced polyethylene sheeting weighted with sandbags.
- Placement in Water: Construction of earthen levees in water is not recommended. A temporary sandbag levee can be constructed and the area behind pumped. Then the earthen levee can be constructed behind the sandbag levee.

*Each project should be analyzed and designed by an engineer competent in earthen structure construction.

SANDBAGGING

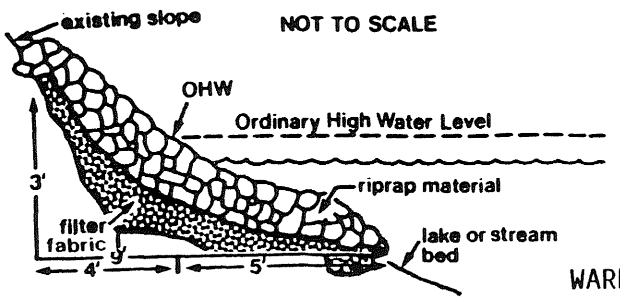


SECTION

A sandbag levee provides temporary protection from short term rises in lake elevations.

- Site Preparation: Remove topsoil and vegetation. Dig a bonding trench to key in the levee to the foundation.
- Construction Materials and Placement: Sand or predominantly sandy or gravelly material should be used. Woven plastic sandbags are preferred if the levee is long term, as burlap bags will deteriorate over time. Bags should be filled ½ full, lapped when placed, and tamped tightly in place. The bags should be staggered when placing to prevent gaps through the levee.
- Cross Section: The base width should be 3 times the height, as a minimum. The top width should be sufficient to add additional bags to raise the levee if needed. A maximum height of 3 feet is recommended.
- Seepage Barrier: Polyethelyne sheeting may be incorporated into the lakeward face of the levee to reduce seepage. Placement is similar to placement on an earthen levee.
- Interior Drainage: Pumping will be required for removal of seepage and rainfall behind the levee. Sandbag levees will seep more than earthen levees, as the material is pervious and the cross section is not as wide.
- Placement in Water: If the levee is placed in the water, it is important to monitor the levee for settlement, erosion under the levee and excessive seepage.

RIPRAP: NATURAL SHORELINE OR FILL EMBANKMENT PROTECTION



- Natural rock riprap 12" in diameter or larger
- Finished side slope no steeper than 3:1 (3' horizontal to 1' vertical)
- A transitional layer of filter fabric is required to be placed between the slope or embankment material and the riprap.

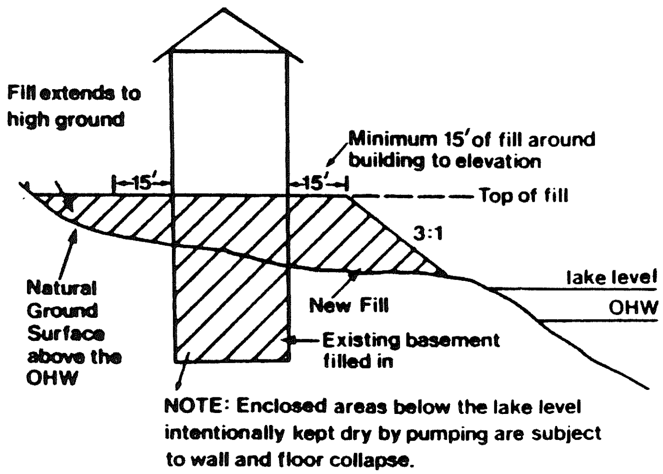
WARNING: Fill placed below the Ordinary High Water Level may require a permit.

PLATE 12
FLOOD PROTECTION MEASURES

TYPE OF PROTECTION

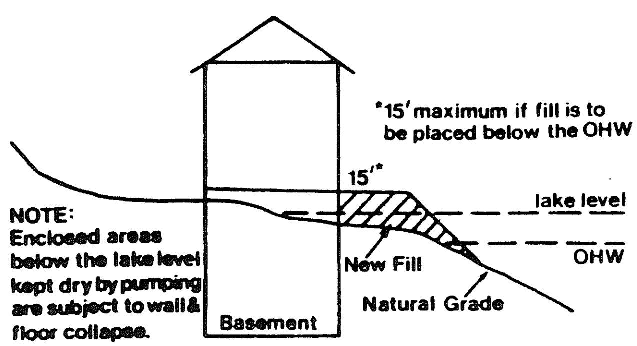
GENERAL DESIGN CONSIDERATIONS

ELEVATED STRUCTURE (PERMANENT)



- Stabilized fill elevation underneath and 15' around the structure
- Fill selection and placement shall recognize the effects of saturation from flood waters on slope stability, uniform and differential settlement and scour/wave action.
- Fill material would be preferably granular and free-graining, placed in compacted layers.
- The minimum distance from any point of the building perimeter to the top of the edge of the fill slope shall be 15'.
- Side slope sections of fill areas should be anticipated to experience wave action and must be properly riprapped or otherwise protected.
- The area to be filled shall be properly cleared of trees, brush, debris or other growth which the building officials considers unstable as a foundation material.

PERMANENT FILLING AROUND STRUCTURE



- The side slope of the fill area shall be properly protected by a method of protection as outlined above.
- Pumping lower level enclosed areas may result in hydrostatic pressure levels being higher on the outside of the walls as compared to the inside of the walls. This pressure differential can cause walls to collapse or floors to buckle.

WARNING: Fill placed below the Ordinary High Water Level may require a permit.

RESOURCE MANAGEMENT - THE DIRECT ROLE OF THE STATE

The preceeding sections in Part II indicate that the federal government plays the primary role in providing flood insurance and local government is actively involved in regulating development adjacent to the Long Lake Chain of Lakes. The State, pursuant to Minnesota Statutes Chapter 105, regulates directly those actions affecting the course, current or cross section (i.e., the bed) of public waters and protected wetlands, as defined in Minnesota Statutes Section 105.37, Subd. 14. Each of the Basins listed in Table 1 on pages 16-18 is identified as a public water or protected wetland in the Protected Waters Inventory for Sherburne County and, thus, fall under the jurisdiction of Minnesota Statutes Section 105.42.

A common response to rising lake levels is to: 1) artificially control a lake's level by constructing an outlet or pumping; 2) protecting existing structures by constructing temporary levees, placing fill around structures or elevating structures on-site with fill; and 3) constructing shoreline erosion protection measures. Pursuant to Minnesota Statutes Section 105.42, a state permit is required for the following specific activities below the Ordinary High Water Level (OHW) of each Basin in the Lake Chain (this is not an all inclusive list of state permit requirements):

- Any action which would attempt to control the lake to prevent it from returning to its OHW;

- Any fill or obstruction placed below the OHW to protect a structure; or

- Placement of any shoreline protection measure which does not meet the following criteria:

  Riprap shall be natural rock 12" in diameter or larger;

  The finished side slope shall be no steeper than 3:1 (3' horizontal to 1' vertical);

  A transitional zone or layer of gravel, small stone or fabric is placed between the slope or embankment material and the riprap; and

  The shore protection measure does not extend more than 5' horizontally lakeward of the OHW.

Also a DNR permit would be required: 1) to lower a lake below its OHW ; or 2) to control a lake above its OHW, when:

1) Water is pumped in excess of 10,000 gallons a day or 1,000,000 gallons a year; or

2) The OHW of another public water or protected wetland is affected.

State Rules for managing public waters and protected wetlands do allow for controlling a land-locked waterbody up to 1.5' below its OHW when its in the public's interest to do so. State Rules balance the public's interest in protecting a public resource in a natural condition versus a landowner's (or group of landowners) right to alter a statewide resource to protect existing development. This balancing of interests is paramount for any activity which changes the course, current or cross section of protected wetlands and public waters.

The following statements are excerpts from DNR Rules which address the above-noted "balancing of interests" concept:

Goals, Objectives and Standards

-Maintain natural flow and natural water level conditions to the maximum extent feasible;

-Encourage the construction of small upstream retarding structures for the conservation of waters in natural waterbasins and watercourses consistent with any overall plans for the affected water;

-Limit the artificial manipulation of water levels except where the balance of affected public interest clearly warrants the establishment of appropriate controls and it is not proposed solely to satisfy private interests;

-The project will involve a minimum of encroachment, change or damage to the environment including but not limited to fish and wildlife habitat, navigation, water supply, storm water retention and agricultural uses;

-Adverse effects on the physical and biological character of the waters shall be subject to feasible and practical measures to mitigate the effects;

-Where no natural or artificial outlet exists and the lake for all practical purposes "landlocked", the control elevation shall not be more than 1½ feet below the ordinary high water mark; and

-Justification has been made of the need in terms of public and private interests and the available alternatives, including the impact on receiving waters and public uses thereof, through a detailed hydrologic study.

Those considering any action which would alter the course, current or cross-section of the Long Lake Chain of Lakes should contact the DNR area hydrologist in St. Cloud at: DNR-Division of Waters, 3725 12th Street North, P.O. Box 370, St. Cloud, MN 56302, Phone: (612) 255-4278.

IMPLEMENTING MITIGATION MEASURES/INTRODUCTION

This report up until now has attempted to provide landowners and local government officials with the resource management information necessary to judge which mitigation strategies would be most successful on the Long Lake Chain of Lakes. The Department's experience in similar flooding situations indicates that implementation of mitigation strategies is most successful when a local unit of government (i.e., below the level of state and federal government) takes the lead role. The remainder of this report will emphasize: 1) those non-local funding programs which may be available to assist local interests; and 2) institutional arrangements (both governmental and quasi-governmental) which are available to secure funding or direct mitigation strategies.

COST-SHARING ASSISTANCE

This section will give an overview of the non local funding sources that the Department of Natural Resources is aware have been used to alleviate flooding problems in Minnesota. Some of these funding sources have been used more successfully than others.

U.S. Army Corps of Engineers/Flood Control Assistance

The U.S. Army Corps of Engineers has two primary authorities for providing technical and financial assistance for constructing local flood control measures. Flood control measures can consist of "structural" measures, such as levees, dams, lake outlet structures, pumping stations, etc., and "non-structural" measures, such as flood proofing structures, acquisition/relocation of structures, etc. The two primary federal funding authorities are:

1) Small Projects - Continuing Authorities Program. This is an ongoing program established by Congress to provide a more timely response to local flood control, erosion and navigational problems. Funding decisions are made directly by the Corps of Engineers through established review procedures without direct congressional approval on a project-by-project basis. By virtue of the small projects connotation, federal financial assistance is limited to $5,000,000 or less for each project; and

2) Congressionally Authorized Projects. The federal government, via the Corps of Engineers, can participate in "large" flood control projects where the federal cost would exceed $5,000,000. The study and funding mechanism is time consuming and requires direct congressional approval at each stage of each project.

The Small Projects, Continuing Authorities Program has been successful in assisting many Minnesota communities. Two recent successful projects are the Lake Pulaski outlet and the City of Halstad ring levees. Any future Corps of Engineers assistance in the Long Lake Chain area would likely be from the Small Projects - Continuing Authorities Program.

It must also be noted that this federal assistance will be premised upon an acceptable local sponsor and non-federal cost-sharing. Generally, the local sponsor must provide the lands, easements and rights-of-way necessary to construct the project or approximately 35% of the total project, whichever is greater. A political entity must sponsor the project and eventually enter into contractual agreements to insure all guarantees and cost-sharing commitments are met (the reader should refer to the next section on institutional arrangements).

If local interests should desire Corps of Engineers' flood control assistance, a written request should be submitted to: Flood Plain Management and Small Projects, Planning Division, St. Paul District Corps of Engineers, St. Paul, Minnesota 55101-1479. The Corps of Engineers will conduct an initial appraisal and assess federal interest and potential economic feasibility.

SMALL CITIES DEVELOPMENT PROGRAM

The Small Cities Development Program (SCDP) is the state-administered portion of the U.S. Department of Housing and Urban Development Community Block Grant Program. The SCDP is a competitive program for smaller general purpose local units of government to provide a suitable living environment and expanding economic opportunities, primarily for persons of low to moderate income. It must be stressed that the program is competitive and that application requests have traditionally exceeded the grant monies available.

This program is designed to address a broad range of community development needs, including: 1) housing grants to rehabilitate local housing stock; 2) public facilities grants; and 3) comprehensive grants, comprising a combination of housing and public facilities grants or other economic development components. Smaller general purpose local units of government, defined as cities and towns with populations under 50,000 and counties with populations under 200,000 can apply for SCDP grant funds.

The SCDP has been used successfully by a number of Minnesota communities to alleviate flooding problems. Examples include:

- St. Vincent Township, Kittson County: purchase of the right-of-way to construct permanent flood control levees, designed and cost-shared by the Corps of Engineers;

- City of Argyle: acquisition and relocation/demolition of flood prone structures, as part of an overall Corp of Engineers' permanent levee project. Approximately one-dozen structures will be acquired and relocated from the flood plain, as they could not be included within a levee system which will protect the City; and

- City of Austin: acquisition and relocation/demolition of approximately 75 frequently flooded structures.

It should be noted that use of the SCDP appears most probable (i.e., the application becomes more competitive) as the amount of non SCDP matching funds increases. Therefore, it is in the local sponsor's best interest to attempt to package a number of assistance programs if possible. This not only reduces the cost to the sponsoring local government/individual landowners but oftentimes one grant program can be used as offsetting matching funds for another grant program.

The SCDP is administered by the state's Department of Energy and Economic Development. An annual application cycle has been established. Currently, applications are due by the end of January. Potential applicants should contact the Department of Energy and Economic Development immediately so they can be notified of the deadline for submitting future applications. To qualify for funding, an applicant must meet one of the three following federal objectives:

-Benefit low and moderate income people;

-Eliminate slum or blight; or

-Eliminate threats to public health and safety.

Inquiries should be addressed to:

Department of Energy and Economic Development
Division of Community Development
9th Floor, American Center Building
150 East Kellogg Boulevard
St. Paul, Minnesota 55101
Phone: (612) 296-5005

State Assistance Programs

The state until this last legislative session has acted with emergency funds when responding to high water problems. An example of this was the $250,000 made available in 1986 by the Governor through the Legislative Advisory Committee. These funds were made available on a competitive basis to respond to ongoing high water problems. As expected, the requests for assistance outweighed the funds available (on the order of 2:1, for projects totalling $2.3 million).

The Department of Natural Resources sponsored a statewide flood loss reduction program in the 1987 Legislative Session. The primary benefit is that increased state funding levels would be available for advance, pre-flood mitigation measures on a priority basis. The Legislature did fund the DNR's proposed legislation by: 1) making approximately $2,000,000 of bonding money available for a portion of the local share (i.e., cost) for a number of proposed Corps of Engineers' flood control projects; and 2) establishing an approximate $430,000 cost-share program for locally initiated structural and non-structural flood loss reduction measures in this biennium.

The cost-share program is to be administered by DNR. Projects must be funded 50/50 by State and non-State funds, respectively. Application forms will be available from the DNR in November of 1987. The cost-share program is broad based in that applications can be submitted for most structural or non-structural projects which reduce potential flood losses.

The Standard Flood Insurance Policy

The State of Minnesota has encouraged the National Flood Insurance Program, primarily through the standard flood insurance policy, to fund advance hazard mitigation measures. The thought being that the NFIP will pay for insured losses as structures adjacent to land-locked basins are flooded (many of which sustain severe damage or near total loss). It is reasoned that, with the generally gradual rise of flood waters on land-locked basins and the likelihood the water will continue to rise, it would be prudent and cost-effective to either relocate a potentially damaged structure from the site or elevate it in place. As the NFIP would be a primary beneficiary of these actions (i.e., reduced insurance payments), the state suggested the NFIP should consider bearing part of the cost for advance mitigation measures.

Unfortunately, the federal legislation for the National Flood Insurance Program prevents federal participation in these advance mitigation measures. This may be short-sighted, but the NFIP by legislation is presently put in a reactionary mode of only being able to pay for eligible, insured losses as they occur. The only ongoing hazard mitigation program currently administered by the Federal Emergency Management Agency is Section 1362 of the Flood Disaster Protection Act of 1973.

The Section 1362 Program, which is strictly a voluntary program, is reactionary in nature because damages must have already occurred prior to the submittal of an application to FEMA. This competitive, nationwide program is designed to acquire and relocate/demolish frequently flooded or severely damaged structures and to return the flood plain to an "open space" nature.

The program is of limited application to lake flooding situations and is to complex to discuss in any great detail in this report. It must be stressed though that only those structures covered with a flood insurance policy <u>at the time of loss</u> are eligible for the program. As mentioned, the program is competitive nationwide where application requests have far outweighed the funds appropriated by Congress. Similar to the Small Cities Development Program discussed earlier, applications become more competitive as a package of non Section 1362 Program, matching funds are proposed in the application.

Further information on the FEMA's Section 1362 Program can be secured from:

Federal Emergency Management Agency
175 W. Jackson Blvd., 4th Floor
Chicago, Illinois 60604
ATTN: Flood Hazard Mitigation Officer

IMPLEMENTATION AUTHORITIES

The immediately preceeding section dealt with non local funding sources for cost-sharing hazard mitigation measures. A focal point of this discussion was that a local sponsoring authority is necessary to enter into formal (contractual) arrangements with potential funding agencies. Generally, aside from the actions of individual landowners, basinwide mitigation strategies require at least one political entity to take the lead role if for no other reason than to secure the necessary funding.

The authorities and obligations for implementing comprehensive or basinwide mitigation strategies (and the securing of local or matching funds) does not lie solely with municipalities or counties, as the case may be for incorporated and unincorporated areas, respectively. State legislation has provided for establishing special purpose quasi-governmental districts or special taxing authorities which may be used for implementing mitigation strategies.

Experience has shown that city and county governments have been willing to take varying degrees of active participation in solving local high water problems. Therefore, the remainder of this section will discuss how existing local authorities, special districts and special taxing authorities can be used for implementing hazard mitigation measures.

Local Government Capabilities

Municipal and county government can: 1) appropriate general funds for hazard mitigation measures; and 2) act as a local sponsoring agency. It is totally at the discretion of the respective governmental body to determine their degree of participation. This is a local matter. The Department's experience has shown that some governmental bodies have been hesitant to appropriate community-wide funds to benefit a select group of landowners (e.g., landowners in flood prone areas).

To bypass the issues of uniform local tax rates and providing community-wide funds for a select category of landowners, most counties, including Sherburne County, can establish "subordinate service districts" pursuant to Minnesota Statutes Chapter 375. Subordinate service districts, once established, allow a county to provide additional governmental services only within that service district. Importantly, the revenues to fund these additional government services come only from within the subordinate service district.

Subordinate service districts are initiated either by a resolution of the county board or by petition to the county board signed by ten percent of the qualified voters within the portion of the county proposed for the subordinate service district. The reader should refer to Minnesota Statute, Chapter 375 for a more detailed explanation of subordinate service districts.

Lake Improvement Districts

Pursuant to Minnesota Statutes Chapter 378, a lake improvement district (LID) is a local unit of government established by resolution of the county board. A LID provides the opportunity for greater landowner involvement in lake management activities by actions initiated at the local level of government.

As with the following discussion on the establishment of watershed districts, there is no upper or lower size limit for the area which may be included in a LID. Establishing a LID versus a watershed district is a matter of weighing the pro's and con's of each approach. Each lake improvement district may be delegated different levels of authority by the county board depending upon existing problems and proposed activities. It does allow those [landowners] closest to the situation to directly seek solutions to their problem. A county board may grant powers to LID to, amongst other things:

-Acquire, construct and operate a dam or other lake control structure;
-Undertake research projects;
-Conduct programs of water improvement and conservation;
-Construct and maintain water and sewer systems;
-Serve as local sponsors for state and federal projects or grants; and
-Provide and finance governmental services.

To finance LID projects, services and general administration, a county may:

-Assess costs to benefitted properties;
-Impose service charges;
-Issue general obligation bonds;
-Levy an ad valorem tax solely on property within the LID boundaries; or
-Any combination of the above.

The minimum guidelines and requirements for the formation of a LID are contained in (Minnesota Rules Part 6115.0920 - 6115.0980). These rules provide specific guidance on the content and issues to be addressed by the petition or county board resolution.

Specific questions pertaining to lake improvement districts can be directed to:

Minnesota Department of Natural Resources
Division of Waters
500 Lafayette Road, Box 32
St. Paul, MN 55155-4032
Phone: (612) 296-4800

<u>Watershed Districts</u>

Watershed districts are independent units of government established pursuant to Minnesota Statutes Chapter 112. Watershed districts are initiated following a formal petition to the state's Board of Water and Soil Resources. Once established, watershed districts can have broad powers including (but not limited to):

-Control or alleviation of damage by flood waters;

-Imposition of preventative or remedial measures for the control or alleviation of land and soil erosion and siltation of watercourses of bodies of water affected thereby; and

-Regulating improvements by riparian landowners of the beds, banks and shores of lakes, streams, and marshes by permit or otherwise in order to preserve the same for beneficial use.

