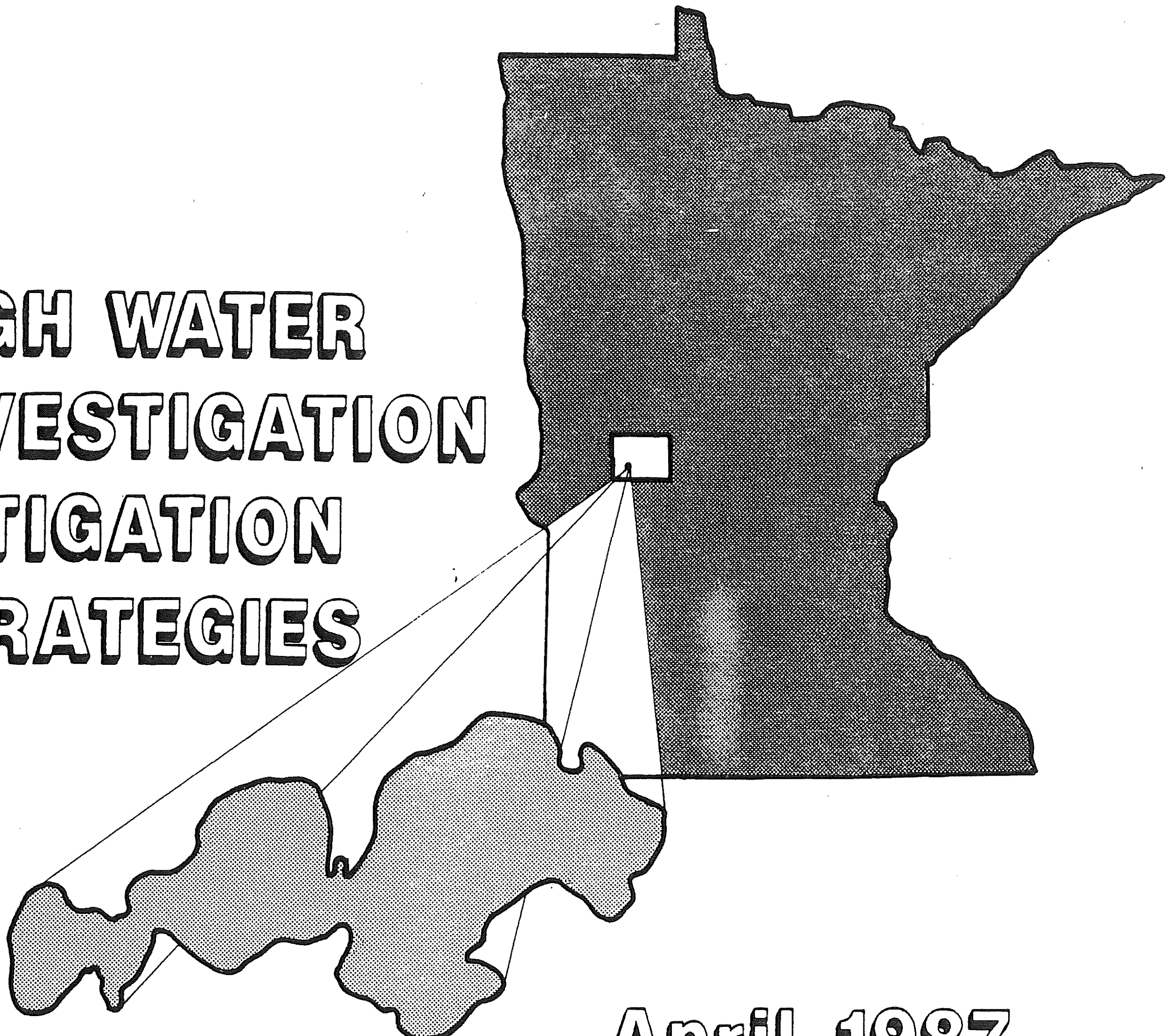
OSCAR LAKE

(Douglas County, 21-257)

HIGH WATER INVESTIGATION MITIGATION STRATEGIES



April 1987

Revised 12/87

Minnesota Department of Natural Resources
Division of Waters

HIGH WATER INVESTIGATION

AND

MITIGATION STRATEGIES

FOR

OSCAR LAKE

BASIN #21-257

DOUGLAS 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 effects and mitigation strategies for high water problem basins. 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

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INTRODUCTION

Oscar Lake is located in southwestern Douglas County, Minnesota, approximately 150 miles northwest of the Twin Cities metropolitan area. The lake is about 9 miles west southwest of the City of Alexandria, and most of its area is within Sections 4 through 9 of Township 127 North, Range 39 West (Plate 1).

Oscar Lake is one of over 50 landlocked lakes within glaciated terrain in Minnesota that, in recent years, have been experiencing highwater level problems. These lakes have no active natural outlet 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.

Oscar Lake is situated within glacial drift of the Alexandria Moraine Association. The lake level began to rise during the early 1980's and is associated with above normal precipitation years. By April 29, 1987, the lake rose to within 1.55' of the Ordinary High Water Level (OHW elevation 1381.0'; NGVD, 1929)[1] or to elevation 1379.45'. As the water level rose, a number of structures were flooded.

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 a high water level problem lake. 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 identify the source of the problem, project future conditions and identify the potential impact of continued rising water levels. Part 2 will identify mitigation options and implementation strategies. The Appendices will provide additional background data to be used by landowners and local, state and federal officials.