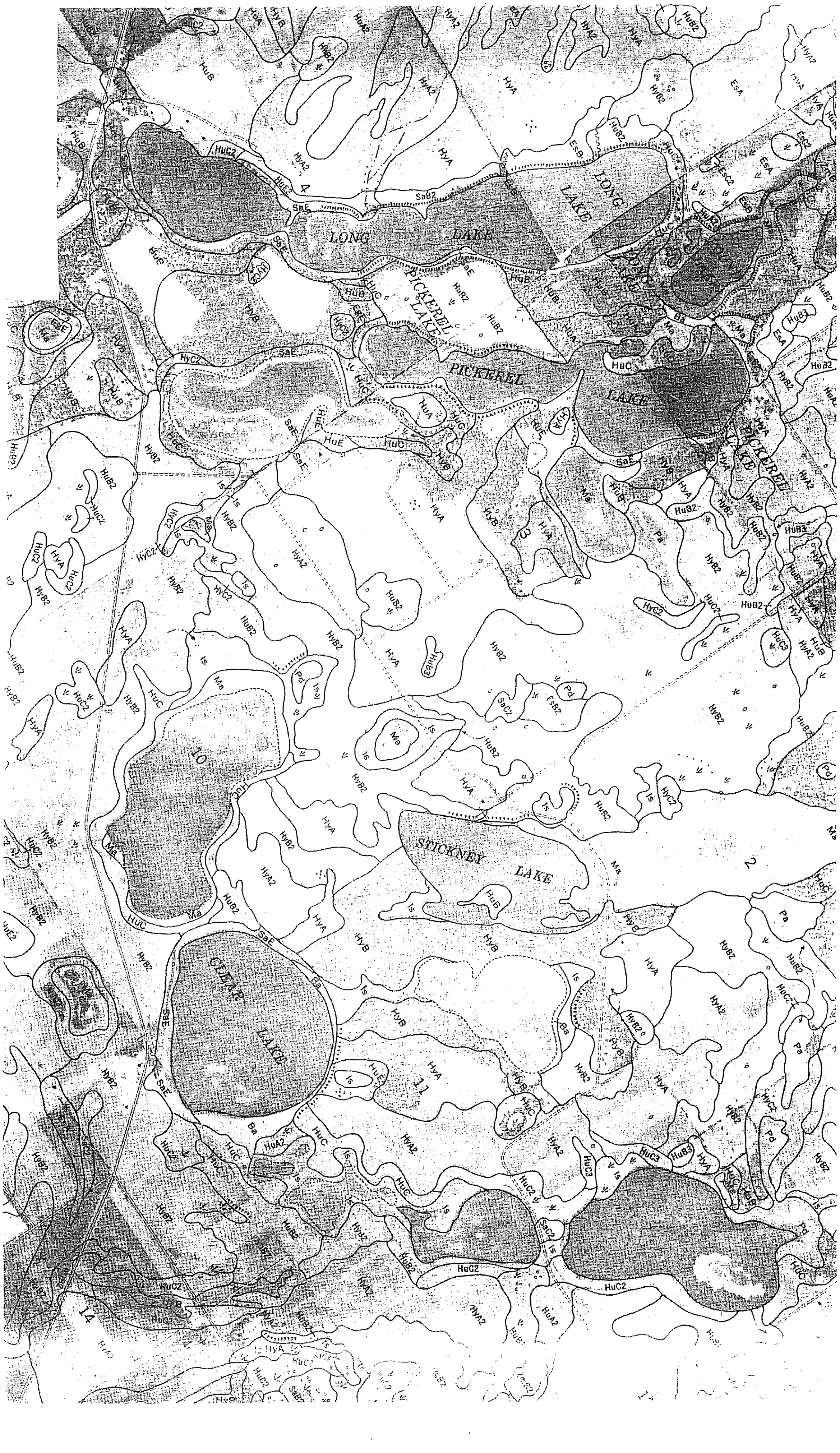
Watershed districts are suited to resolving multiple water resource issues over a large area. As noted earlier, there is no upper or lower limit on the geographic area which may be included in a watershed district. Establishment of a watershed district requires development of an overall plan, adoption of formalized rules for operation of business and preparation of yearly reports.

Questions concerning watershed districts should be directed to:

Minnesota Board of Water and Soil Resources
90. W. Plato Blvd.
St. Paul, MN 55107
Phone: (612) 296-2840

APPENDIX A

SOIL TYPES AND CHARACTERISTICS


LONG LAKE
LONG LAKE
PICKEREL LAKE
PICKEREL LAKE
STICKNEY LAKE
CLEAR LAKE

SOIL SURVEY FOR LONG LAKE CHAIN

MAP SYMBOL	SOIL CLASSIFICATION	% SLOPE
Ba	Beach Sand	
EgE	Emmert gravelly loamy sand	12-35
EsA	Estherville sandy loam	0-2
EsB	Estherville sandy loam	2-6
EsC2	Estherville sandy loam, eroded	6-12
HuA	Hubbard loamy sand	0-2
HuA2	Hubbard loamy sand, wind eroded	0-2
HuB	Hubbard loamy sand	2-6
HuB2	Hubbard loamy sand, eroded	2-6
HuB3	Hubbard loamy sand, severely eroded	2-6
HuC	Hubbard loamy sand	6-12
HuC2	Hubbard loamy sand, eroded	6-12
HuE	Hubbard loamy sand	12-25
HuE2	Hubbard loamy sand, eroded	12-25
HyA	Hubbard sandy loam	0-2
HyA2	Hubbard sandy loam, eroded	0-2
HyB	Hubbard sandy loam	2-6
HyB2	Hubbard sandy loam, eroded	2-6
HyC2	Hubbard sandy loam, eroded	6-12
Is	Isanti loamy fine sand	
Ma	Marsh	
SaB2	Salida complex, eroded	0-6
SaC2	Salida complex, eroded	6-12
SaE	Salida complex	12-25
WaA	Wadena loam	0-2
ZmB2	Zimmerman loamy fine sand, eroded	2-6

Beach Sand

Beach sand (Ba) consists of nearly level or gently sloping areas of loose sandy material along some of the lakes in the county. These areas are generally not used for agriculture.

Emmert gravelly loamy sand, 12 to 35 percent slopes (EgE).

This soil consists mainly of uneroded virgin areas but includes a small acreage that has been eroded. On the crests of slopes in cultivated areas, the original surface layer is gone and the gravelly or cobbly subsoil is exposed. The topography is moderately steep to very steep. Slopes generally are short and complex.

This soil is suitable for woodland but is too steep and too droughty to be suitable for either cropland or pasture. At best, the yield of pasture grasses is poor. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Most of the acreage is either oak forest or permanent pasture.

Estherville sandy loam, 0 to 2 percent slopes (EsA).

This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed.

This soils is suited to most crops commonly grown in the county. Yields are fair. Wind erosion is a hazard in cultivated areas. Low moisture-holding capacity is a serious limitation. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture.

Estherville sandy loam, 2 to 6 percent slopes (EsB).

This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through wind erosion. In these spots the present surface layer is a mixture of the original surface layer and material from the subsoil. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards in cultivated areas. Low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture.

Estherville sandy loam, 6 to 12 percent slopes, eroded (EsC2). Between one-third and two-thirds of the original surface layer of this soil has been removed by wind and water erosion. The rest has been mixed with materials from the subsoil and has a very dark brownish cast. In spots on the crests of slopes, almost all of the original surface layer is gone and the subsoil has been turned up in plowing. The topography is sloping or rolling. Slopes generally are short. Some rills have formed.

This soil can be used for most of the crops commonly grown in the county, but yields are poor. Both wind and water erosion are hazards. Low moisture-holding capacity and low natural fertility are serious limitations. Nevertheless, most of the acreage is cropland. Controlling erosion, conserving moisture, and increasing fertility are the main management needs.

Hubbard loamy sand, 0 to 2 percent slopes (HuA).

This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. A few areas near the Mississippi River are dissected by the remnants of old, shallow, braided glacial drainageways.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, most of the acreage is cropland. The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Hubbard loamy sand, 0 to 2 percent slopes, wind eroded (HuA2).

Wind erosion has removed between one-half and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. Included in mapping were some severely eroded spots where more than two-thirds of the original surface layer is gone and the present surface layer is dark grayish brown instead of black. In slight depressions are shallow accumulations of wind-deposited surface material. Sand has drifted along fence lines and road ditches. A few areas near the Mississippi River are dissected by the remnants of old, shallow, braided drainageways.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Hubbard loamy sand, 2 to 6 percent slopes (HuB).

This soil has a surface layer slightly thicker than that in the profile described for the series. Virgin areas are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer has been lost through wind erosion and the present surface layer is a mixture of the subsoil and the remaining surface material. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, most of the acreage is cropland. The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Hubbard loamy sand, 2 to 6 percent slopes, eroded (HuB2).

Wind erosion has removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the remaining surface material with material from the subsoil. Included in mapping were severely eroded spots where more than two-thirds of the original surface layer is gone and the present surface layer is dark grayish brown instead of black. In slight depressions are shallow accumulations of wind-deposited surface material. Sand has drifted along fence lines and in road ditches. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Hubbard loamy sand, 2 to 6 percent slopes, severely eroded (HuB3).

Wind erosion has removed nearly all of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. The present surface layer is dark grayish brown instead of black. Spots in shallow depressions or swales have shallow accumulations of wind-shifted surface material. Sand has drifted along fence line and road ditches. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too severely eroded to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity is a serious limitation. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, controlling erosion, and increasing fertility are the main management needs. All of the acreage should be in permanent vegetation.

Hubbard loamy sand, 6 to 12 percent slopes (HuC).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer is gone and plowing has mixed the rest with material from the subsoil. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Some of the acreage is cropland, but most is oak forest or permanent pasture. Cultivated fields should be seeded to permanent vegetation.

Hubbard loamy sand, 6 to 12 percent slopes, eroded (HuC2).

Wind and water erosion have removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. The present surface layer is dark grayish brown instead of black. Included in mapping were spots on the crests of slopes where all of the original surface layer is gone and the subsoil is exposed. There are rills and gullies on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too droughtly and too highly susceptible to erosion to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity and low natural fertility are the major limitations. The erosion hazard is severe. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation.

Hubbard loamy sand, 12 to 25 percent slopes (HuE).

For the most part, this soil has not been cultivated, and consequently it has been little affected by erosion. It has a surface layer thinner than that in the profile described for the series. The topography is moderately steep or steep. Slopes generally are short.

This soil is suitable for woodland, but it is too steep and too droughtly to be suitable for cropland. The very low moisture-holding capacity is the major limitations. The erosion hazard is severe. Most of the acreage is oak forest or permanent pasture.

Hubbard loamy sand, 12 to 25 percent slopes, eroded (HuE2).

Between one-third and two-thirds of the original surface layer has been removed from this soil by wind and water erosion, and the rest has been mixed with the subsoil in plowing. The present surface layer is dark grayish brown instead of black. In severely eroded spots, particularly on the crests of slopes, all of the original surface layer is gone and the dark-brown subsoil is exposed. There are rills and gullies on side slopes. The topography is moderately steep or steep. Slopes generally are short.

This soil is suitable for woodland but is too droughty and too steep to be suitable for cropland. Very low moisture-holding capacity is the major limitations. The erosion hazard is severe. In many places the slope is too steep to be safe for farm machinery. Nevertheless, most of the acreage is cropland. The entire acreage should be permanent vegetation.

Hubbard sandy loam, 0 to 2 percent slopes (HyA).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface soil layer has been removed.

This soil is suited to most crops commonly grown in the county. Yields are fair. Very low moisture-holding capacity is the major limitation. Wind erosion is a hazard in cultivated fields. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture.

Hubbard sandy loam, 0 to 2 percent slopes, wind eroded (HyA2).

Between one-third and two-thirds of the original surface layer of this soil has been removed by wind erosion, and the rest has been mixed with the subsoil in plowing. In slight depressions are shallow accumulations of wind-deposited surface material.

This soil is suited to most crops commonly grown in the county. Yields are fair. Very low moisture-holding capacity is the major limitation. Wind erosion is a hazard. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland.

Hubbard sandy loam, 2 to 6 percent slopes (HyB).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer is gone and the rest has been mixed with the subsoil in plowing. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards in cultivated areas. Very low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture.

Hubbard sandy loam, 2 to 6 percent slopes, eroded (HyB2).

Between one-third and two-thirds of the original surface layer of this soil has been removed by wind erosion, and the rest has been mixed with material from the subsoil. In spots on the crests of slopes, most of the original surface layer is gone and the subsoil has been turned up in plowing. In slight depressions are shallow accumulations of wind-deposited surface material. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards. Very low moisture-holding capacity is a serious limitation. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland.

Hubbard sandy loam, 6 to 12 percent slopes, eroded (HyC2).

Wind and water erosion have removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. The present surface layer has a very dark brownish cast. On the crests of slopes, much of the original surface layer is gone and subsoil has been turned up in plowing. There are a few rills on side slopes. Included in mapping was about 25 acres that is uneroded. The topography is sloping or rolling. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Both wind and water erosion are hazards. Very low moisture-holding capacity and low natural fertility are serious limitations. Nevertheless, most of the acreage is cropland. Controlling erosion, conserving moisture, and increasing fertility are the main management needs.

Isanti loamy fine sand (Is).

In many places this soil has a thin layer of peat or muck on the surface. The slope range is 0 to 1 percent. Included in mapping were areas of very poorly drained coarse sand.

If adequately drained, this soil can be used for most crops grown in the county, but it is generally not suitable for alfalfa. Yields are poor or fair. Poor drainage and low fertility are the major limitations. Controlling excess surface water and improving internal drainage are the main management needs. Most of the acreage is undrained and supports aquatic grasses, sedges, and willows. Only a small part is drained and suitable for cropland.

Marsh

Marsh (Ma) consists of areas that are covered with water most of the year. The slope range is 0 to 1 percent. The vegetation consists of aquatic grasses, sedges, and cattails.

Salida complex, 0 to 6 percent slopes, eroded (SaB2).

Between one-third and two-thirds of the original surface layer of these soils has been removed by wind erosion, and some of the subsoil has been mixed with the remaining surface material in plowing. Included in mapping were severely eroded spots where more than two-thirds of the original surface layer has been lost and the present surface layer is dark grayish brown instead of black. Also included were spots in slight depressions where there are shallow accumulations of wind-shifted surface material. The topography is nearly level or undulating. Slopes generally are short.

The soils in this complex can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs.

Salida complex, 6 to 12 percent slopes, eroded (SaC2).

Wind and water erosion have removed between one-third and two-thirds of the original surface layer from these soils, and plowing has mixed the rest with material from the subsoil. The present surface layer is dark grayish brown instead of black. Included in mapping were spots on the crests of slopes where all of the original surface layer has been removed and the subsoil is exposed. There are a few rills and gullies on side slopes. The topography is sloping or rolling. Slopes generally are short.

These soils are suitable for meadow, pasture, and woodland, but are limited for use as cropland because they are too droughty and too highly susceptible to erosion. Yields of cultivated crops are very poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation.

Salida complex, 12 to 25 percent slopes (SaE).

The profile of these soils is shallower than the representative profile described for the series, and the surface layer is thinner than that in the representative profile. Virgin areas are uneroded, but cultivated areas have lost much of their original surface layer through wind and water erosion. In eroded spots, particularly on the crests of slopes, most of the original surface layer has been removed and the subsoil is exposed. The topography is moderately steep or steep. Slopes generally are short.

These soils are suitable for woodland but are too steep and too droughtly to be suitable for cropland or pasture. At best, yields of pasture grasses are poor. The very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Most of the acreage is oak forest or permanent pasture. The rest is cropland.

Wadena Loam, 0 to 2 percent slopes (WaA).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots more than a third of the original surface layer has been removed. Included in mapping were spots where the subsoils is slightly finer textured than that in the profile described for the series.

This productive soil is suited to all crops commonly grown in the county. A slightly less than adequate moisture-holding capacity is the major limitation. There is a slight erosion hazard. Conserving moisture, increasing fertility, supplying organic matter, preserving tilth, and controlling erosion are the main management needs. Most of the acreage is cropland. The rest is permanent pasture.

Zimmerman loamy fine sand, 2 to 6 percent slopes, eroded (ZmB2).

Between one-third and two-thirds of the original surface layer of this soil has been removed or shifted by wind erosion. The present surface layer is slightly browner than the subsoil; the change in color is ordinarily at a sharp line at the base of the plow layer. In spots on slight rises or on the crests of slopes, the present surface layer is lighter colored and the sand is looser because some of the fine silt and clay particles have blown away. Drifts of sand are common, particularly along fence lines and road ditches. There are a few blowouts, mainly near the Sand Dunes State Forest. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

For more detailed information, see the Soil Conservation Service Soil Survey of Sherburne County, Minnesota dated February, 1968.

APPENDIX B

BACKGROUND DATA ON WATER QUALITY, FISH AND WILDLIFE AND DEVELOPMENT HISTORY

71-0158
45 28 15.0 094 03 50.0 3
LAKE: PICKEREL 4 MI N OF CLEAR LAKE
27141 MINNESOTA SHERBURNE
AREA: 49.0 HECTARE M 070317
MEAN DEPTH: - M MAX DEPTH: 6.4 M
21MINNL 810829 07010203 HQ
0000 FEET DEPTH

/TYPA/AMBNT/LAKE

INDEX
MILES

INITIAL DATE			73/05/20	73/05/28	73/06/17	73/07/01	73/07/15	73/07/29	73/08/02	73/10/27	74/06/26
INITIAL TIME			0001	0001	0001	0001	0001	0001	0001	0001	0001
MEDIUM			WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
DEPTH-FT(SMK)			0	0	0	0	0	0	0	0	0
00029 FIELD	IDENT	NUMBER	201	201	201	201	201	201	201	201	201
00078 TRANSP	SECCHI	METERS	2.29	2.44	4.27	2.13	2.13	2.29	.76	4.27	4.27
74041 WQF	SAMPLE	UPDATED									870130

INITIAL DATE			74/07/03	74/07/10	74/07/17	74/07/24	74/07/31	74/08/07	74/08/14	74/08/21	74/08/28
INITIAL TIME			0001	0001	0001	0001	0001	0001	0001	0001	0001
MEDIUM			WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
DEPTH-FT(SMK)			0	0	0	0	0	0	0	0	0
00029 FIELD	IDENT	NUMBER	201	201	201	201	201	201	201	201	201
00078 TRANSP	SECCHI	METERS	3.66	2.44	2.44	3.05	3.05	4.27	4.27	4.27	4.27
74041 WQF	SAMPLE	UPDATED	870130	870130	870130	870130	870130	870130	870130	870130	870130

INITIAL DATE			74/09/04	74/09/11	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28
INITIAL TIME			0001	0001	0930	0930	0930	0930	0930	0930	0930
MEDIUM			WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
DEPTH-FT(SMK)			0	0	0	3	6	9	13	16	19
00008 LAB	IDENT.	NUMBER			129273						
00010 WATER	TEMP	CENT			21.5	21.5	21.0	21.0	19.0	18.0	15.5
00011 WATER	TEMP	FAHN			70.7$	70.7$	69.8$	69.8$	66.2$	64.4$	59.9$
00029 FIELD	IDENT	NUMBER	201	201	101						
00078 TRANSP	SECCHI	METERS	4.27	4.27	1.80						
00080 COLOR	PT-CO	UNITS			10						
00098 VSAMPLOC	DEPTH	METERS			.00	1.00	2.00	3.00	4.00	5.00	6.00
00300 DO		MG/L			9.5	9.5	9.5	8.9	7.1	2.5	.0
00301 DO	SATUR	PERCENT			105.6$	105.6$	105.6$	98.9$	75.5$	26.3$	.0$
00403 LAB	PH	SU			8.1						
00410 T ALK	CACO3	MG/L			120						
00605 ORG N	N	MG/L			.860						
00610 NH3+NH4-	N TOTAL	MG/L			.160						
00612 UN-IONZD	NH3-N	MG/L			.008$						
00619 UN-IONZD	NH3-NH3	MG/L			.010$						
00625 TOT KJEL	N	MG/L			1.020						
00630 NO2&NO3	N-TOTAL	MG/L			.02						
00665 PHOS-TOT		MG/L P			.098						
32211 CHLRPHYL	A UG/L	CORRECTD			13.40						

INITIAL DATE			74/09/04	74/09/11	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28
INITIAL TIME			0001	0001	0930	0930	0930	0930	0930	0930	0930
MEDIUM			WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
DEPTH-FT(SMK)			0	0	0	3	6	9	13	16	19
32218 PHEOPHTN	A	UG/L			.02K						
74041 WQF	SAMPLE	UPDATED	870130	870130							
81903 DPTH BOT	AT SITE	FEET			24.0						

71-0159
45 28 05.0 094 04 30.0 3
LAKE: LONG 4 MI NW OF CLEAR LAKE
27141 MINNESOTA SHERBURNE
AREA: 73.7 HECTARE M 070317
MEAN DEPTH: - M MAX DEPTH: 7.9 M
21MINNL 810829 07010203 HQ
0000 FEET DEPTH

/TYPA/AMBNT/LAKE

INDEX
MILES

	INITIAL DATE			81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28	81/06/28
	INITIAL TIME			0900	0900	0900	0920	0920	0920	0920	0920	0920
	MEDIUM			WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
	DEPTH-FT(SMK)			0	3	6	0	3	6	9	13	16
00008	LAB	IDENT.	NUMBER	129271			129272					
00010	WATER	TEMP	CENT	21.0	21.0	21.0	21.5	21.5	21.5	21.5	19.5	19.0
00011	WATER	TEMP	FAHN	69.8$	69.8$	69.8$	70.7$	70.7$	70.7$	70.7$	67.1$	66.2$
00029	FIELD	IDENT	NUMBER	102			101					
00078	TRANSP	SECCHI	METERS	3.40			3.40					
00080	COLOR	PT-CO	UNITS	10			10					
00098	VSAMPLOC	DEPTH	METERS	.00	1.00	2.00	.00	1.00	2.00	3.00	4.00	5.00
00300	DO		MG/L	9.8	9.8	9.8	9.9	9.9	9.9	9.4	6.2	5.0
00301	DO	SATUR	PERCENT	108.9$	108.9$	108.9$	110.0$	110.0$	110.0$	104.4$	66.0$	53.2$
00403	LAB	PH	SU	8.1			8.3					
00410	T ALK	CACO3	MG/L	110			120					
00605	ORG N	N	MG/L	.720			.720					
00610	NH3+NH4-	N TOTAL	MG/L	.100			.090					
00612	UN-IONZD	NH3-N	MG/L	.005$			.007$					
00619	UN-IONZD	NH3-NH3	MG/L	.006$			.009$					
00625	TOT KJEL	N	MG/L	.820			.810					
00630	NO2&NO3	N-TOTAL	MG/L	.03			.10					
00665	PHOS-TOT		MG/L P	.064			.071					
32211	CHLRPHYL	A UG/L	CORRECTD	6.20			5.30					
32218	PHEOPHTN	A	UG/L	.01K			.65					
81903	DPTH BOT	AT SITE	FEET	10.0			19.0					

PIC DATA

PHYSICAL CHARACTERISTICS FOR LAKE: LONG

Dominant Forest/Soil Type: DECID/SAND
Size of Lake: 180 Acres
Maximum Depth: 26.0
Shorelength: 3.4 Miles
Median Depth: 9.0
Secchi Disk Reading (water clarity): 10.5 feet
Lake Contour Map Number: C0788 (available at cost from Documents Division)
(Phone: (612) 297-3000)

DEVELOPMENT CHARACTERISTICS FOR LAKE: LONG

Shoreland Zoning Classification: Not Available
Public Accesses in 1986: 0

Development	Seasonal Homes	Permanent Homes	Total Homes
1967	11	9	20
1982	8	85	93

DNR SECTION OF FISHERIES INFORMATION FOR LAKE LONG

Water Chemistry   Survey Date: 7/4/83

Water Color: Clear
Cause of Water Color: N/A
Secchi Disk: 11.5
% Littoral: 79

Lake Description

Surface Water Area: 182
Management Class: CENTRARCHID
Ecological Type: CENTRARCHID
Accessibility: State-Owned Public Access at North End of Lake - Undeveloped

Area Fisheries Supervisor: Paul Diedrich
P.O. Box 158
Montrose, MN 55363
(612) 675-3301

NET CATCH DATA

Gill Nets   No. of Sets: 6   Gill Net Survey Date: 7/5/83

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
White Sucker	5	0.8	10.90	1.82
Black Bullhead	1081	180.2	97.30	16.22
Northern Pike	53	8.8	114.20	19.03
Yellow Perch	56	9.3	3.60	0.60
Largemouth Bass	9	1.5	7.30	1.22
Pumpkinseed Sunfish	57	9.5	8.40	1.40
Bluegill Sunfish	83	13.8	9.40	1.57
Black Crappie	18	3.0	2.40	0.40
Hybrid Sunfish	2	0.3	0.50	0.08

Trap Nets   No. of Sets: 6   Trap Survey Date: 7/5/83

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
White Sucker	7	1.2	21.00	3.50
Black Bullhead	577	96.2	144.80	24.13
Northern Pike	11	1.8	18.80	3.13
Yellow Perch	16	2.7	1.80	0.30
Largemouth Bass	5	0.8	0.90	0.15
Pumpkinseed Sunfish	86	14.3	11.90	1.98
Bluegill Sunfish	283	47.2	40.30	6.72
Black Crappie	25	4.2	5.00	0.83
Hybrid Sunfish	9	1.5	2.20	0.37

Fish Stocking Data is Not Available.