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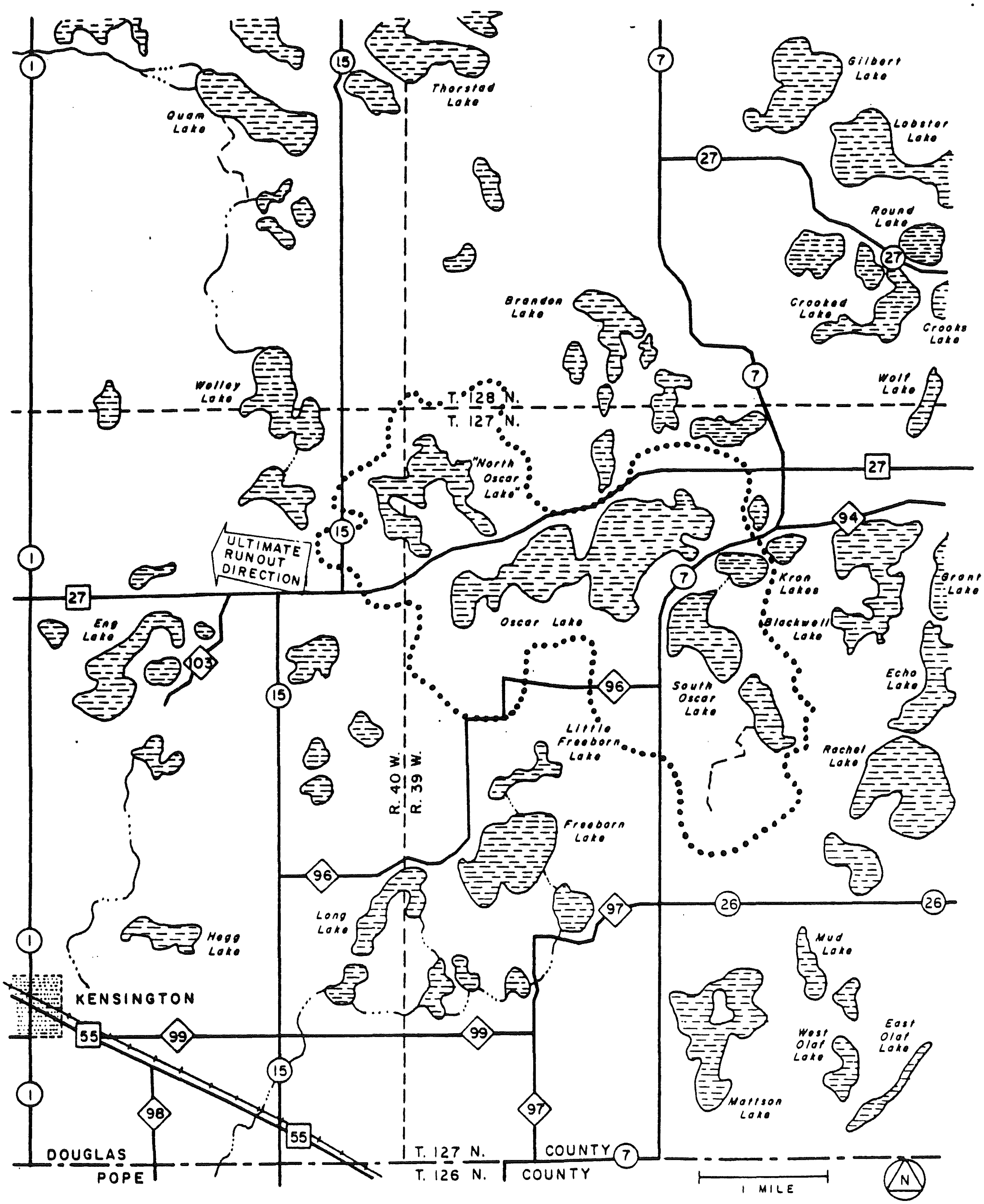
[1] National Geodetic Vertical Datum of 1929 is used for all elevations included in this report.

PLATE 1



OSCAR LAKE

LOCATION MAP

BOUNDARY OF OSCAR LAKE WATERSHED

SUMMARY AND CONCLUSIONS/RECOMMENDATIONS

Water Level Data (See Part 1)

-In April of 1987 Oscar Lake was at elevation 1379.45', an elevation 1.55' below the lakes ordinary high water elevation of 1381.0'. Oscar Lake's water level reacts to both surface (above ground) runoff and ground water inflow.

-There is a correlation between the area's annual precipitation and Oscar Lake's water level. During the last 5-year period, there has been an excess of 37.35" of precipitation above the normal annual precipitation for this general area. This has resulted in significant surface and ground water inflow and caused the current high water problems.

-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 the lake were to rise to elevation 1388.45', 22 additional structures would be flooded with 1986 assessed market values totalling $267,341. At this elevation, it is estimated a minimum $267,339 of damage would occur.

-Methodologies do not exist which can predict what Oscar Lake's maximum elevation will be in the future. The major factor on limiting potential increases in lake levels would be if the lake should reach its natural runout elevation of 1382.1'.

-Methodologies do exist which can calculate the probabilities of future water levels considering the long-term impact of above or below normal precipitation (i.e., both increases and decreases in water levels). There is a one-percent probability that Oscar Lake will: 1) rise above elevation 1380.2' on December 1, 1987; or 2) will exceed elevation 1380.8' on December 1, 1991. Conversely, there is a one-percent probability the lake will: 1) fall below elevation 1376.5' by December 1, 1987; or 2) fall below elevation 1372.4' on December 31, 1991. There is a 50% probability (a 50/50 chance) that Oscar Lake will be at elevation 1378.4' on December 1, 1987 and elevation 1367.9' in December of 1991.

Mitigation Strategies (See Part II)

-The flood protection standards for new development in Douglas County's current flood plain ordinance do not apply to the Oscar Lake shoreline because a flood delineation is not currently shown for the lake on the County's current flood plain zoning map. The County must properly regulate new development with its existing state-approved shoreland regulations with two recommended revisions, as follows:

1) New development within the lake's shoreland district must be elevated, at a minimum to elevation 1382.45' (3' above the highest known water level). However, since there exists physical evidence that the lake's water level was approximately 1384.0' in the past, it is recommended that the County adopt a flood protection elevation of 1384.0'. This will insure that all new development is above Oscar Lake's natural runout elevation; and

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 (presently 1382.45' and recommend at 1384.0').

-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 <u>all</u> landowners and renters in the unincorporated areas of Douglas County. A structure and/or its contents can be insured. Landowners or renters adjacent to Oscar Lake should explore purchasing flood insurance, especially those located within 2'-3' of the lake'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 elevation 1384.0' or elevating a structure at its existing site on fill to a minimum recommended flood protection elevation of 1384.0'. 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 the U.S. Army Corps of Engineers' flood control authorities, Small Cities Development Block Grant Program, Section 1362 or the Federal Flood Disaster Protection Act of 1973 and the State's Flood Loss Reduction Legislation. 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 permit requirements for future actions which would affect the lake basin proper. The reader is encouraged to read the remainder of ths report. The Department of Natural Resources will assist local interests in the degree possible in implementing future flood loss reduction measures.