PERMIT DATA FOR LAKE LONG

SUMMARY OF DNR PERMIT APPLICATIONS ISSUED OR DENIED AS OF JUNE 1986 FOR LAKE: LONG

Permit Types:	Number Issued	Number Denied
Public (Protected) Waters Permits		
Sand blanket	4	0
General Appropriation Permits	0	0

PHYSICAL CHARACTERISTICS FOR LAKE: CLEAR

Dominant Forest/Soil Type: NOT AVAILABLE
Size of Lake: 109 Acres
Maximum Depth: N/A
Shorelength: N/A
Median Depth: N/A
Secchi Disk Reading (Water Clarity): N/A
Lake Contour Map Number: D0205 (available at cost from Documents Division)
(Phone: (612) 297-3000)

DEVELOPMENT CHARACTERISTICS FOR LAKE: CLEAR

Shoreland Zoning Classification: NOT AVAILABLE
Public Accesses in 1986: 0

DNR SECTION OF FISHERIES INFORMATION FOR LAKE CLEAR

Water Chemistry Survey Date: 7/11/78

Water Color: Dark Green
Cause of Water Color: Algae
Secchi Disk: 9.0
% Littoral: 50

Lake Description

Surface Water Area: 109
Management Class: CENTRARCHID
Ecological Type: CENTRARCHID
Accessibility: None

Area Fisheries Supervisor: Paul Diedrich
P.O. Box 158
Montrose, MN 55363
(612) 675-3301

NET CATCH DATA

Gill Nets No. of Sets: 2 Gill Net Survey Date: 7/11/78

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
Brown Bullhead	48	24.0	13.80	6.90
Northern Pike	18	9.0	35.45	17.73
Walleye	1	0.5	4.00	2.00
Bluegill Sunfish	4	2.0	0.65	0.33
Black Crappie	1	0.5	0.75	0.38

Trap Nets No. of Sets: 3 Trap Survey Date: 7/11/78

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
Brown Bullhead	236	78.7	67.70	22.57
Northern Pike	1	0.3	1.30	0.43
Green Sunfish	1	0.3	0.35	0.12
Pumpkinseed Sunfish	1	0.3	0.30	0.10
Bluegill Sunfish	441	147.0	93.00	31.00
Black Crappie	1	0.3	1.00	0.33
Hybrid Sunfish	3	1.0	0.80	0.27

FISH STOCKING DATA

Year	Species	Size	# Released
72	Walleye	FINGERLING	200

PERMIT DATA FOR LAKE CLEAR

SUMMARY OF DNR PERMIT APPLICATIONS ISSUED OR DENIED AS OF JUNE 1986 FOR LAKE: CLEAR

	Number Issued	Number Denied
Permit Types:		
Public (Protected) Waters Permits	0	0
General Appropriation Permits Irrigation	1	0

PHYSICAL CHARACTERISTICS FOR LAKE: STICKNEY

Dominant/Forest Soil Type: NOT AVAILABLE
Size of Lake: 85 Acres
Maximum Depth: N/A
Shorelength: N/A
Median Depth: N/A
Secchi Disk Reading (water clarity): N/A
Lake Contour Map Number: C1054 (available at cost from Documents Division)
(Phone: (612) 297-3000)

DEVELOPMENT CHARACTERISTICS FOR LAKE: STICKNEY

Shoreland Zoning Classification: NOT AVAILABLE
Public Accesses in 1986: 0

DNR SECTION OF FISHERIES INFORMATION FOR LAKE STICKNEY

Water Chemistry Survey Date: 7/9/59

Water Color: Brownish
Cause of Water Color: Suspended Mud Particles
Secchi Disk: 1.0
% Littoral: 100

Lake Description

Surface Water Area: 88
Management Class: WARM-WATER GAMEFISH
Ecological Type: ROUGHFISH-GAMEFISH
Accessibility: No designated public access; possible from C.A.R. #76 on N. shore

Area Fisheries Supervisor: Paul Diedrich
P.O. Box 158
Montrose, MN 55363
(612) 675-3301

NET CATCH DATA

GILL NET DATA IS NOT AVAILABLE

Trap Nets No. of Sets: 5 Trap Survey Date: 7/5/59

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
Black Bullhead	448	89.6	59.80	11.96

FISH STOCKING DATA IS NOT AVAILABLE

PERMIT INFORMATION NOT AVAILABLE

Note: Data was available only for the above lakes.

APPENDIX C

CLIMATOLOGICAL DATA

St. Cloud WSO Airport, MN Monthly Precipitation

####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
7294	1887	0.90	1.01	0.14	m	m	m	m	m	m	m	m	m	m
7294	1888	m	m	1.60	m	m	m	m	m	m	m	m	m	m
7294	1890	m	m	m	m	m	m	m	2.20	m	m	m	m	m
7294	1893	1.00	0.90	0.90	5.74	2.62	0.54	3.67	2.41	0.81	1.68	0.81	1.36	22.44
7294	1894	0.81	0.00	2.55	4.93	8.54	4.15	0.51	0.90	2.12	1.95	0.72	0.69	27.87
7294	1895	0.48	0.70	0.24	2.30	3.99	2.55	3.16	2.28	3.84	0.00	0.94	0.00	20.48
7294	1896	1.05	0.18	3.05	6.31	2.57	5.00	2.32	1.66	2.59	4.30	2.76	0.00	31.79
7294	1897	2.75	1.40	4.53	1.56	1.96	6.77	12.81	2.48	4.18	1.69	0.60	0.28	41.01
7294	1898	0.00	1.78	1.75	0.32	2.96	3.73	1.83	3.34	2.28	4.17	1.85	0.00	24.01
7294	1899	0.30	1.05	2.22	2.22	3.79	2.78	4.51	7.91	0.95	7.94	1.10	0.36	35.14
7294	1900	0.27	0.45	1.40	0.81	0.20	2.05	4.28	9.28	7.12	2.39	0.58	0.86	29.69
7294	1901	0.42	0.00	1.34	2.00	1.21	4.67	2.38	1.54	3.25	0.76	0.50	0.23	18.30
7294	1902	0.30	0.00	0.35	0.88	2.79	2.92	4.75	2.32	2.19	1.63	1.53	1.43	21.09
7294	1903	0.20	0.33	2.75	3.74	5.46	1.28	10.53	2.64	5.20	2.80	0.25	0.55	35.73
7294	1904	0.35	0.18	1.06	1.37	2.95	3.89	5.87	6.00	3.02	5.01	0.08	0.39	30.17
7294	1905	0.49	0.36	0.60	2.06	5.47	7.42	5.41	6.96	3.38	3.13	1.41	0.00	36.69
7294	1906	1.20	0.26	1.03	1.68	6.50	7.61	3.17	3.42	4.33	3.22	1.15	0.54	34.11
7294	1907	1.80	0.78	0.75	0.21	3.53	5.05	2.22	3.55	5.15	1.67	3.57	0.26	28.54
7294	1908	0.29	0.69	1.44	3.21	6.77	6.82	2.55	1.60	2.74	1.64	1.09	0.47	29.31
7294	1909	1.56	1.21	0.14	1.57	3.34	4.84	3.08	2.43	4.06	0.71	2.10	1.63	26.67
7294	1910	0.65	0.46	0.18	1.52	1.90	1.85	0.63	3.90	2.53	0.47	0.31	0.24	14.64
7294	1911	0.55	0.37	0.87	2.19	5.86	5.28	3.33	3.56	3.41	4.87	1.65	0.75	32.69
7294	1912	0.26	0.10	0.28	2.96	9.68	2.29	5.23	4.79	1.78	0.68	0.01	0.82	28.88
7294	1913	0.42	0.37	0.48	2.91	4.26	3.05	9.49	2.61	4.12	2.27	1.23	0.00	31.21
7294	1914	0.88	0.35	0.95	2.42	2.79	8.35	0.90	3.37	6.49	1.59	0.23	0.05	28.37
7294	1915	0.33	1.29	0.54	2.83	3.97	m	4.26	1.62	3.41	2.62	2.13	0.70	m
7294	1916	2.16	0.37	1.38	1.92	5.86	6.04	3.21	4.65	2.98	1.71	0.00	0.74	31.02
7294	1917	1.85	1.09	2.98	2.69	1.02	4.65	3.35	2.61	1.39	1.04	0.05	0.44	23.16
7294	1918	0.48	0.27	0.72	1.79	4.14	1.64	4.43	3.21	0.84	3.23	2.99	0.72	24.46
7294	1919	0.30	2.22	1.17	2.53	2.85	5.30	3.83	2.10	0.80	2.18	m	0.42	m
7294	1920	1.61	0.66	3.14	1.53	4.61	10.56	0.75	0.89	3.87	2.62	m	0.76	m
7294	1921	0.29	0.00	0.80	1.21	2.07	3.18	2.86	1.70	6.10	0.80	1.02	0.52	20.55
7294	1922	1.88	2.94	1.39	1.25	2.01	4.50	0.86	1.16	0.74	2.37	4.16	0.20	23.46
7294	1923	1.42	0.25	0.20	2.66	2.49	5.17	3.26	1.00	0.93	0.42	0.57	0.17	18.54
7294	1924	0.14	0.35	0.95	3.26	1.80	5.17	1.49	4.76	4.63	0.76	0.52	1.04	24.87
7294	1925	0.39	0.37	0.34	2.16	1.07	4.96	4.63	1.29	2.46	0.44	0.50	0.51	19.12
7294	1926	0.98	0.44	0.89	0.08	0.98	4.67	4.31	7.22	10.72	1.22	1.53	0.32	33.36
7294	1927	0.41	0.31	1.73	3.31	2.98	3.04	2.74	2.18	2.55	1.97	1.93	1.75	24.90

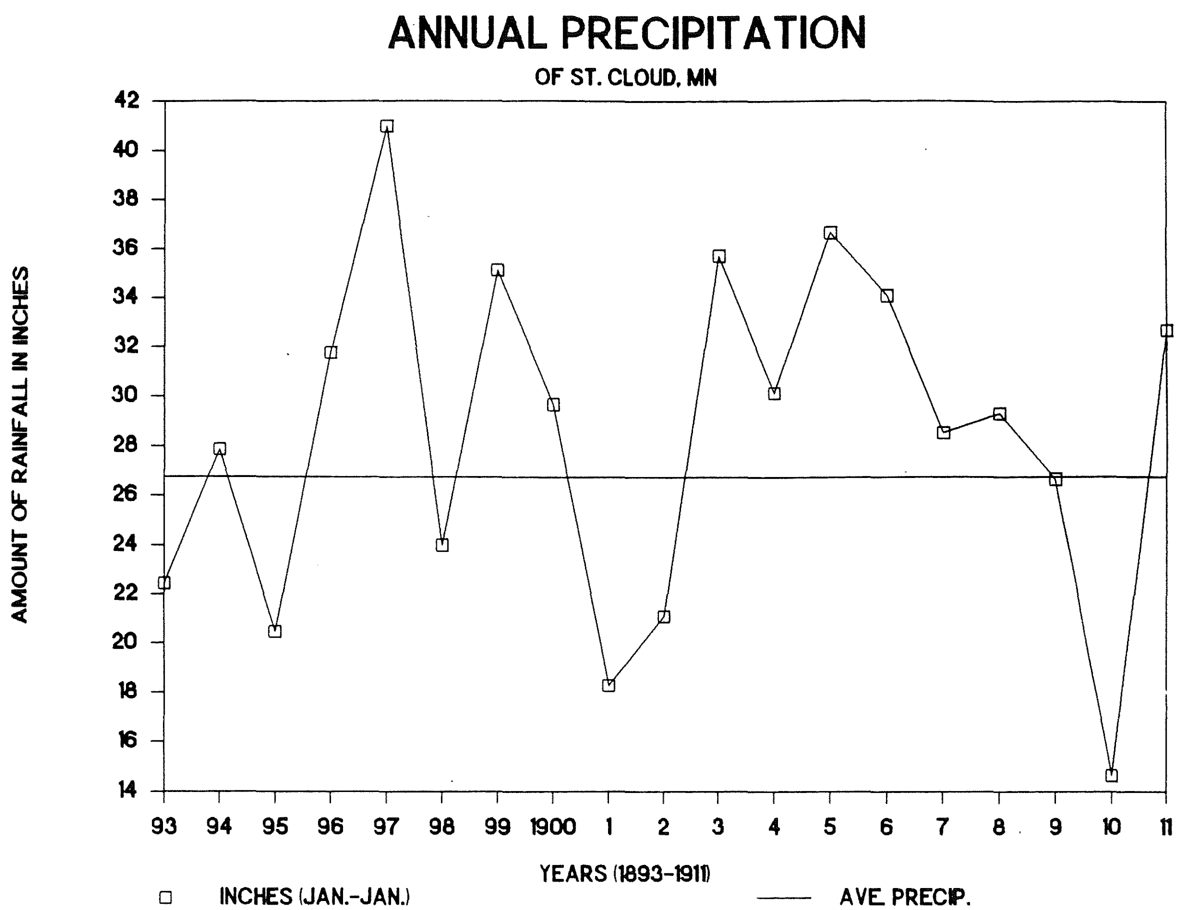
####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
7294	1928	0.40	0.88	0.39	2.31	1.34	3.61	4.62	5.28	4.28	2.15	0.81	0.71	26.78
7294	1929	0.93	0.50	1.19	1.40	2.10	1.19	2.37	1.97	6.60	2.11	0.67	0.57	21.60
7294	1930	0.82	0.96	0.73	0.59	3.61	2.89	2.17	1.46	3.10	1.43	1.78	0.08	19.62
7294	1931	0.07	1.35	1.30	0.96	1.81	2.94	1.37	2.65	1.56	3.54	4.02	0.31	21.88
7294	1932	1.02	0.26	0.73	1.16	4.32	3.55	3.94	2.52	0.78	1.46	1.51	0.23	21.48
7294	1933	0.48	0.27	0.84	0.46	4.22	1.96	5.75	0.42	1.36	1.46	0.54	0.43	18.19
7294	1934	0.74	0.05	0.82	0.25	1.01	3.89	1.30	1.84	6.12	2.83	1.32	0.82	20.99
7294	1935	0.89	0.27	1.28	2.02	1.97	4.41	4.02	6.30	0.90	2.18	0.57	0.95	25.76
7294	1936	0.79	1.10	1.30	2.25	4.05	0.80	0.94	4.98	2.15	0.54	1.89	1.53	22.32
7294	1937	1.04	0.76	0.37	3.18	5.72	2.43	2.43	5.12	1.26	1.03	0.49	0.33	24.16
7294	1938	0.41	0.64	2.07	3.62	6.80	4.29	4.87	2.84	3.16	0.34	1.43	0.67	31.14
7294	1939	1.26	1.20	0.27	1.96	2.72	6.91	2.74	3.17	1.39	1.22	0.00	m	m
7294	1940	0.26	0.84	1.93	2.48	2.21	2.84	3.39	3.61	1.07	2.66	3.14	0.57	25.00
7294	1941	0.86	0.95	0.72	2.08	5.23	6.19	1.23	5.83	5.02	3.28	0.01	0.86	32.26
7294	1942	0.02	0.26	1.94	1.87	4.47	3.21	3.45	3.28	4.89	0.38	0.16	1.11	25.04
7294	1943	0.77	0.67	1.61	0.87	6.18	2.90	3.16	1.36	0.68	2.30	1.54	0.01	22.05
7294	1944	0.63	1.37	1.07	3.48	5.11	5.57	5.19	3.67	2.55	0.07	1.11	0.41	30.23
7294	1945	0.87	1.29	2.07	1.91	2.08	6.58	4.22	1.96	3.06	0.33	1.60	1.74	27.71
7294	1946	0.43	1.14	0.64	1.00	4.41	5.73	1.86	0.77	4.19	4.24	1.35	0.85	26.61
7294	1947	0.31	0.23	0.63	4.40	2.38	3.55	1.75	2.90	1.63	1.10	2.15	0.03	21.06
7294	1948	0.16	1.42	1.89	2.09	0.32	4.38	2.86	2.89	2.13	0.51	1.74	0.39	20.78
7294	1949	1.61	0.21	1.76	0.97	2.04	3.77	5.93	1.43	2.34	2.28	1.13	0.94	24.41
7294	1950	2.12	0.31	2.44	3.32	5.54	1.33	1.72	0.46	1.79	3.76	1.98	1.80	26.57
7294	1951	0.35	2.76	2.41	2.26	2.87	7.85	4.73	4.95	2.75	3.14	1.54	1.65	37.26
7294	1952	1.33	0.70	1.97	0.92	2.25	9.08	3.40	6.95	0.07	0.07	0.47	0.13	27.34
7294	1953	0.92	1.61	1.19	3.52	2.83	9.34	2.01	3.86	0.99	0.51	1.55	1.40	29.73
7294	1954	0.49	0.57	1.62	5.31	4.46	6.90	3.13	2.94	3.96	2.23	0.38	0.21	32.20
7294	1955	0.57	1.58	0.73	1.17	0.88	2.90	8.00	5.43	2.10	1.99	1.26	1.35	27.96
7294	1956	1.01	0.22	1.13	2.01	2.69	5.46	4.79	7.55	1.88	1.08	2.34	0.33	30.49
7294	1957	0.40	1.10	2.03	0.90	4.58	8.54	2.07	6.35	3.88	0.94	1.28	0.38	32.45
7294	1958	0.69	0.23	0.69	2.03	2.05	2.25	2.63	6.95	4.97	1.44	1.75	0.16	25.84
7294	1959	0.20	0.58	0.10	0.34	5.70	2.42	2.64	4.36	2.20	1.85	0.30	1.69	22.38
7294	1960	0.92	0.09	0.75	1.81	4.29	2.68	2.35	4.47	1.71	0.32	1.31	0.55	21.25
7294	1961	0.07	0.38	0.57	2.18	2.77	2.60	3.15	2.58	2.96	2.11	0.68	0.80	20.85
7294	1962	0.67	1.40	1.12	1.13	8.01	2.93	6.20	3.21	3.71	0.19	0.44	0.13	29.14
7294	1963	0.43	0.40	1.39	2.91	5.79	2.51	2.04	5.90	3.40	0.60	0.76	0.66	26.79
7294	1964	0.18	0.04	1.22	3.31	3.62	1.30	1.71	6.66	1.38	0.19	0.98	0.58	21.17
7294	1965	0.48	0.91	3.43	3.44	6.78	6.43	4.66	4.65	4.94	0.94	1.55	1.11	39.32
7294	1966	0.70	1.17	1.53	1.66	2.22	3.18	3.51	4.67	0.95	1.41	0.49	0.79	22.28
7294	1967	1.99	0.75	0.39	1.05	0.82	7.00	0.59	4.72	1.43	1.14	0.14	1.12	21.14
7294	1968	0.86	0.21	1.17	4.51	2.80	6.98	1.95	2.13	4.74	5.80	0.58	1.95	33.68

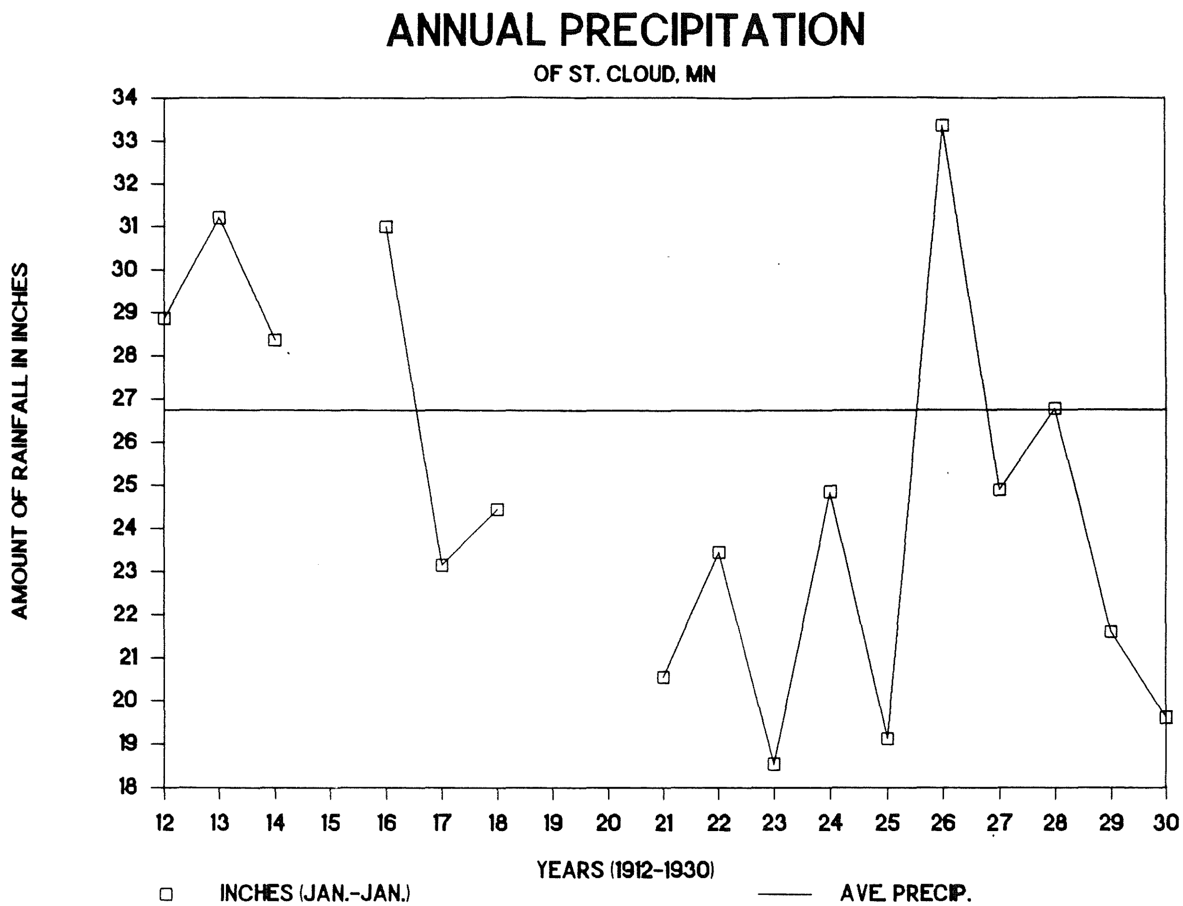
####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
7294	1969	2.52	0.69	0.47	3.48	2.16	2.27	2.81	2.16	1.71	1.29	0.38	2.04	21.98
7294	1970	0.24	0.18	1.05	3.01	2.52	3.43	3.26	1.73	1.66	5.10	2.73	0.24	25.15
7294	1971	0.86	1.53	0.31	1.66	3.86	6.49	2.28	2.79	3.12	6.16	2.56	0.39	32.01
7294	1972	0.55	0.47	1.56	1.59	3.30	1.91	7.26	4.94	1.64	2.54	0.74	1.31	27.81
7294	1973	0.52	0.31	1.40	1.65	2.89	2.92	2.94	4.27	2.80	3.13	1.64	0.73	25.20
7294	1974	0.09	0.83	0.88	1.16	3.26	4.36	2.25	3.20	1.97	1.58	1.29	0.54	21.41
7294	1975	2.39	0.40	1.75	3.69	3.02	5.78	0.21	4.83	2.27	1.08	3.24	0.28	28.94
7294	1976	0.85	0.83	1.78	0.92	0.93	4.84	1.92	0.60	1.37	0.44	0.14	0.31	14.93
7294	1977	0.58	0.98	3.03	3.17	3.57	3.48	4.27	6.10	2.34	2.93	3.74	1.40	35.59
7294	1978	0.19	0.17	0.81	3.49	3.20	6.04	4.43	2.88	4.59	0.14	0.95	1.02	27.91
7294	1979	1.28	1.67	3.02	0.74	5.17	6.34	1.21	4.88	1.58	4.36	0.62	0.31	31.18
7294	1980	1.17	0.84	0.76	0.48	1.62	6.06	1.28	7.01	5.99	0.71	0.20	0.22	26.34
7294	1981	0.44	1.10	1.05	3.29	1.40	6.65	1.92	0.00	1.26	4.40	0.45	1.04	23.00
7294	1982	0.97	0.13	1.75	0.97	3.91	2.53	3.90	3.37	4.38	4.52	2.31	1.72	30.46
7294	1983	0.61	0.13	2.60	1.57	2.39	9.52	2.21	3.48	6.55	3.09	3.11	0.92	36.18
7294	1984	0.67	0.87	0.65	4.16	2.02	8.11	2.94	2.57	3.39	5.84	0.17	1.81	33.20
7294	1985	0.43	0.23	1.70	3.83	2.81	5.28	2.80	4.57	9.48	1.28	1.43	0.57	34.41
7294	1986	0.72	0.83	0.89	5.55	2.36	3.75	7.54	5.18	6.03	0.49	1.05	0.35	34.74

Note: Values in hundredths of inches; 'm' = missing; 'e' = estimated; '####' is the National Weather Service Coop Station Number.

All data were supplied to this State Climatology Office by the National Climate Data Center, NOAA, Asheville, NC, 28801. "Certified Data" can only be supplied by NCDC directly.

State Climatology Office, Minnesota Department of Natural Resources - Waters, Jim Zandlo, (612) 296-4214.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
93 94 95 96 97 98 99 1900 1 2 3 4 5 6 7 8 9 10 11
YEARS (1893-1911)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
34
33
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25
24
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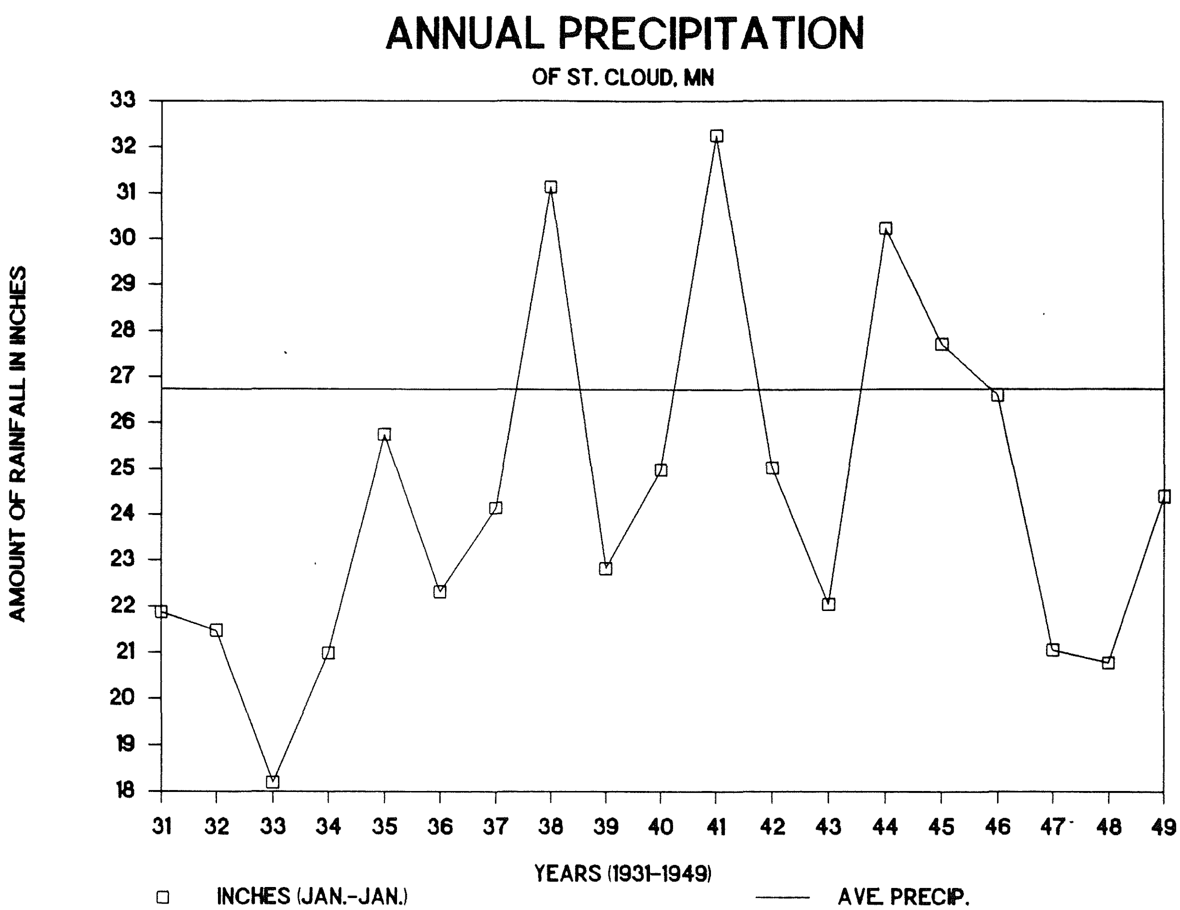
YEARS (1912-1930)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
33
32
31
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25
24
23
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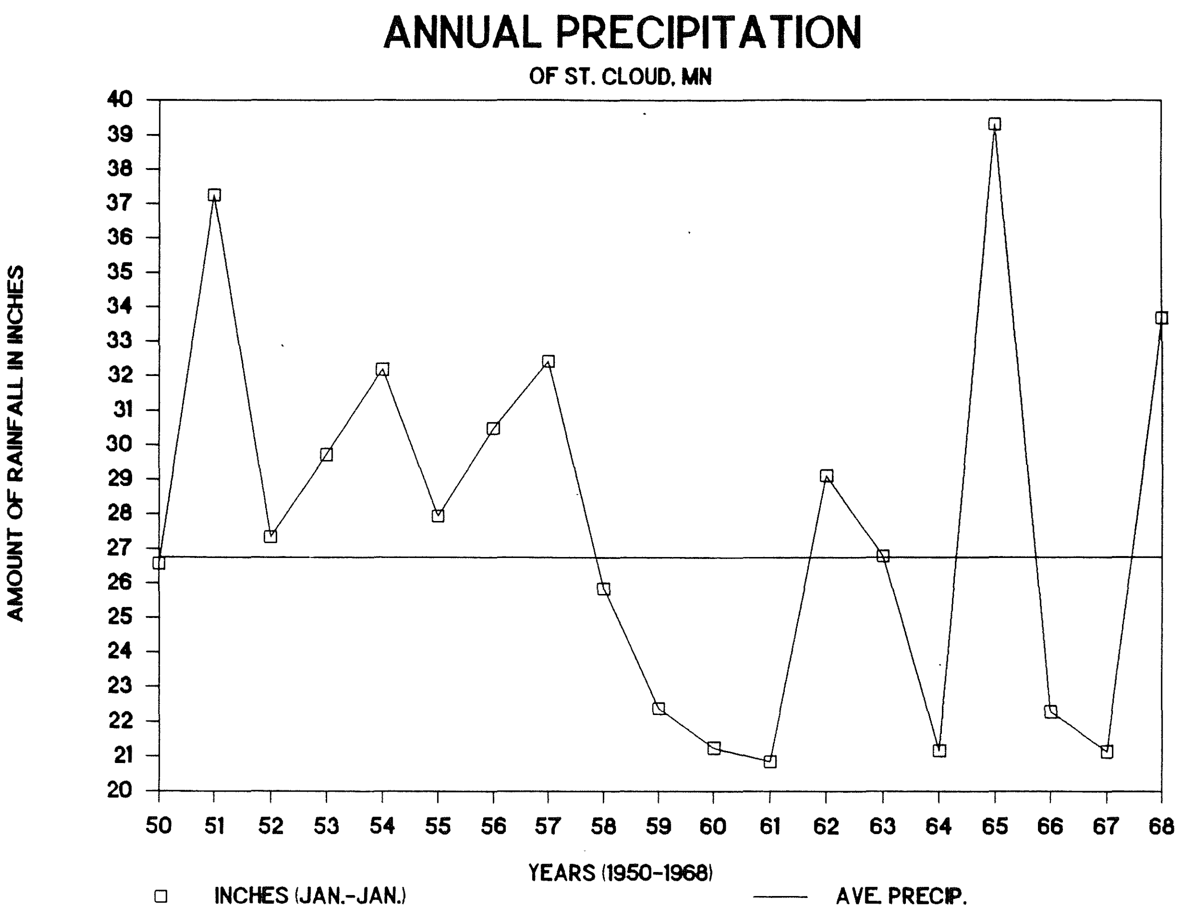
18
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
YEARS (1931-1949)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
40
39
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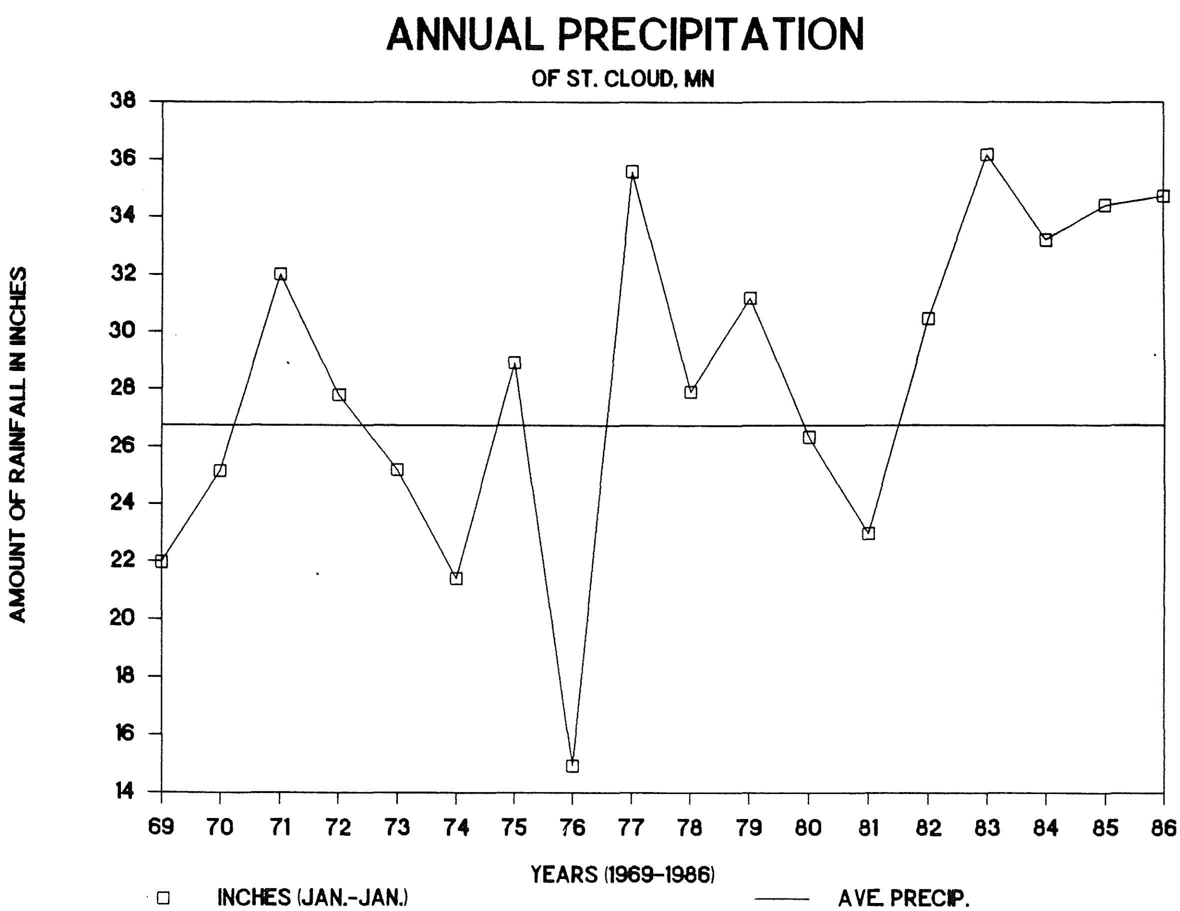
68
YEARS (1950-1968)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
38
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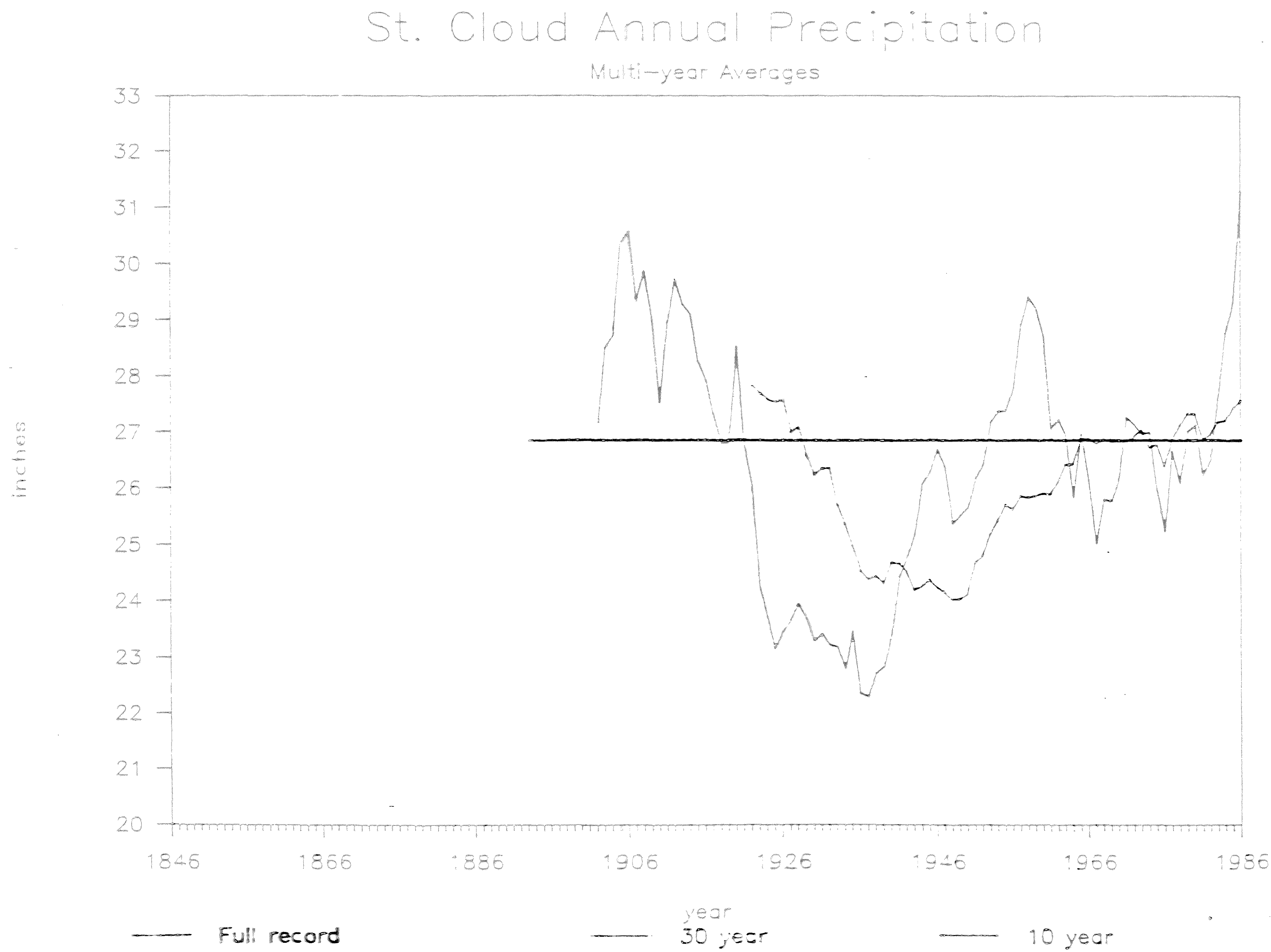
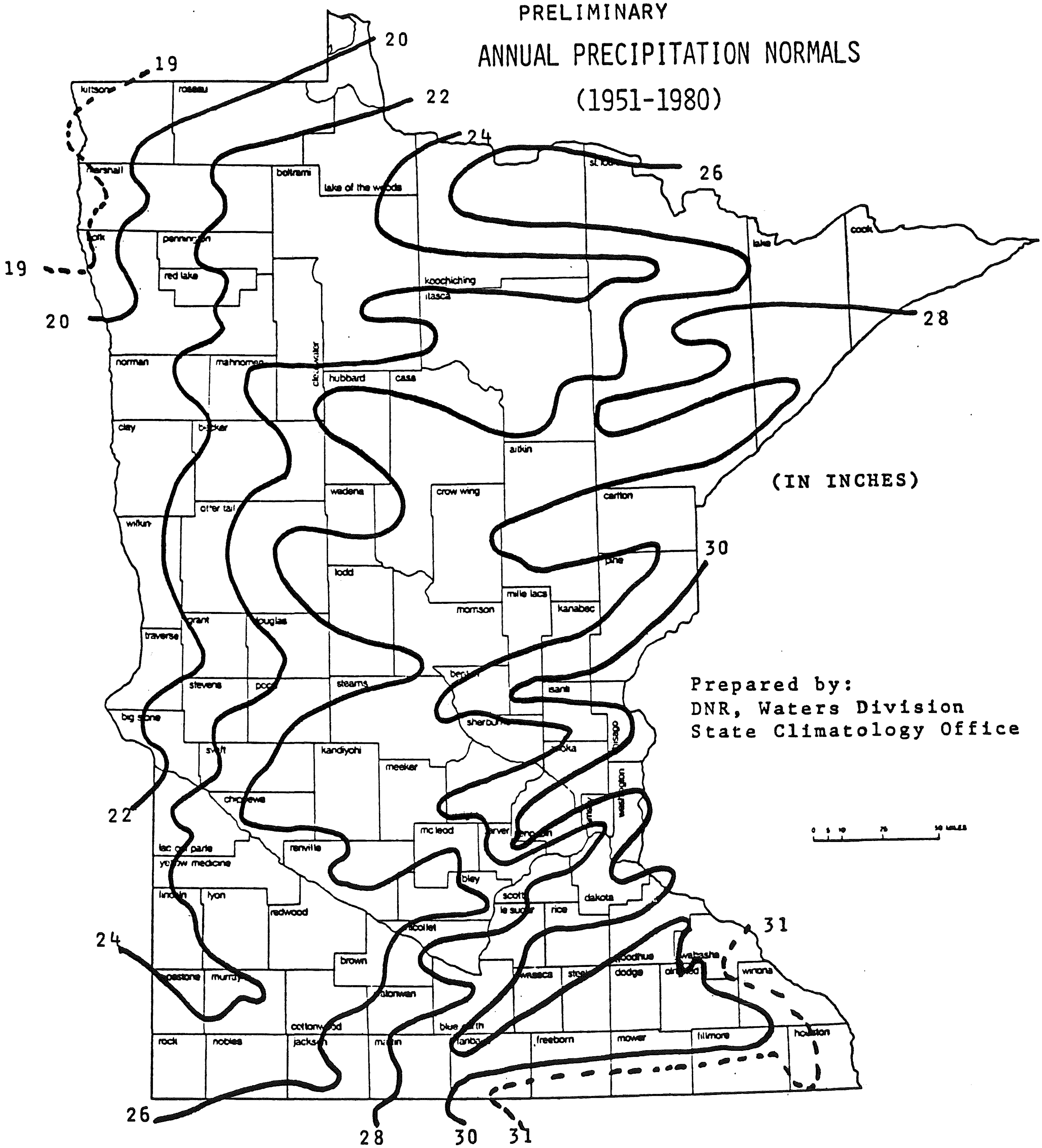
14
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS (1969-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.