PART 1

GEOLOGIC SETTING

Oscar Lake and South Oscar Lake are located within glacial drift of the Alexandria moraine association in an area of ice contact topography. The glacial drift in the area is around 300 feet thick, and consists primarily of gray calcareous till. The till contains deposits of sand and gravel, both buried and at or near the land surface. The glacial drift is underlain by Pre-Cambrian crystalline bedrock. Driller's logs from wells near Oscar Lake show thick sections of till (recorded as "yellow clay" or "blue clay") extending to well below the level of the bottom of the lake.

SOILS

Soils in the area around the lakes consist primarily of loam of the Waukon series. The soils are deep, well-drained, undulating to steep, and are developed under mixed grasses and trees from the calcareous glacial till substrate. Soil Conservation Service maps show some sandy lake beach deposits around Oscar Lake which are now covered by water at the present lake elevation.

The bottom of Oscar Lake is primarily mud, but some areas of sandy lake bottom are present in the eastern part of the lake. Near surface sand and gravel deposits can be seen in the area between South Oscar Lake and Oscar Lake.

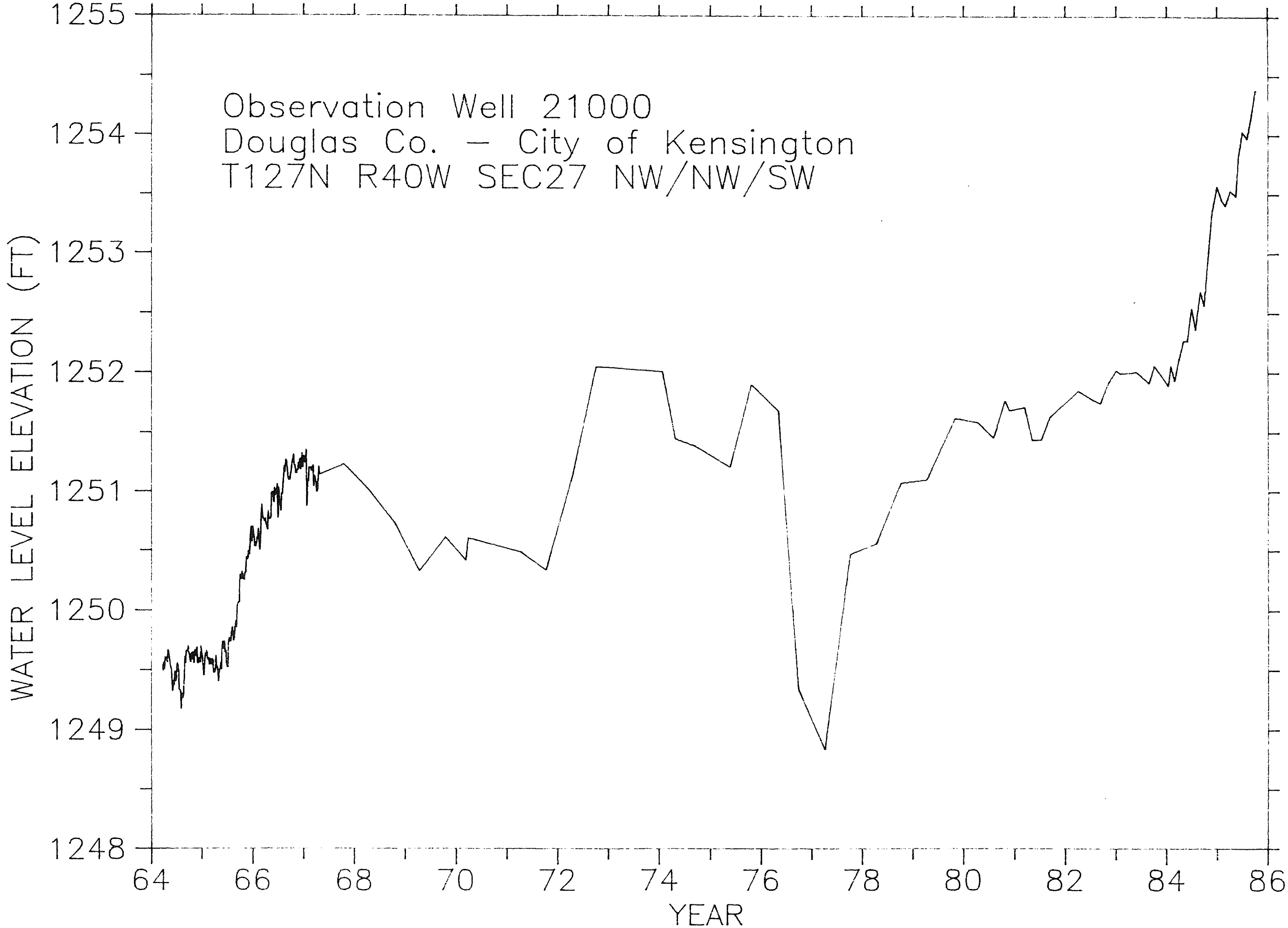
HYDROGEOLOGIC SETTING

The primary water-bearing units in the area are buried sands and gravels within the till. Wells in the area obtain water from these deposits. The regional direction of ground water flow in the area is east to west, toward the Chippewa River, but local ground water flow systems may exist around the lakes.

The lakes are mostly in contact with clayey glacial till, implying slower rates of ground water seepage into and out of the lakes. However, even at these slower rates, the contribution to the lakes' water budget can be significant, especially if a ground water mound develops on the down-gradient (west) side of the lakes and blocks outflow to the ground water system. It is not known whether any of the buried sand/gravel deposits intersect the lake basins. Such a connection would provide more direct communication between the ground water system and the lakes.

Ground water levels in the area have been steadily increasing during the last decade, as can be seen in the hydrograph of observation well No. 21000, located 4 miles southeast of Oscar Lake in the City of Kensington (Plate 2). The rising lake levels reflect the rising ground water levels. Increased net ground water inflow to the lakes should be expected if the lake levels are artificially lowered by the installation of an outlet.