St. Cloud Annual Precipitation
Multi-year Averages
33
32
31
30
29
28
27
26
25
24
23
22
21
20
inches
1846
1866
1886
1906
1926
1946
1966
1986
year
Full record
30 year
10 year

PRELIMINARY

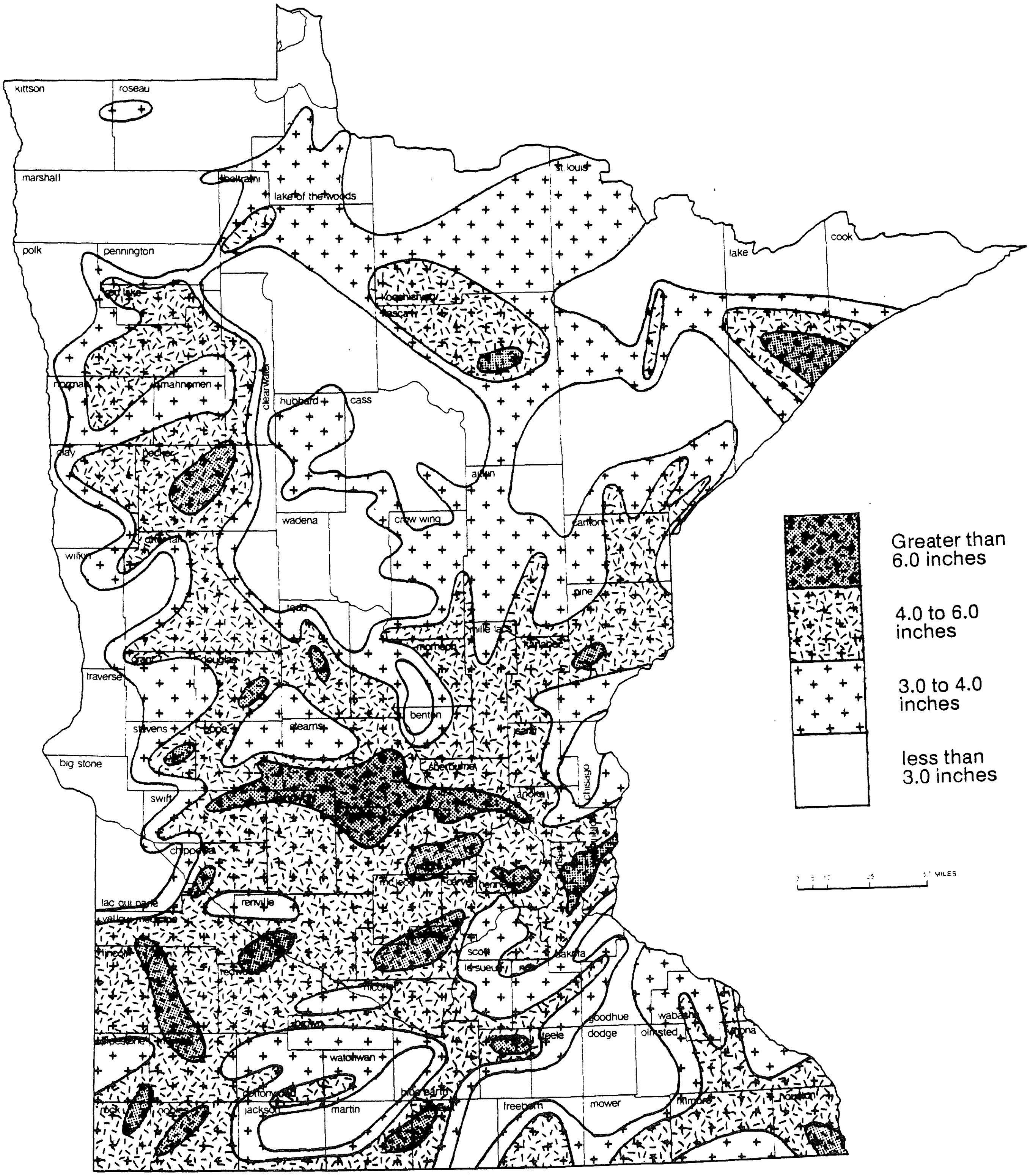
ANNUAL PRECIPITATION NORMALS (1951-1980)



(IN INCHES)

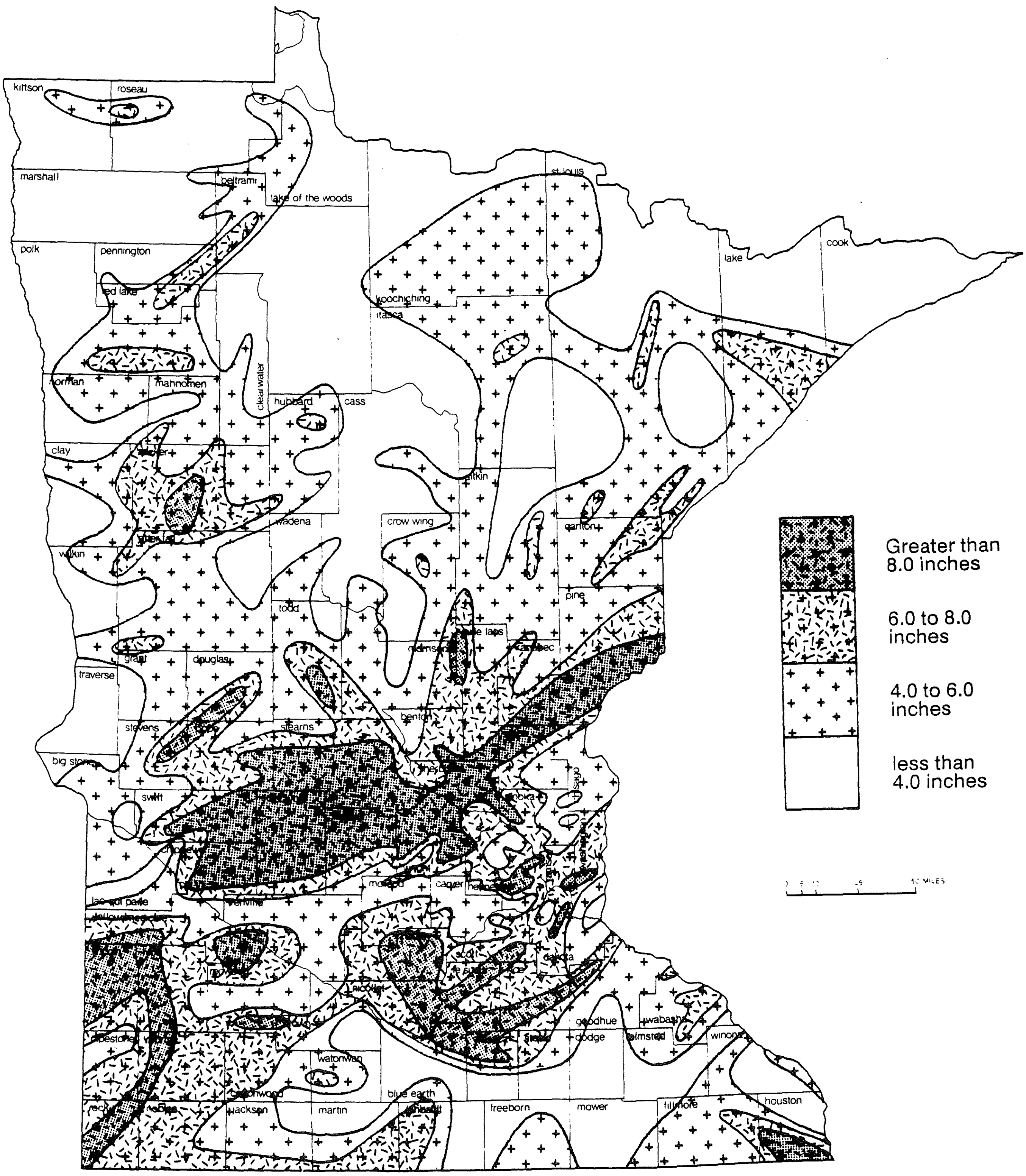
Prepared by:
DNR, Waters Division
State Climatology Office

AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1977 - 1986 (10 YEARS)



Prepared by: DNR, Division of Waters, State Climatology Office

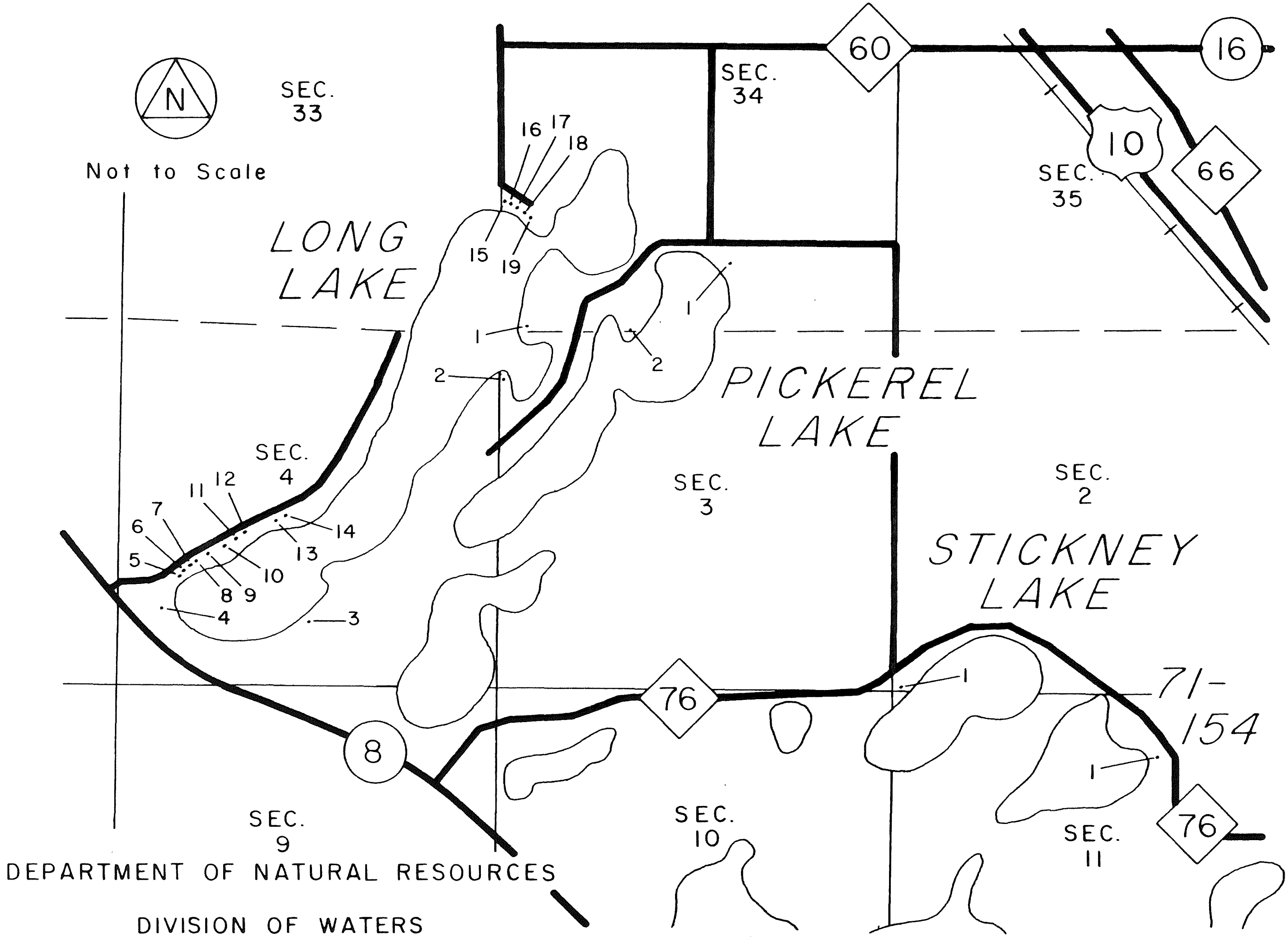
AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1982 - 1986 (5 YEARS)



Prepared by: DNR, Division of Waters, State Climatology Office

APPENDIX D

FACT SHEET FOR EACH POTENTIALLY DAMAGED STRUCTURE



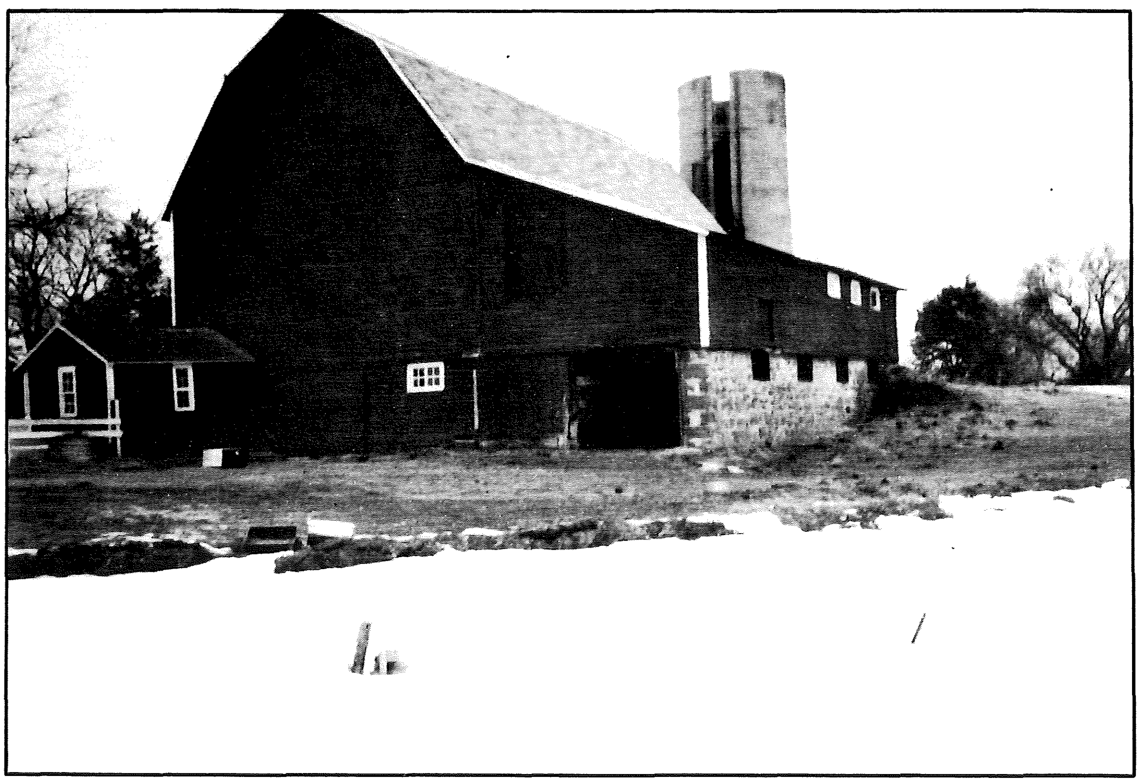
DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATERS

Structure Number	:	1
Name	:	Unknown
Address	:	--
Legal Description	:	Sec. 2 & 3, Twp. 34N, R. 30W.
Walkout/1stFl Elev.	:	985.47
Ground Elevation	:	
Basement	:	NO
Walkout	:	NO

Market Value

Buildings	:	Unknown
Land	:	Unknown
Total	:	Unknown
Flood Insurance	:	--



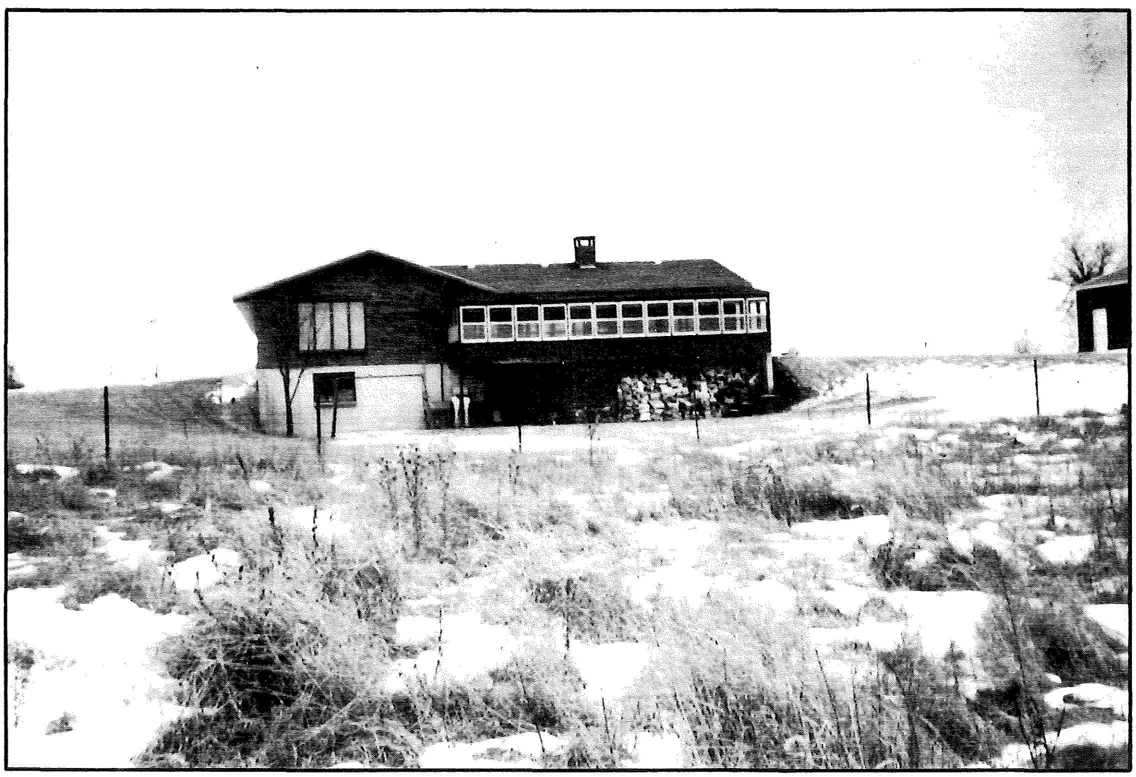
STICKNEY LAKE SHERBURNE CO

Structure Number :	1
Name :	Peterson, Keery
Address :	Rt. 2 Clear Lake, Mn 55319
Legal Description :	Sec. 11, Twp. 34N, R. 30W, S. 400 ft. of E. 700 ft of N.W. 1/4 of N.E. 1/4 S. of road. Sub. to part taken for County road #76.
Walkout/1stFl Elev. :	985.10
Ground Elevation :	
Basement :	NO
Walkout :	YES

Market Value

Buildings :	$93,300.00
Land :	$12,100.00
Total :	$105,400.00

Flood Insurance :	NO



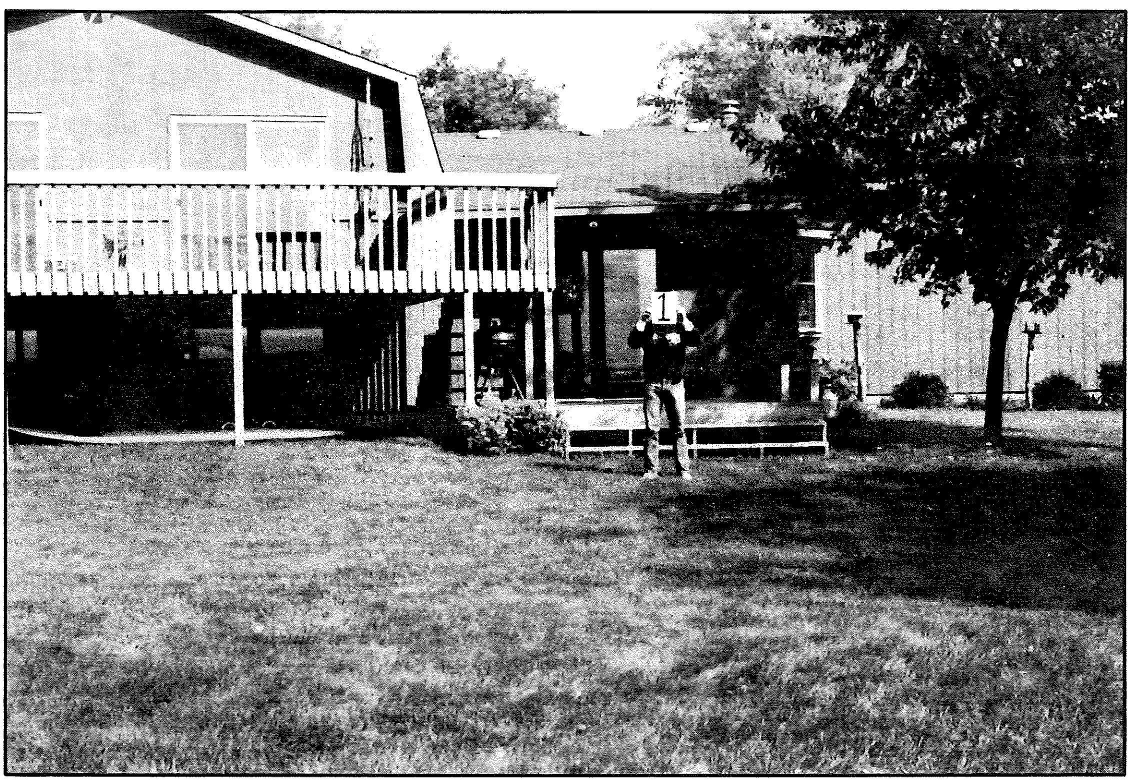
PICKEREL LAKE SHERBURNE CO.

Structure Number :	1
Name :	Hentages, Bruce
Address :	Rt. 5 St. Cloud, MN 56301
Legal Description :	Sec. 34, Twp. 35, r. 30 Part of Gov't. Lot 3 on file in County Assessor's Office. Pin Number: 230-000-344300.
Walkout/1stFl Elev. :	984.44
Ground Elevation :	988.7
Basement :	Yes
Walkout :	NO

Market Value

Buildings :	$56,700.00
Land :	$15,000.00
Total :	$71,700.00

Flood Insurance : NO



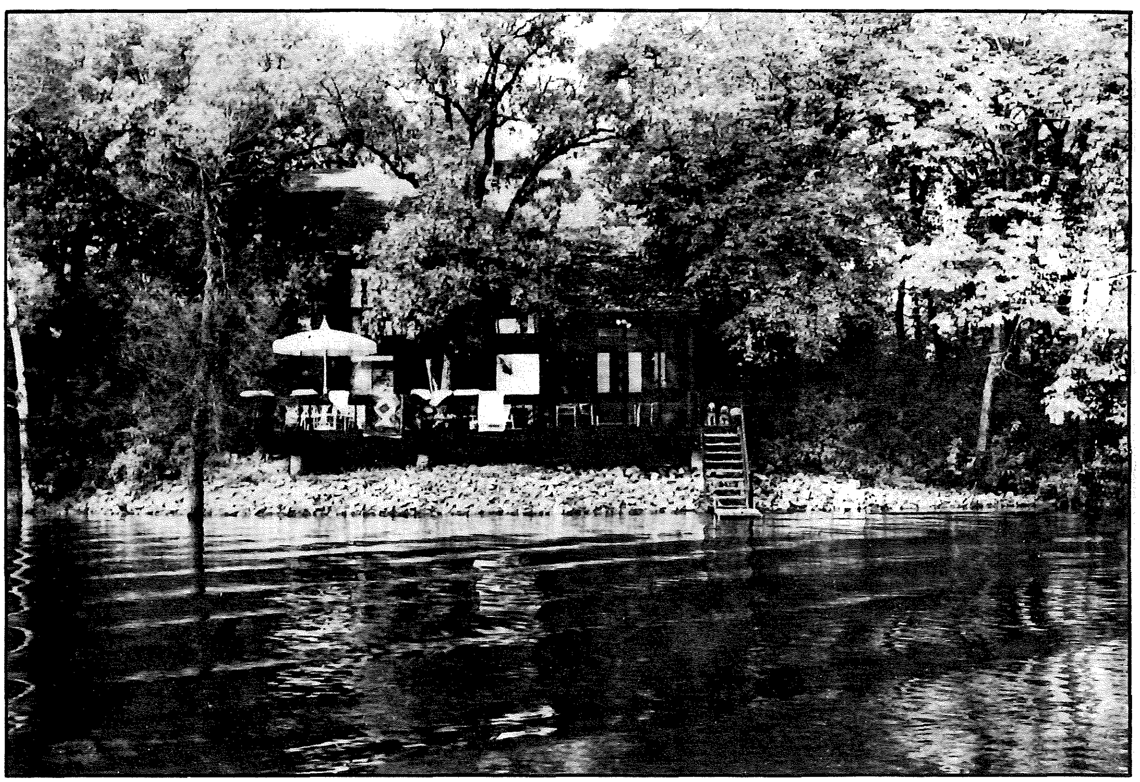
PICKEREL LAKE SHERBURNE CO.

Structure Number :	2
Name :	Miley, Rodney
Address :	Rt. 5, 30 Island Rd. Shrwd. S. St. Cloud, MN 56301.
Legal Description :	Sec. 3, Twp. 34, R. 30 Sherwood Shores Third Addition Part of Lot 4.
Walkout/1stFl Elev. :	990.56
Ground Elevation :	989.8
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$138,500.00
Land :	$35,000.00
Total :	$173,500.00

Flood Insurance : NO



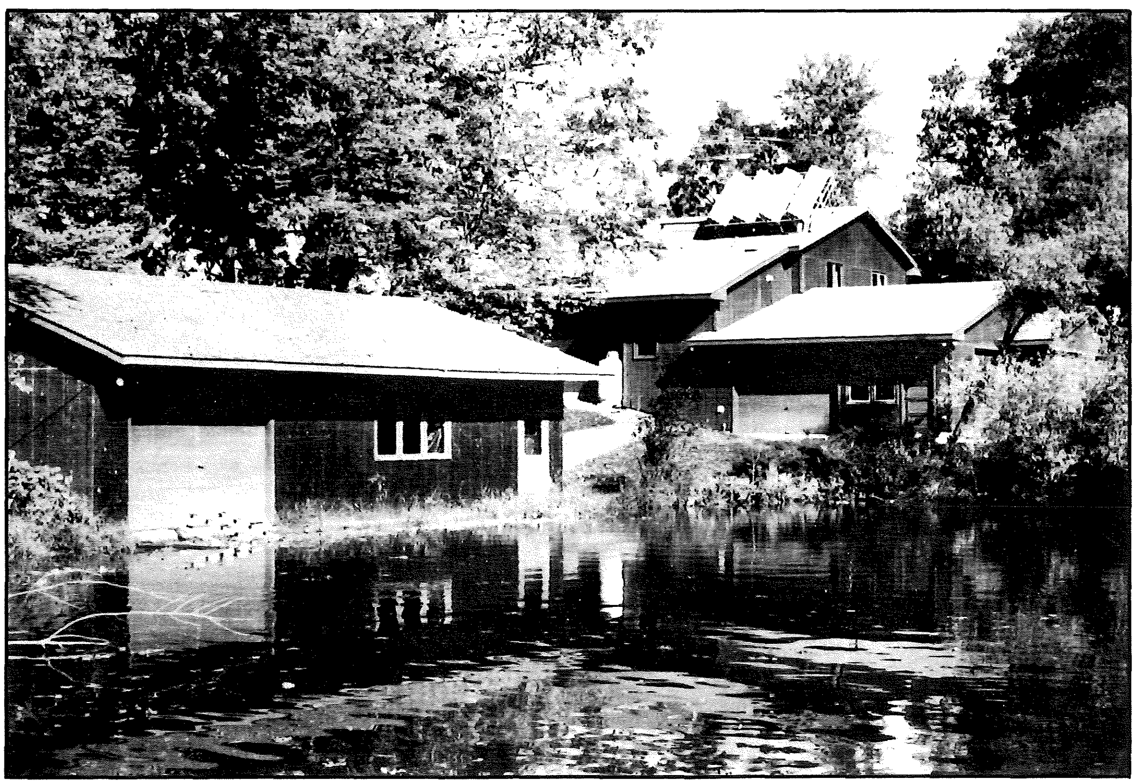
LONG LAKE SHERBURNE CO.

Structure Number :	1
Name :	Thompson, David
Address :	53 Burr Oak Dr. Sherwood Shore St. Cloud, MN 56301
Legal Description :	Sec. 3, Twp. 34, R. 30 Sherwood Shores Lot 13, Block 2
Walkout/1stFl Elev. :	984.4
Ground Elevation :	987.6
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$84,800.00
Land :	$29,000.00
Total :	$113,800.00

Flood Insurance : NO



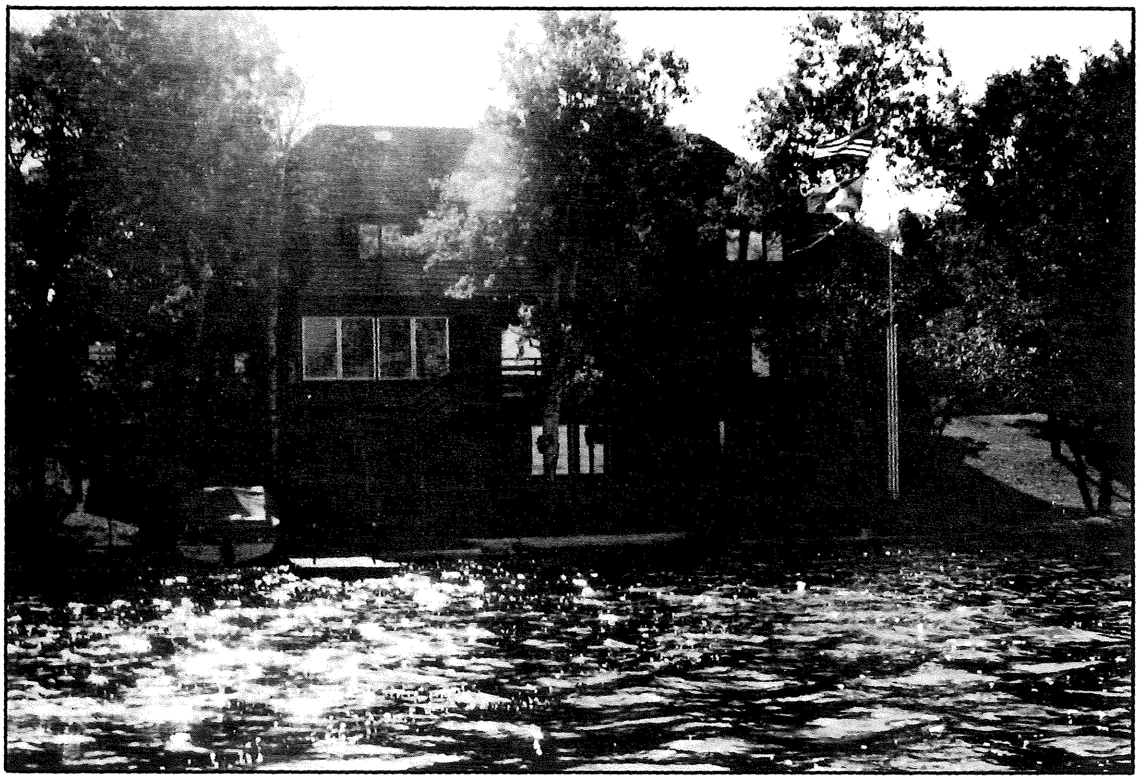
LONG LAKE SHERBURNE CO.

Structure Number :	2	
Name :	Streed, Jean	
Address :	89 W. Lakeshore Drive St. Cloud, MN 56301	
Legal Description :	Sec. 3, Twp. 34, R. 30 Sherwood Shores Lot 25, Block 2	
Walkout/1stFl Elev. :	988.1	
Ground Elevation :	987.9	
Basement :	NO	
Walkout :	Yes	

Market Value

Buildings :	$130,700.00
Land :	$29,000.00
Total :	$159,700.00

Flood Insurance : NO



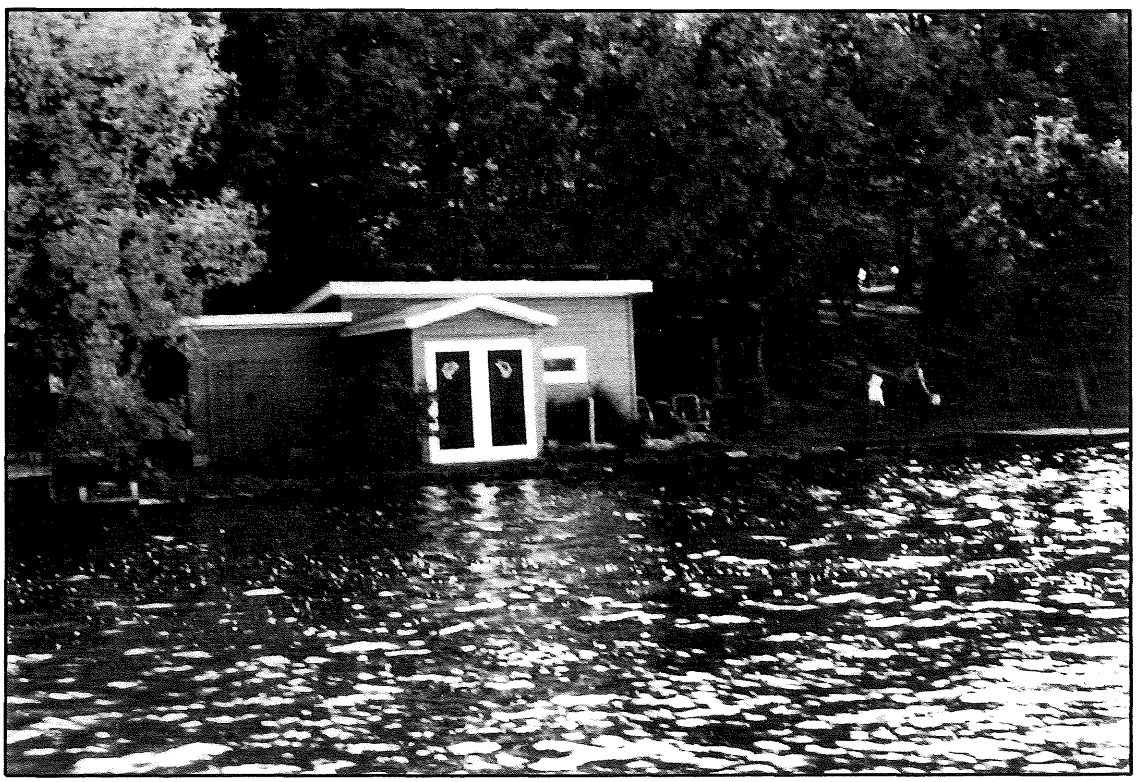
LONG LAKE SHERBURNE CO.

Structure Number :	3	
Name :	Boatman, L.H. and Marie	
Address :	Rt. 2, Box 189 Clear Lake, MN 55319	
Legal Description :	Sec. 4, Twp. 34, R. 30 Imholtes Lake Shore Acres Lot 20, Block 2	
Walkout/1stFl Elev. :	985.5	
Ground Elevation :	985.3	
Basement :	NO	
Walkout :	NO	

Market Value

Buildings :		$40,700.00
Land :		$13,000.00
Total :		$53,700.00

Flood Insurance : NO



LONG LAKE SHERBURNE CO.

Structure Number :	4
Name :	Zapf, Alphonse et al
Address :	235 8th Ave. So. St. Cloud, MN 56301
Legal Description :	Sec. 4, Twp. 34, R. 30 Long Lake Park Number 2 Lot 5
Walkout/1stFl Elev. :	990.2
Ground Elevation :	987.2
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$18,400.00
Land :	$13,000.00
Total :	$31,400.00

Flood Insurance : NO

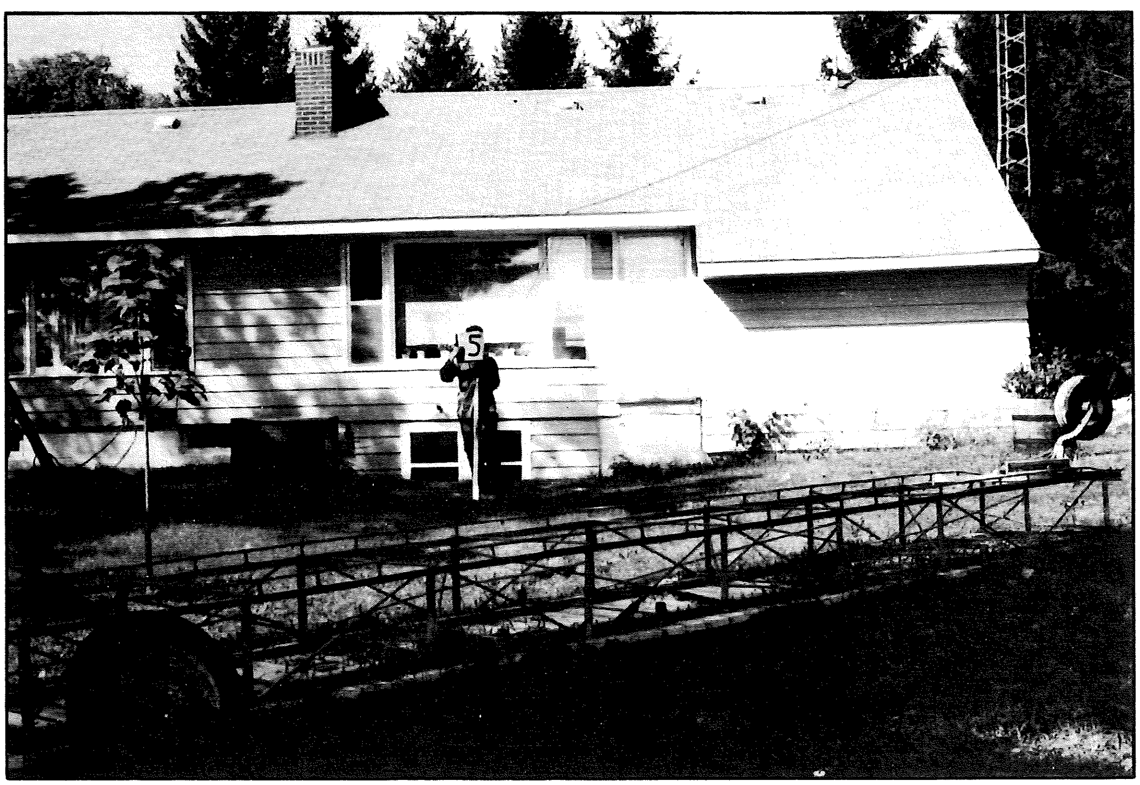
LONG LAKE SHERBURNE CO.