PLATE 2


Observation Well 21000
Douglas Co. — City of Kensington
T127N R40W SEC27 NW/NW/SW
WATER LEVEL ELEVATION (FT)
1255
1254
1253
1252
1251
1250
1249
1248
64
66
68
70
72
74
76
78
80
82
84
86
YEAR

WATERSHED

The total watershed area for Oscar Lake (including North Oscar, South Oscar, Lewis and Kron Lakes and unnamed basin #564W) is approximately 4,604 acres (Plate 1 on Page ii). The watershed of 4,604 acres minus the water surface areas of about 1,403 acres equals 3,201 acres or a total watershed area to lake area ratio of about 2½ to 1.

This watershed to lake area ratio of about 2½ to 1 is generally not considered adequate to maintain lake levels during periods of normal precipitation without significant contributions from groundwater sources. During periods of below normal precipitation the lake level would probably drop in elevation and during periods of above normal precipitation it would be expected to see a rise in elevation. Since, in recent years, the area has been experiencing periods of above normal precipitation it is not surprising to see a rise in the lake water level.

From the available data, it would appear that Oscar Lake is experiencing above normal lake water levels due primarily to above normal precipitation which results in increased surface water runoff together with increased net groundwater flow into the lake.

Based on the Division of Waters survey of August, 1986, Oscar Lake would have to rise above elevation 1382.1' before any outflow would occur from the Oscar Lake basin (See Page 6 comparing pertinent elevations at Oscar Lake). This is known as the runout elevation or the minimum ground elevation which prohibits outflow until lake levels rise above it. It is located n the NE¼ of Section 12, T127N, R40W (Solem Township). Should levels exceed the runout elevation the flow would pass under County Road 15 into Roses Slough, Wally Lake, Quan Lake, Venus Lake and into Grant County and the Chippewa River upstream of Ellingson Lake. Several local persons have indicated that they remember the lake outflowing in this manner. The Geology of Minnesota authored by N.H. Winchell (published in 1888) states on Page 474 "The outlet of Lake Oscar, in high water, is into the Chippewa River". In addition to documenting the path of waters that outflow from Oscar, these observations indicate that Oscar Lake has, in the past, outflowed.

An investigation of the outlet by the U.S. Soil Conservation Service to determine the degree of sedimentation that has occurred in the outlet was completed in September, 1986. This investigation concluded that no evidence of sedimentation is apparent at the soil boring locations, that native grasses exist in the outlet area, that there is no evidence of the area ever having been ditched and in essence that the outlet currently exists in its natural state.

PERTINENT ELEVATIONS
OSCAR LAKE
DOUGLAS COUNTY

1385 -		
	- 1384.4	NOHW EVIDENCE
	- 1382.7	
	- 1382.1	NATURAL SURFACE OUTFLOW (RUNOUT)
	1382±	ESTIMATED WATER SURFACE - 1880
	- 1380.9	FLOWLINE 24" CMP THROUGH CO. RD. 15
1380 -		
	- 1379.45	WATER SURFACE (4-29-87)
	- 1378.5	WATER SURFACE (9-8-86)
	- 1376.8	INVERT 24" RCP THROUGH STH 27
1375 -		
	-	
	-	
	-	
	- 1371.4	1966 USGS QUADRANGLE
1370 -		
	- 1369.3	WATER SURFACE (10-20-77)
	-	
	-	
	- 1366±	1938 AERIAL PHOTO ESTIMATE
1365 -		

WATER QUALITY

Water quality information for Oscar Lake exists in the files of the Department of Natural Resources for the years 1942, 1949, 1965, 1978, and 1987. Oscar Lake is a hard-water, eutrophic (nutrient enriched) lake. Conductivity and alkalinity measurements are typical of a lake with a small surface watershed.

Oscar Lake rarely stratifies and has abundant and diverse aquatic weed populations, which lead to the presence of adequate dissolved oxygen in the water column. Secchi disc depths in mid-summer range from 8 to 3 feet, but the field notes attribute reduced clarity to suspension of mineral matter. There are no other direct measurements of nutrient enrichment.

Water quality problems have included an occasional winterkill. Oscar Lake has experienced recent water level increases, the effect of which has been to improve water clarity. The bacteriological water quality issues of flooded septic systems and pastures were not addressed.

FISH AND WILDLIFE

A 1987 Fisheries Lake Survey Report indicates that Oscar Lake, in ecological and management terms, is a Centrarchid-Walleye (largemouth bass/walleye) lake. The fish population of the lake includes northern pike, walleye, largemouth bass, black crappie, pumpkinseed, bluegill, yellow perch, white sucker and black, yellow and brown bullhead, sunfish, carp and some muskellunge. In general, Oscar Lake is a good recreational fishing lake with spawning conditions favorable for largemouth bass, pumpkinseeds, bluegills and walleyes.

THe Department of Natural Resources has not performed a wildlife field survey for Oscar Lake. However, the lake and its riparian areas does provide important habitat for a large number of wildlife species. Of the approximately 290 species of birds regularly found in the Lake States, 100 inhabit wetlands and another 80 are attracted to wetland edges. Of the 67 mammalian species in the Lake States, 6 have wetland habitats and approximately 40 other mammals are associated with or attracted to wetland edges. Reptiles and amphibians show a similar dependence on wetland habitats.

Wildlife such as gulls, terns, loons, pelicans, grebes, coots, cormorants, ducks, geese, swans, eagles, osprey, as well as other species of birds, use lakes for feeding and migrational resting areas. Shallow lakes and shallow portions of deeper lakes together with their riparian areas, provide important feeding, breeding, nesting and brooding habitat for greater variety of bird species including herons, egrets, bitterns, rails, cranes, hawks, snipe, sandpipers, kingfishers, warblers, sparrows, and pheasants, as well as ducks, geese and swans.

In addition, mink, muskrat, beaver, otter and water shrew also rely on lake and wetland habitats. Their riparian areas provide habitat for a variety of species of mammals such as raccoons, hares, weasles, moles, shrews, fox and deer.