Structure Number :	5
Name :	Nikko, George and Cynthia
Address :	Rt. 2, Box 210 Clear Lake, Mn 55319
Legal Description :	Sec. 4, Twp. 34, R. 30 That part of Gov't. Lot 6 on file with the County Assessor's Office. Pin Number: 220-000-043119-742-008662.
Walkout/1stFl Elev. :	990.0
Ground Elevation :	987.5
Basement :	YES
Walkout :	NO

Market Value

Buildings :	$51,500.00
Land :	$12,500.00
Total :	$64,000.00

Flood Insurance : NO



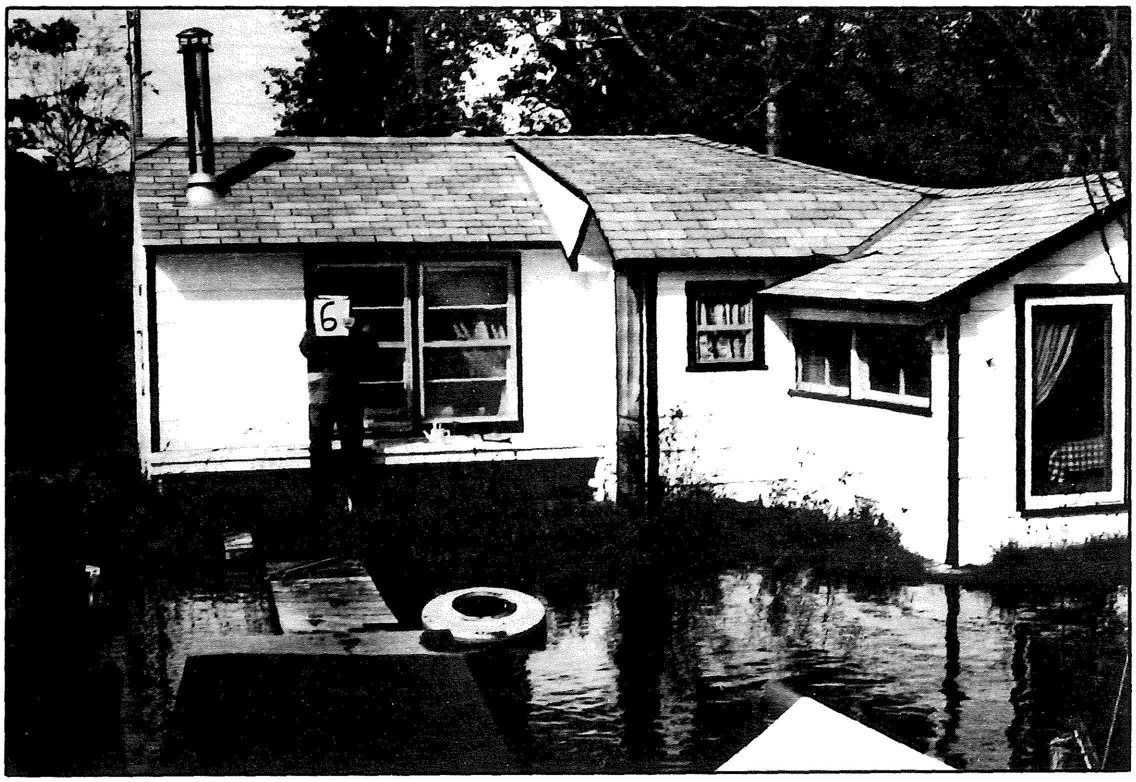
LONG LAKE SHERBURNE CO.

Structure Number :	6
Name :	Theisen, Marcellus and J.
Address :	Rt. 2 Sauk Rapids, MN 55379
Legal Description :	Sec. 4, Twp. 34, R. 30 Unplatted, That part of Gov't. Lot 6 Description as follows - See 1976 Tax Statement. Pin Number: 220-000-043118-742-015010.
Walkout/1stFl Elev. :	984.4
Ground Elevation :	983.6
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$8,000.00
Land :	$11,000.00
Total :	$19,000.00

Flood Insurance : NO



LONG LAKE SHERBURNE CO.

Structure Number : 7
Name : Barrett, Roger and Gary
Address : Rt. 2, Box 211
Clear Lake, MN 55319

Legal Description : Sec. 4, twp. 34, R. 30
Unplatted, that part of Gov't. Lot 6, Description as follows - See 1976 tax Statement.
Pin Number: 220-000-043117-742-013540.

Walkout/1stFl Elev. : 987.9
Ground Elevation : 985.1

Basement : NO
Walkout : NO

Market Value

Buildings : $17,900.00
Land : $12,500.00
Total : $30,400.00

Flood Insurance : NO

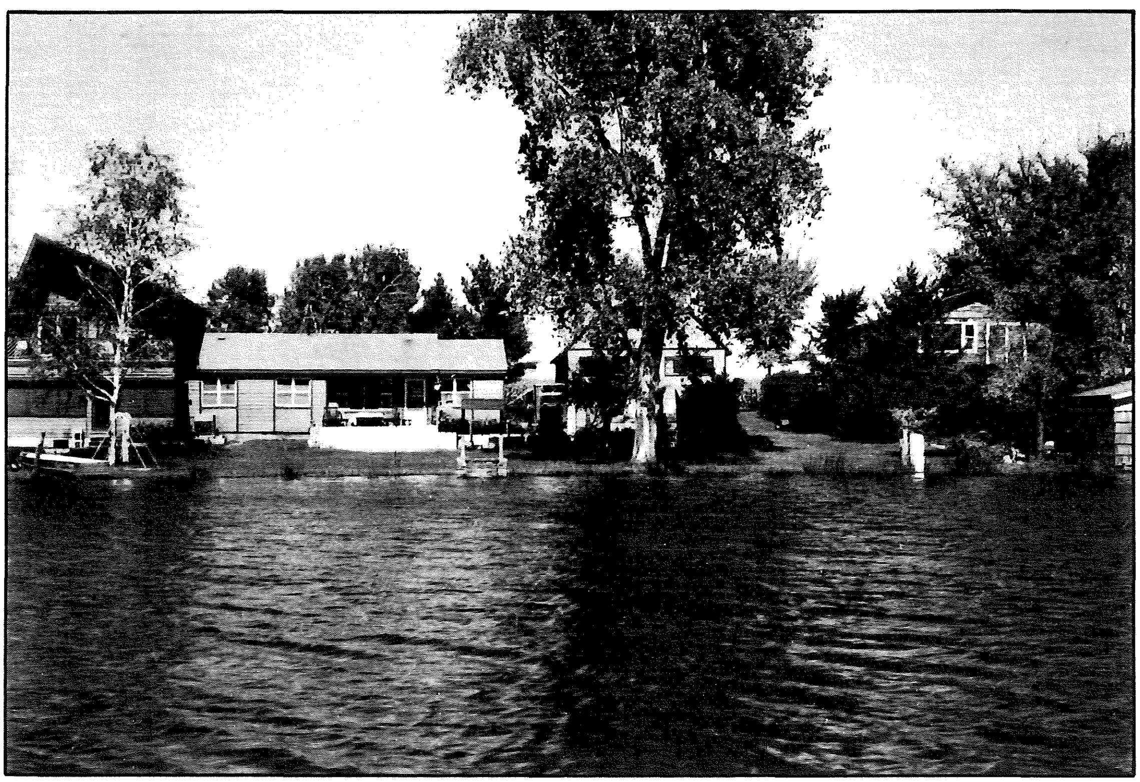
LONG LAKE SHERBURNE CO.

Structure Number :	8
Name :	Iten, Robert and Una
Address :	Rt. 2, Box 248 Clear Lake, MN 55319
Legal Description :	Sec. 4, Twp. 34, R. 30 That part of Gov't. Lot 6 on file with the County Assessor's Office. Pin Number: 220-000-043111-742-00540.
Walkout/1stFl Elev. :	989.1
Ground Elevation :	987.1
Basement :	NO
Walkout :	NO

Market Value

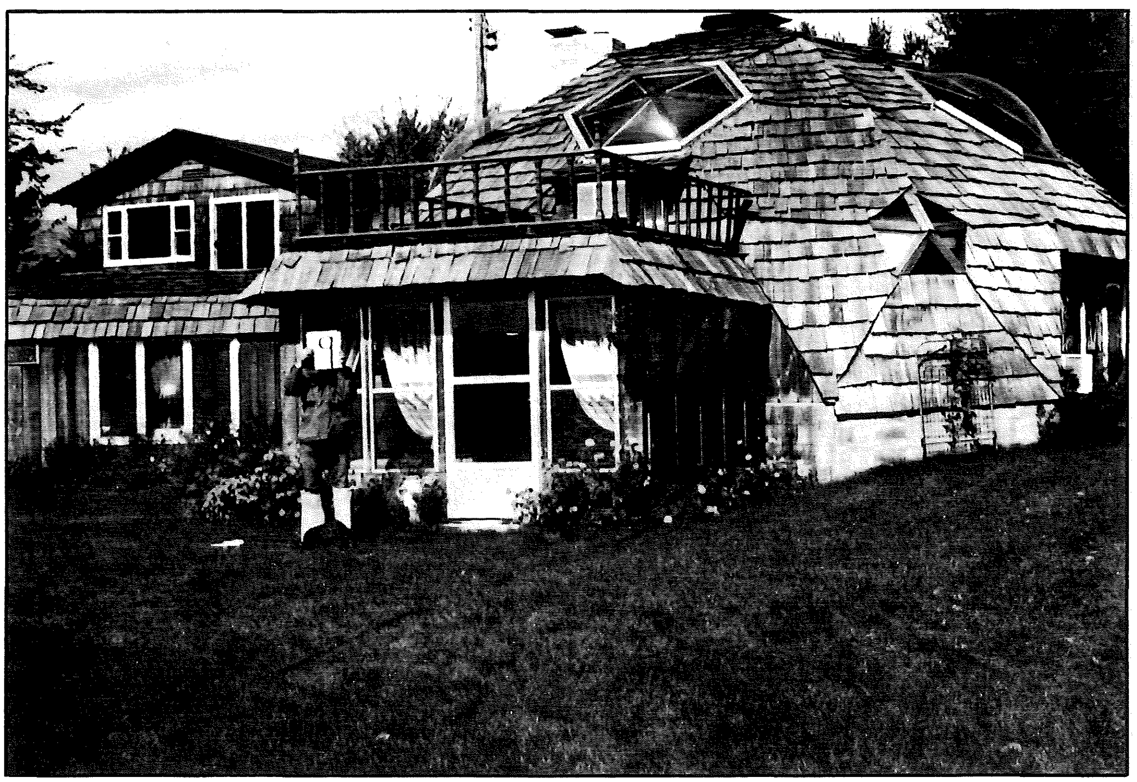
Buildings :	$72,800.00
Land :	$19,500.00
Total :	$92,300.00

Flood Insurance : NO



LONG LAKE SHERBURNE CO.

Structure Number :	9	
Name :	Gohl, Roger and Bernice	
Address :	Rt. 2, Box 215 Clear Lake, MN 55319	
Legal Description :	Sec. 3, Twp. 34, R. 30 Unplatted, tracts 6 and 7 - that part of Gov't. Lot 6, Description as follows - See 1976 Tax Statement. Pin Number: 220-000-043112-742-003935	
Walkout/1stFl Elev. :	986.1	
Ground Elevation :	985.8	
Basement :	NO	
Walkout :	NO	
Market Value		
Buildings :		$61,200.00
Land :		$14,500.00
Total :		$75,700.00
Flood Insurance :	NO	



LONG LAKE SHERBURNE CO.

Structure Number :	10
Name :	Bromenschenkel, Bernard
Address :	321 Benton Street Anoka, MN 55303
Legal Description :	Sec. 4, Twp. 34, R. 30 Unplatted, Tract 8 that part of Gov't. Lot 6 Description as follows - See 1976 Tax Statement. Pin Number: 220-000-043113-742-001526.
Walkout/1stFl Elev. :	990.6
Ground Elevation :	988.1
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$14,900.00
Land :	$11,000.00
Total :	$25,900.00

Flood Insurance : NO

LONG LAKE SHERBURNE CO.

Structure Number :	11
Name :	Schirmer, Donald
Address :	Rt. 2, Box 218 Clear Lake, MN 55319
Legal Description :	Sec. 4, twp. 34, R. 30 Unplatted, Tract 9 that part of Gov't. Lot 6, Description as follows - See 1976 Tax Statement. Pin Number: 220-000-043114-742-010601.
Walkout/1stFl Elev. :	987.4
Ground Elevation :	
Basement :	NO
Walkout :	YES

Market Value

Buildings :	$70,000.00
Land :	$12,500.00
Total :	$82,500.00

Flood Insurance : NO

LONG LAKE SHERBURNE CO.

Structure Number :	12
Name :	Lardy, Robert and Barbara
Address :	Rt. 2, Box 220 Clear Lake, MN 55319
Legal Description :	Unplatted, that part of Gov't Lot 6, Description as follows - See 1976 Tax Statement. Pin Number: 220-000-043103-742-006835.
Walkout/1stFl Elev. :	987.5
Ground Elevation :	
Basement :	NO
Walkout :	YES

Market Value

Buildings :	$46,800.00
Land :	$12,500.00
Total :	$59,300.00

Flood Insurance : NO

LONG LAKE SHERBURNE CO.

Structure Number :	13
Name :	Sogard, Walter and Edith
Address :	Rt. 2, Box 221 Clear Lake, MN 55319
Legal Description :	Sec. 4, Twp. 34, R. 30 Unplatted, that part of Gov't. Lot 6, Description as follows - See 1976 Tax Statement. Pin Number: 220-000-043109-742-011312.
Walkout/1stFl Elev. :	988.3
Ground Elevation :	987.7
Basement :	NO
Walkout :	YES

Market Value

Buildings :	$28,300.00
Land :	$11,000.00
Total :	$39,300.00

Flood Insurance : NO

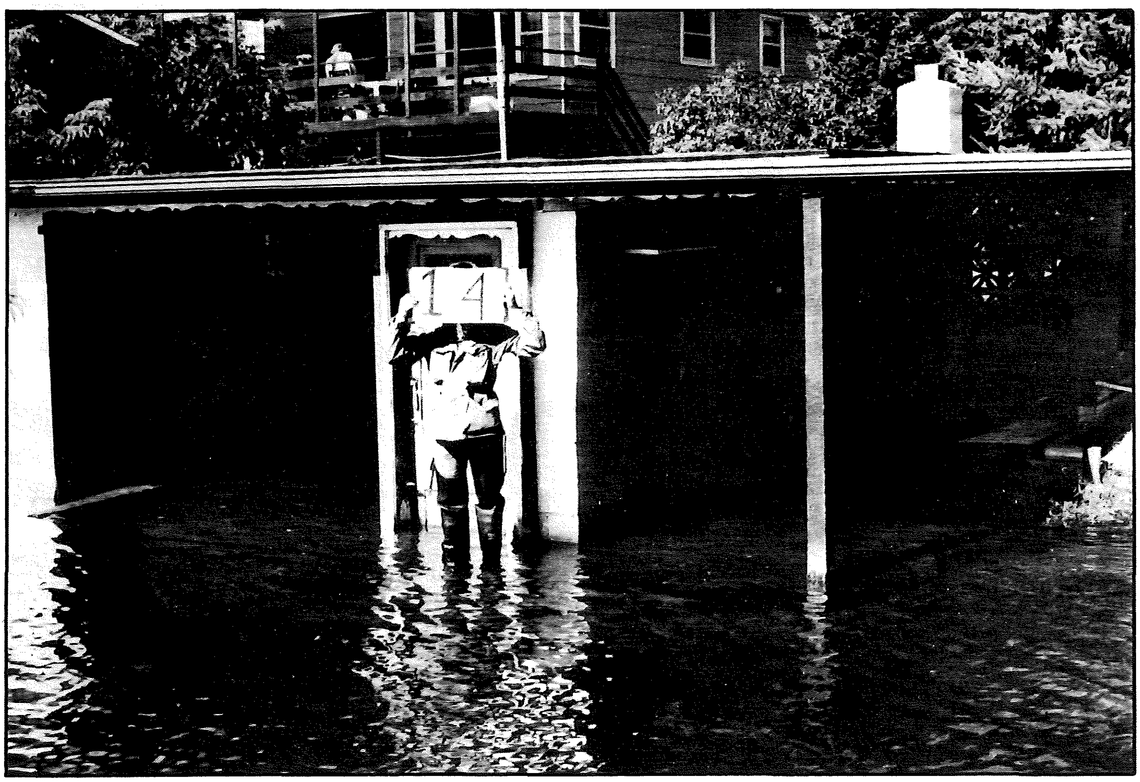
LONG LAKE SHERBURNE CO.

Structure Number :	14
Name :	Lardy, Marcust and Loyola
Address :	Rt. 2, box 207 Clear Lake, MN 55319
Legal Description :	Sec. 4, Twp. 34, R. 30 Unplatted, that part of Gov't. Lot 6, Description as follows - See 1976 Tax Statement. Pin Number: 220-000-043102-006832.
Walkout/1stFl Elev. :	
Ground Elevation :	983.4
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$1,200.00
Land :	$12,500.00
Total :	$13,700.00

Flood Insurance : NO



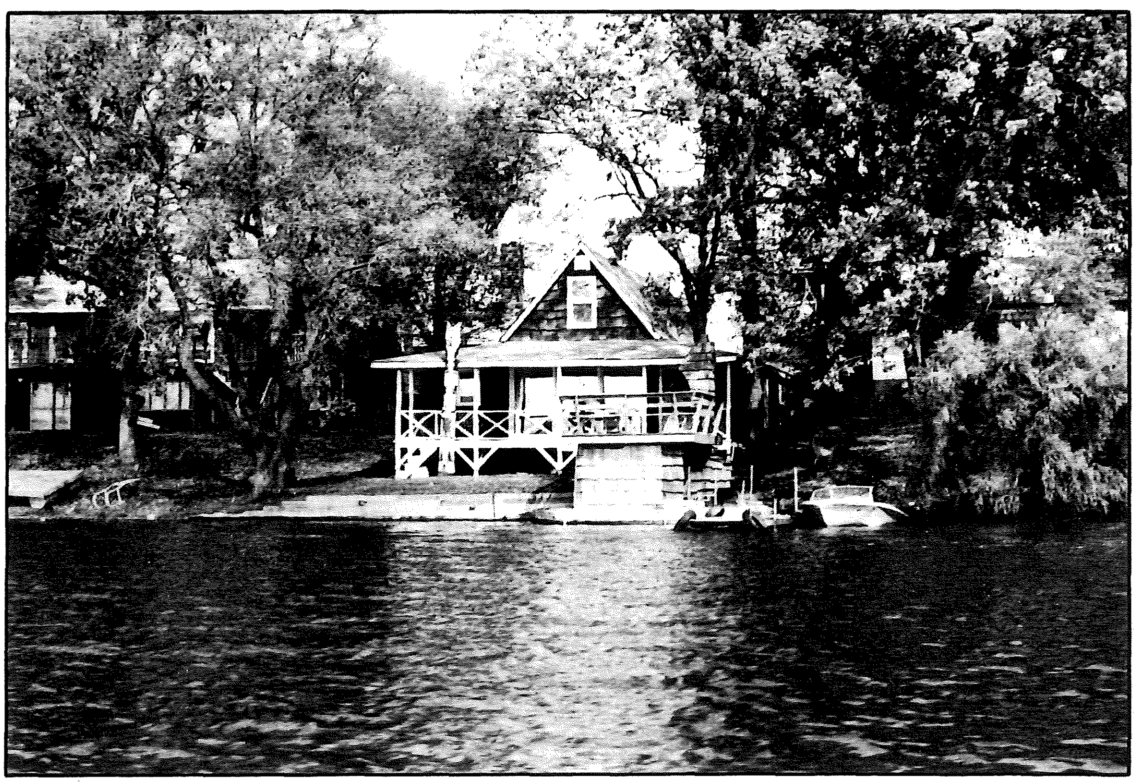
LONG LAKE SHERBURNE CO.

Structure Number :	15
Name :	Schur, Wallace E.
Address :	3725 Evergreen Lane Plymouth, MN 55441
Legal Description :	Sec. 34, Twp. 35, R. 30 Long Lake Park Easterly 50 ft. of Lot 1.
Walkout/1stFl Elev. :	990.7
Ground Elevation :	988.9
Basement :	NO
Walkout :	NO

Market Value

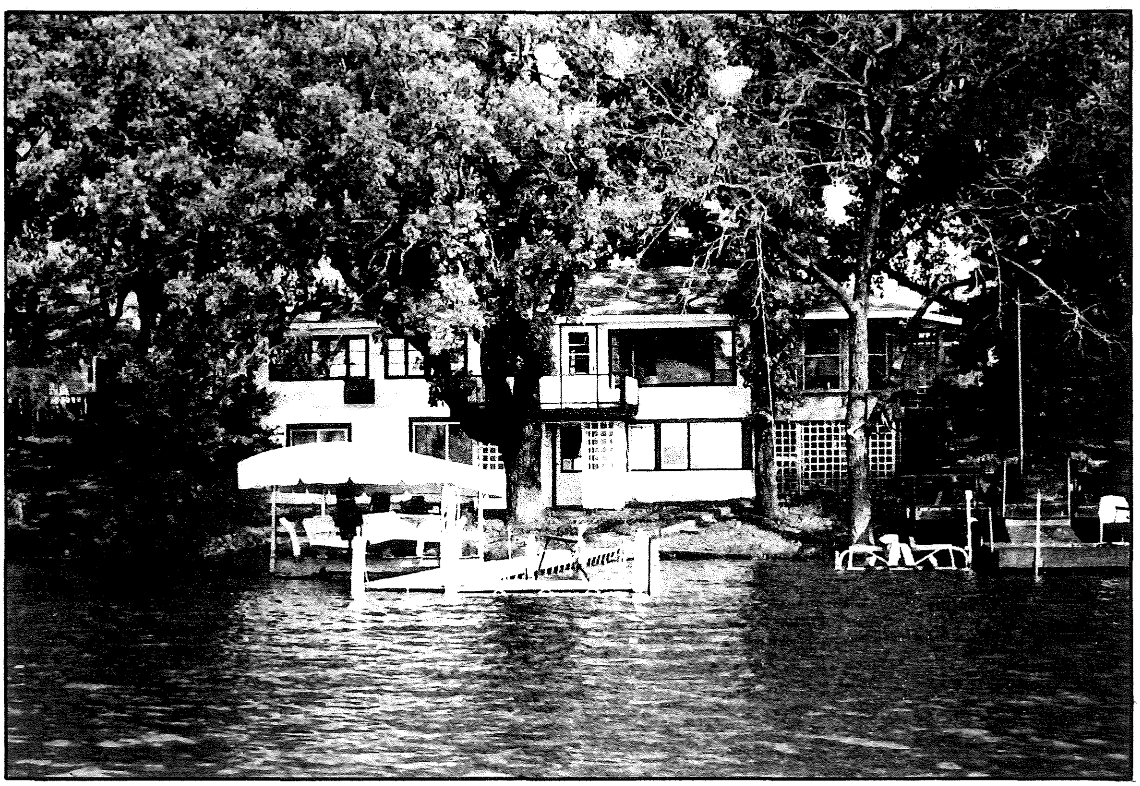
Buildings :	$36,800.00
Land :	$13,000.00
Total :	$49,800.00

Flood Insurance : NO



LONG LAKE SHERBURNE CO.