Appendix B contains a more detailed presentation of water quality, fish and wildlife management, development history, and other information.

PRECIPITATION

Alexandria Area

Long Range Normal Annual Precipitation Average (1888-1986) = 23.85"

Normal Annual Precipitation (current trends) 1957-1986 = 24.59" (Plates 3 and 4)

Actual Annual Precipitation:

1982-1986

1982 = 30.87"
1983 = 26.98"
1984 = 32.73"
1985 = 29.69"
1986 = 40.03"

5-year period, yearly average precipitation = 32.06"/year

Excess above normal precipitation for 5-year period (current trends) = 37.35"

1977-1986

1977 = 35.36"
1978 = 21.66"
1979 = 27.35"
1980 = 23.95"
1981 = 29.78"
1982 = 30.87"
1983 = 26.98"
1984 = 32.73"
1985 = 29.69"
1986 = 40.03"

10-year period yearly average precipitation = 29.84"/year

Excess above normal precipitation for 10-year period (current trends) = 52.5"

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

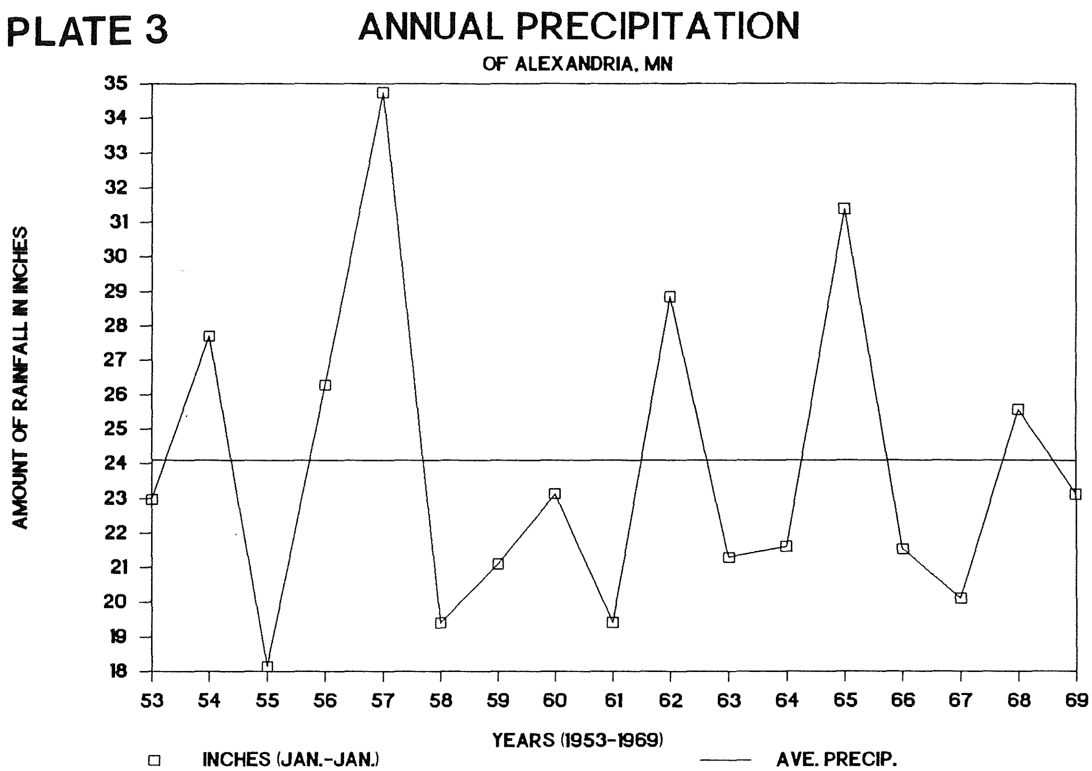


PLATE 3
ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69
YEARS (1953-1969)
INCHES (JAN.-JAN.)
AVE. PRECIP.

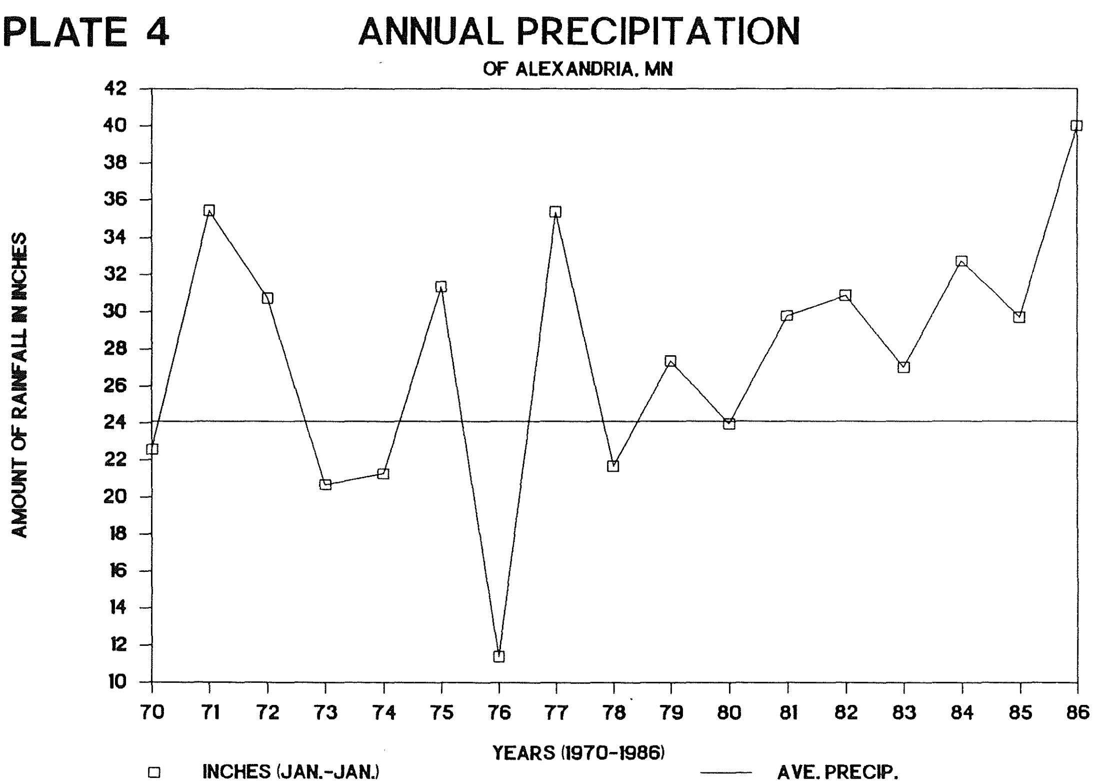


PLATE 4
ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS (1970-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.

WATER LEVEL HISTORY

Historic water level data for Oscar Lake is very limited. As no systematic gaging program exists nor ever has existed at the lake, the only recorded water level data included in this report are those sporadic levels that were recorded when Division of Waters surveys were made at the lake (See Chart 1).

Past correspondence, photographs, aerial photographs and reports located in the Division of Waters and other agency files can often provide information from which estimates of past lake levels and trends can be made. This is also true of statements made by persons familiar with the lake's history. Although the accuracy of these data is not as good as that of recorded data, these estimates are useful as approximate indicators of a lake's water level history (See aerial photography section).

Recorded and estimated elevations documenting Oscar Lake's water level history are shown in Table 1 on Page 12. In general these data show that lake levels have varied by more than 10 feet over the last 120 years; that low levels occurred in the later 1930's and the relatively high levels occurred during the late 1800's, early 1900's and again in recent years. These periods of low and high lake levels correlate well with low and high long term precipitation patterns (Plates 5 and 6).

The long term variations in Oscar Lake levels and recent high water problems are not unique. Many lakes throughout the state are currently experiencing or have recently experienced high water and suffered related problems. Most of these lakes are similar to Oscar in that they generally have watershed to lake are ratios of less than 5 to 1 and they are located in similar geologic settings consisting of morainal materials.