Structure Number :	16	
Name :	Schiller, Harold	
Address :	7445 Winnetka Hts. Drive. Minneapolis, MN 55427	
Legal Description :	Sec. 34,Twp. 35, R. 30 Long Lake Park Lot 2,3,4.	
Walkout/1stFl Elev. :	988.0	
Ground Elevation :	987.5	
Basement :	NO	
Walkout :	Yes	
Market Value		
Buildings :		$43,200.00
Land :		$38,500.00
Total :		$81,700.00
Flood Insurance :	NO	



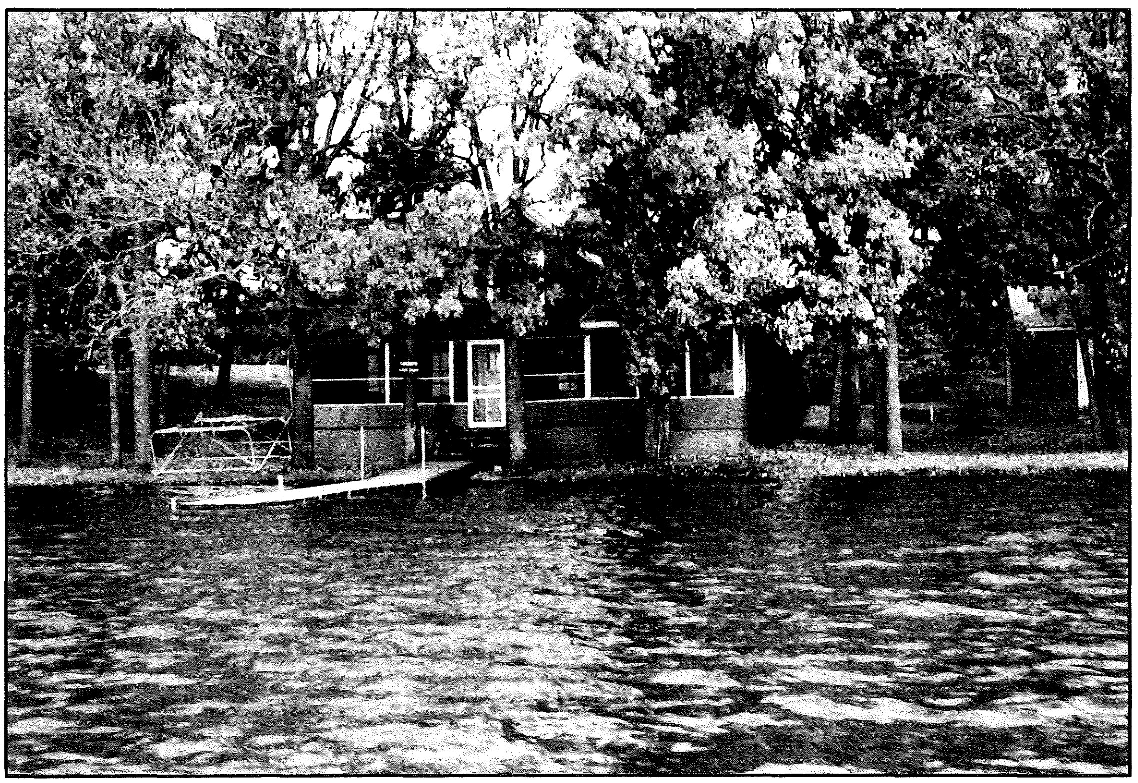
LONG LAKE SHERBURNE CO.

Structure Number :	17
Name :	Leisen, John E.
Address :	1021 Bargert Avenue St. Cloud, MN 56301
Legal Description :	Sec. 34, twp. 35, R. 30 Long Lake Park Lots 5,6,7.
Walkout/1stFl Elev. :	988.2
Ground Elevation :	985.4
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$11,700.00
Land :	$25,000.00
Total :	$36,700.00

Flood Insurance : NO



LONG LAKE SHERBURNE CO.

Structure Number :	18
Name :	Schulte, Olive M.
Address :	Rt. 5 St. Cloud, MN 56301
Legal Description :	Sec. 34, Twp. 35, R. 30 Long Lake Park Lot 9.
Walkout/1stFl Elev. :	987.3
Ground Elevation :	985.8
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$17,900.00
Land :	$13,000.00
Total :	$30,900.00

Flood Insurance : NO

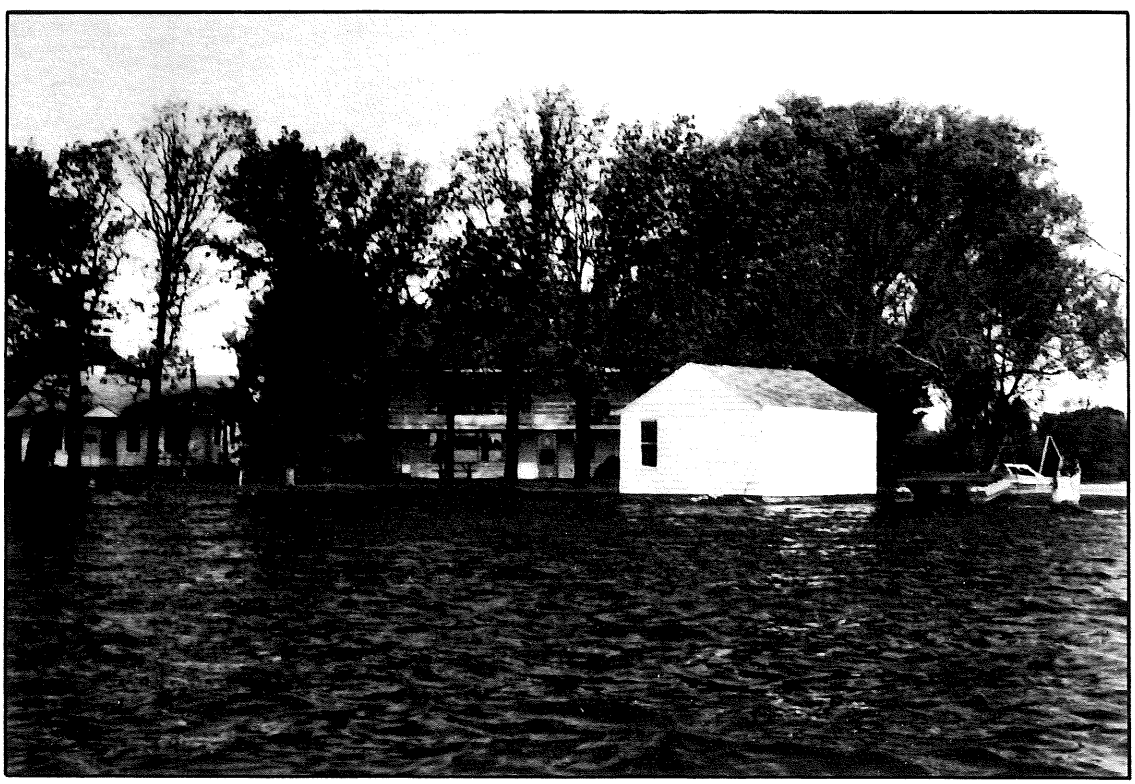
LONG LAKE SHERBURNE CO.

Structure Number :	19
Name :	Schufelt, Fred and Carol
Address :	Rt. 5 St. Cloud, Mn 56301
Legal Description :	Sec. 34, Twp. 35, R. 30 Long Lake Park Lot 10.
Walkout/1stFl Elev. :	985.9
Ground Elevation :	985.6
Basement :	NO
Walkout :	YES

Market Value

Buildings :	$58,700.00
Land :	$13,000.00
Total :	$71,700.00

Flood Insurance :	NO



APPENDIX E

GEOLOGIC MAP OF MINNESOTA

Minnesota Geological Survey
University of Minnesota
Matt Walton, Director

STATE MAP SERIES S-4

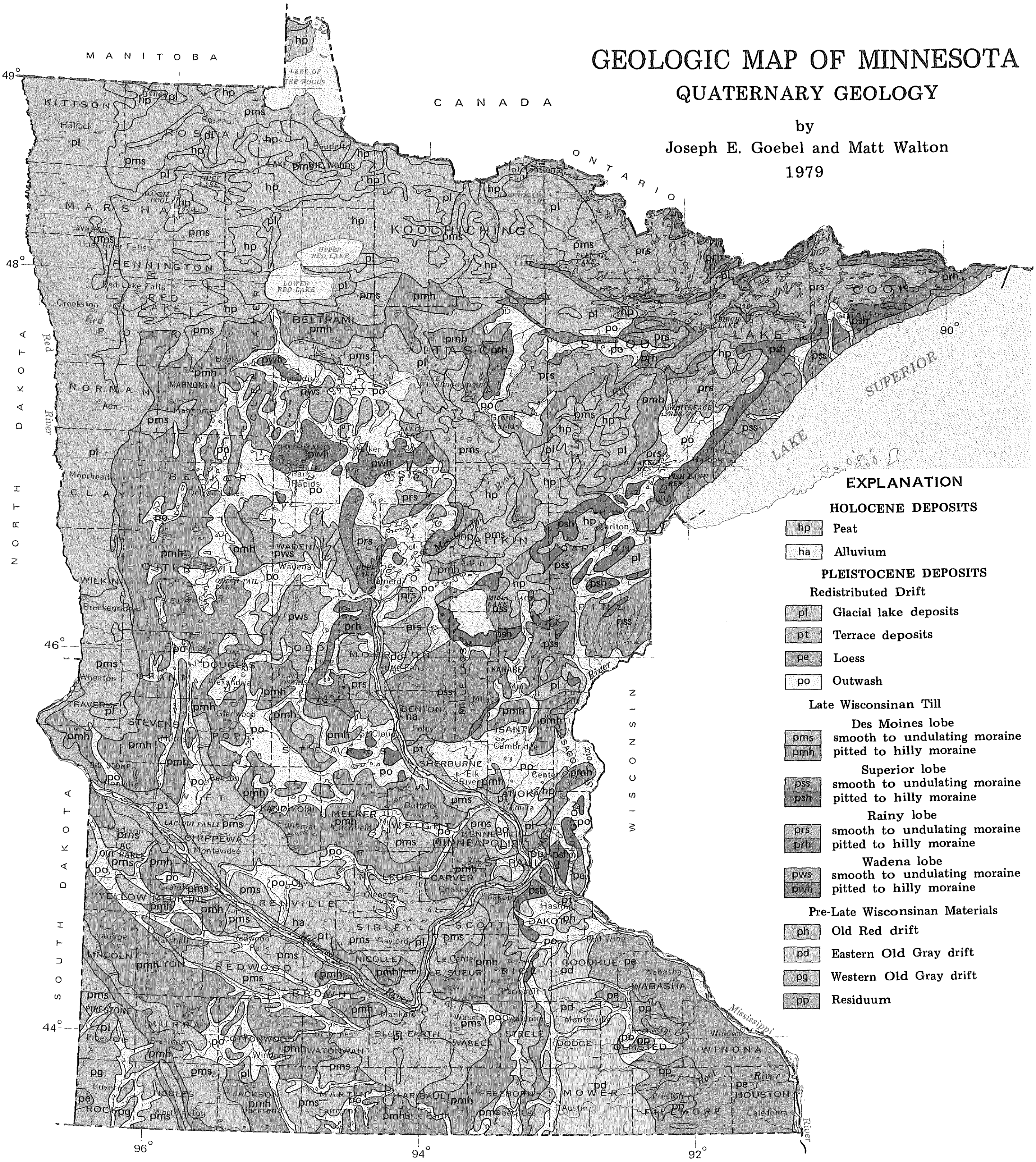
GEOLOGIC MAP OF MINNESOTA

QUATERNARY GEOLOGY

by

Joseph E. Goebel and Matt Walton

1979



EXPLANATION

HOLOCENE DEPOSITS

- hp — Peat
- ha — Alluvium

PLEISTOCENE DEPOSITS

Redistributed Drift

- pl — Glacial lake deposits
- pt — Terrace deposits
- pe — Loess
- po — Outwash

Late Wisconsinan Till

Des Moines lobe
- pms — smooth to undulating moraine
- pmh — pitted to hilly moraine

Superior lobe
- pss — smooth to undulating moraine
- psh — pitted to hilly moraine

Rainy lobe
- prs — smooth to undulating moraine
- prh — pitted to hilly moraine

Wadena lobe
- pws — smooth to undulating moraine
- pwh — pitted to hilly moraine

Pre-Late Wisconsinan Materials

- ph — Old Red drift
- pd — Eastern Old Gray drift
- pg — Western Old Gray drift
- pp — Residuum

SCALE 1:3,168,000
1 inch = 50 miles

0 — 50 Miles

0 — 50 — 100 Kilometers

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QUATERNARY GEOLOGY OF MINNESOTA

The Quaternary Period comprises the "Great Ice Age" or Pleistocene Epoch, which began about 2 million years ago and ended only about 10 thousand years ago. It also includes the Holocene or Recent Epoch, which spans the last 10 thousand years. By comparison with bedrock formations in Minnesota, which range from about 100 million to more than 3,500 million years in age, Quaternary formations represent only a very small part of the state's geologic history. However, glacial drift spread by Pleistocene ice sheets covers most of Minnesota and ranges to hundreds of feet in thickness, so that Quaternary geology is the major influence on topography, soils, water, and land uses--in short, the environment of Minnesota.

Quaternary geologic units are unconsolidated sedimentary materials deposited by water, wind and plant growth, and by glacial ice and meltwaters. This map portrays the distribution of Quaternary formations. Outcrops of bedrock, which are common only in the northeast and along larger river valleys in the south, are not shown on this map.

HOLOCENE DEPOSITS

hp — PEAT—Accumulations of partially decayed vegetation, especially mosses, reeds and sedges, in wet, poorly-drained areas. Peat is valuable as an organic soil conditioner and chemical feedstock and as a potential energy resource. It is a very poor base for roads and other construction.

ha — ALLUVIUM—Sand and gravel, locally interbedded with silt, clay and organic material, deposited on present floodplains. Sand and gravel deposits, copious shallow ground water and flat terrain make alluvial plains attractive for urban and industrial development, but they are flood-prone, and sensitive to pollution. They are valuable for agriculture and wildlife.

PLEISTOCENE DEPOSITS

There were four major ice advances in North America during the Pleistocene Epoch: the Nebraskan, Kansan, Illinoisan and Wisconsinan Glaciations. Each lasted tens of thousands of years and was followed by a warmer period when the ice melted. Each deposited sediments, called drift, over vast areas. Drift deposited during the last stage of the Wisconsinan Glaciation covers most of Minnesota and conceals evidence of older ice advances except in the southeast and southwest corners of the state.

Redistributed Drift

Some drift deposited by glaciers was quickly eroded, transported and redeposited by water and wind in lakes, on floodplains and on land beyond the margin of the ice.

pl — GLACIAL LAKE DEPOSITS—Clay, silt and sand with local gravel bars and beaches deposited on the beds and margins of extensive lakes that existed when outlets for meltwater were blocked by ice or by glacial deposits which have now eroded away. Major glacial lakes were: Lake Agassiz in northwestern and north-central Minnesota, Lakes Upham and Aitkin northwest of Duluth, and Lake Minnesota south of Mankato. Due to the prevalence of fine silt and clay, glacial lake deposits present drainage and construction problems and tend to be poor ground-water sources. They form extensive areas of flat farmland, notably the Red River Valley.

pt — TERRACE DEPOSITS—Stratified sand and gravel with some interbedded silt and clay occurring along stream valleys above the level of present floodplains. During glacial melting, streamflow was larger than at present, and floodplains were built up by glacial sediments. Recent streams have cut into older floodplains leaving remnants as terraces. Terrace tops are commonly flat and well drained. They are attractive for residential and industrial development, but they also contain valuable sand and gravel resources.

pe — LOESS—Eolian silt and fine sand blown from unvegetated drift exposed along major glacial streams. Loess is shown on the map for areas where it is commonly more than 2 meters (6.5 feet) thick. Excellent agricultural soils are formed in loess.

po — OUTWASH—Sand, silt and gravel carried from glaciers by meltwater and spread over wide areas. The deposits are typically sorted into discontinuous and interfingering beds of silt, sand and gravel called stratified drift. Outwash plains have flat topography, sandy soils, and many gravel deposits. Shallow ground water is commonly abundant for irrigation.

Late Wisconsinan Drift Deposited Directly From Glaciers

The ice of each glaciation accumulated in northern Canada and moved southward in a complex series of tongue-like extrusions or lobes. Near the center of ice accumulation, the moving ice scoured the land surface down to hard bedrock and picked up a load of rock fragments and soil. Farther from the center the ice deposited this drift from its base. Areas of ice-scoured, exposed bedrock occur mainly in northeastern Minnesota; deposition predominated throughout the rest of the state. Drift deposited directly from ice is called till. In general, till is an unsorted mixture of all sizes of rock from boulders to clay and "rock flour." It tends to be stiff, stony and impervious. Till of different lobes differs in composition depending on the geology "upstream" along the path of the advancing ice.

Till deposited from the base of an ice lobe forms a smooth to undulating blanket called a ground moraine. Such till is stiff and compact; it yields little ground water.

Till deposited at ice margins or from stagnating masses of melting ice forms irregular pitted to hilly topography with many ponds and lakes. These landforms are called end moraines, recessional moraines and stagnation moraines. These deposits may contain pockets of sand, gravel and boulders with some local ground water.

pms / pmh — DES MOINES LOBE TILL—Smooth to undulating moraine (pms) and pitted to hilly moraine (pmh). The Des Moines lobe is the most recent glacial lobe. It advanced through the Red River Valley into Iowa. Sublobes extended eastward into the St. Louis River basin and northeastward across Minneapolis and St. Paul, incorporating drift from earlier lobes. Des Moines lobe till is typically clay-rich. It is mainly composed of gray (olive-brown where oxidized) calcareous silt and clay, with lesser amounts of sand and gravel. Shale and limestone are diagnostic.

pss / psh — SUPERIOR LOBE TILL—Smooth to undulating moraine (pss) and pitted to hilly moraine (psh). Ice of the Superior lobe moved out of the Lake Superior basin in several pulses, spreading westward across the Mille Lacs area and southward across the Minneapolis-St. Paul area. It interacted with the partly contemporaneous Rainy lobe along the Laurentian Divide. Superior lobe till is generally reddish-brown, sandy to stony, and non-calcareous; it contains abundant fragments of volcanic, granitic, gabbroic and metamorphic rocks, red sandstone and conglomerate. Where it incorporates earlier lake deposits, it is locally silty or clayey.

prs / prh — RAINY LOBE TILL—Smooth to undulating moraine (prs) and pitted to hilly moraine (prh). The Rainy lobe moved southward into Minnesota along a broad front from Lake of the Woods almost to Lake Superior, where it met ice from the Lake Superior basin along the Laurentian divide and moved southwestward. It advanced to the vicinity of Little Falls overriding drift and perhaps encountering ice remaining from the earlier Wadena lobe. Part of the Rainy lobe drift area was later overridden by the St. Louis sublobe of the Des Moines lobe. Rainy lobe till is grayish brown (moderate brown where oxidized), non-calcareous and generally sandy with abundant fragments of granitic, metamorphic and greenstone volcanic rocks.

pws / pwh — WADENA LOBE TILL—Smooth to undulating moraine (pws) and pitted to hilly moraine (pwh). The Wadena lobe was the earliest of the Late Wisconsinan glacial lobes. A large remnant of its till and outwash survives in northwest-central Minnesota in an area that was not overridden by any of the three later lobes. A large drumlin field indicates movement of ice from the north or a little east of north. Wadena lobe till is gray (yellowish brown where oxidized) and calcareous with fragments of igneous and metamorphic rocks, some limestone and little or no shale.

Pre-Late Wisconsinan Materials

At one time or another, prior to the Late Wisconsinan, all of Minnesota must have been covered by glaciers. Evidence is concealed beneath Late Wisconsinan drift except in the southwestern and southeastern corners of the state where there are deposits of weathered and stream-dissected drift that are older than Late Wisconsinan and could be Illinoisan or Kansan in age.

ph — OLD RED DRIFT—Moderate to dusky-brown till and outwash found mainly in Dakota and southern Washington Counties. Fragments of gabbro, felsite and red sandstone are notable. Some exposures show a distinct weathered profile overlain by younger drift.

pd — EASTERN OLD GRAY DRIFT—Moderate yellowish-brown weathered silty till and outwash. It contains fragments of igneous and metamorphic rocks, limestone and sandstone, but lacks shale. It appears to underlie Old Red Drift in southern Dakota County.

pg — WESTERN OLD GRAY DRIFT—Dark-gray, strongly weathered, clayey, stream-dissected till and outwash with fragments of quartzite, granite and limestone.

pp — RESIDUUM—Soils of uncertain age and origin, including some old weathered drift and loess, on weathered pre-Quaternary rocks.

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