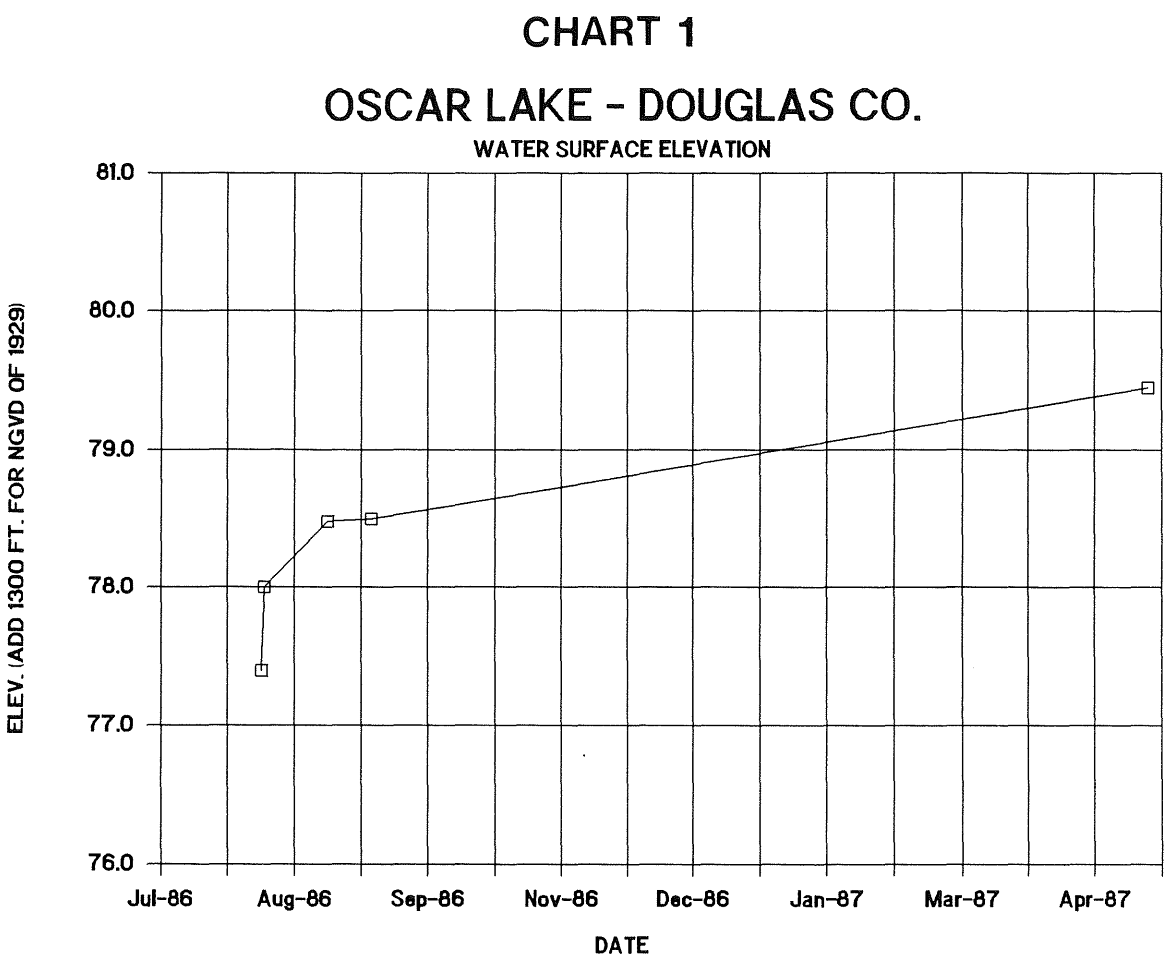


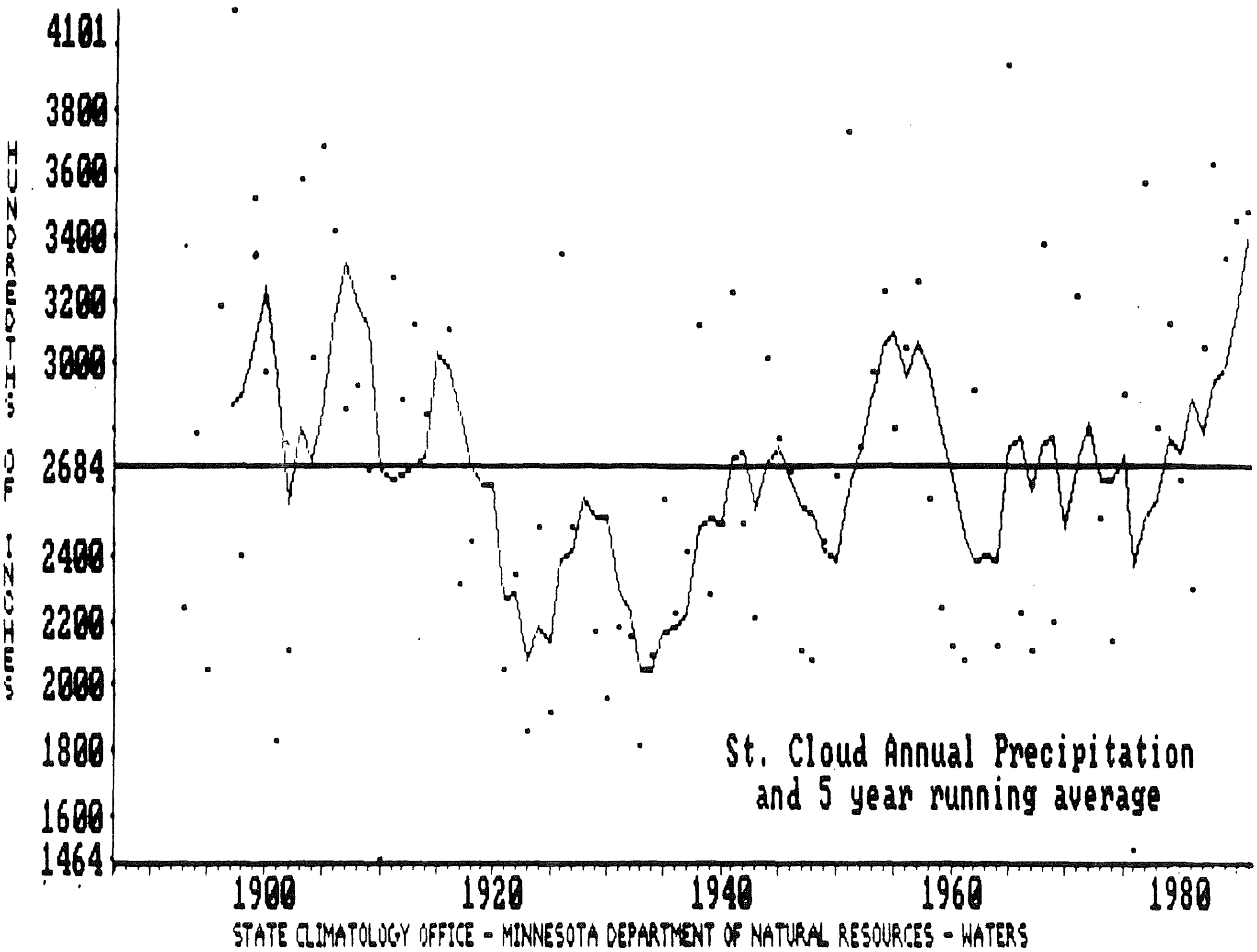
CHART 1
OSCAR LAKE - DOUGLAS CO.
WATER SURFACE ELEVATION
81.0
80.0
79.0
78.0
77.0
76.0
ELEV. (ADD 1300 FT. FOR NGVD OF 1929)
Jul-86
Aug-86
Sep-86
Nov-86
Dec-86
Jan-87
Mar-87
Apr-87
DATE

Table 1

WATER LEVEL HISTORY
OSCAR LAKE
DOUGLAS COUNTY

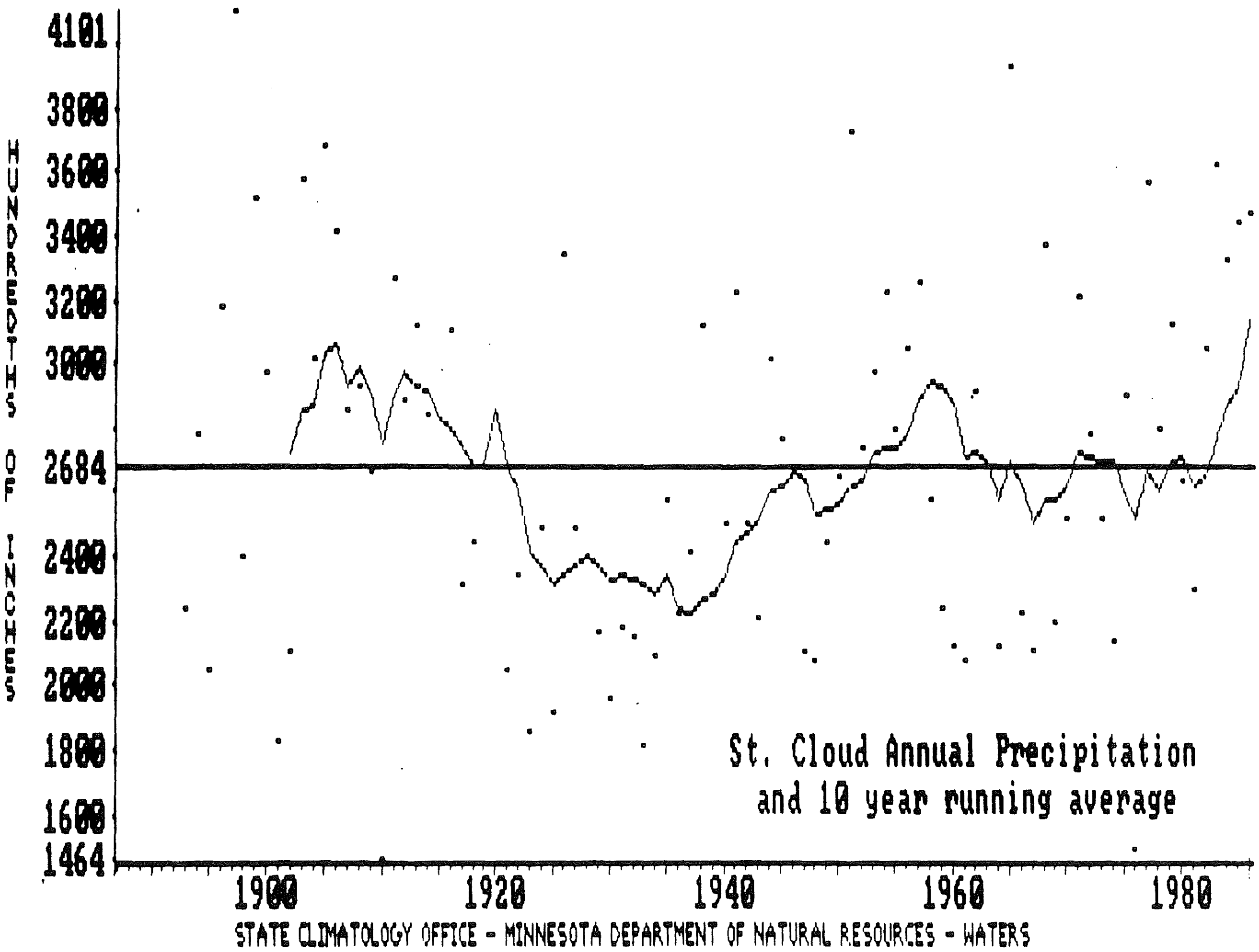
1866 (estimate from GLO Meander lines)	1380±
1880 (estimate from Geology of MN text) (30' depth)	1382±
9-20-38 (estimate from aerial photo)	1366±
6-10-51 (estimate from aerial photo)	1370±
8-6-58 (estimate from aerial photo)	1371±
7-2-64 (GAME AND FISH SURVEY MAP) (19' maximum depth)	1371±
8-10-65 (estimate from aerial photo)	1371±
JUNE 1966 (USGS FIELD WORK FOR QUADRANGLE)	1371.4
AUGUST 1966 (USGS FIELD WORK FOR QUADRANGLE)	1371.1
10-4-72 (estimate from aerial photo)	1373±
10-20-77 (DOW FIELD SURVEY)	1369.3
8-6-86 (DOW FIELD SURVEY)	1377.4
8-7-86 (DOW FIELD SURVEY after 4.75" RAIN)	1378.0
8-26-86 (DOW FIELD SURVEY)	1378.48
9-8-86 (DOW FIELD SURVEY)	1378.5
4-29-87 (DOUGLAS COUNTY SURVEY)	1379.45

PLATE 5



Note: Statistic's on the five and ten year running average were only available for the next closest weather station located at St. Cloud, MN.

PLATE 6



Note: Statistic's on the five and ten year running average were only available for the next closest weather station located at St. Cloud, MN.

AERIAL PHOTOGRAPHY

The U.S. Agriculture Stabilization and Conservation Service (ASCS) has taken aerial photography of the Oscar Lake area on 9-30-38, 6-10-51, 8-6-58, 8-10-65 and 10-4-72.

A significant feature of these photographs are the beaches evident in the 1938 photograph. These beach areas, which are still for the most part void of any significant sized vegetation, are evidence of receding water levels. Comparing the outline that delineates the edge of significant tree growth with contour lines on the 1966 USGS quadrangle shows this tree line to closely correspond to the 1380 contour. Based upon this comparison, lake levels must have been as high as elevation 1380'± within recent years (1 to 3 decades) of this photograph to have kept these beach areas free of vegetation. These beach areas are evident in all of the other photographs but as the photography becomes more recent, the beach areas become more and more obscured by the growth of vegetation.

Also of interest on these photographs is the variation in the lake's water level from photo to photo. In the 1938 photograph the level is so low that the main body of Oscar Lake is almost completely divided into two basins and "North Oscar" is almost completely dry having just one small area of open water. Many of the cultivated fields in the area between "North Oscar" and Oscar are presently under water.

Comparison of the open water outline on the photographs with the contour lines on the USGS quadrangle was used to estimate the water level shown on each photograph. Using this procedure, the 1938 level was approximately 5 feet lower than the 1371 level shown on the 1966 quadrangle or approximately elevation 1366'±. The outlines on the other photographs (1951, 1958, 1965 and 1972 as a group) are very similar to one another and are all estimated to be at approximately elevation 1371'±.

ORDINARY HIGH WATER LEVEL (OHW)

Field work at Oscar Lake includes surveys by the Division of Waters in 1977 and 1986. Primary data pertaining to the OHW[2] of Oscar Lake were collected during the surveys of August 6, 7 and 26, 1986. Additional information was gathered on October 16, 1986. Data collected during these surveys included pertinent elevations at indicator trees, exposed boulders, lake banks, washlines, beachlines, and other visible high water data. During the field investigation of the Oscar Lake basin, the most consistent landscape feature documented was the toe of an old bank at a line of washed and exposed boulders. The elevation at the toe of the bank range from 1382.7 to 1383.7. Washlines were recorded at elevation 1380.0' and 1381.0', and the toe of another bank at 1385.2'.

Due to infrequent surface outflow from Oscar Lake the elevations at which tree growths are located are more varied than would be the case of a lake basin with a larger watershed and continuous or at least more frequent surface outflows. Ground elevations at 39 trees and tree stumps (cottonwood, elm and oak), ranging in size from 1.0' to 3.4' diameter breast high (D.B.H.) were recorded to assist in determining the NOHW of Oscar Lake. The lowest hardwood tree recorded is a 2.0' elm stump, ground elevation at the base is 1380.7'. A ring count (annual increment of growth) was taken from the stump which revealed it to be approximately 80 years old. The main tree growth below this elevation consists of cottonwoods, birch, willow and some smaller elm and ash, including a conspicious fringe of dead trees in water. The oak trees recorded are growing above the toe of the old lake bank on relatively steep slopes. The lowest is a 1.0' oak at elevation 1383.2'. The most consistent line is a group of 7 trees ranging in size from 1.6' to 2.5' D.B.H., with a 1.3' spread in their ground elevations. A ring count of the 1.6' oak showed it to be approximately 100 years old. The oldest hardwood found was a 3.0' elm stump over 200 years old. The ground elevation at this stump is 1386.7'. Another 3.0' elm stump (approximately 104 years old) was recorded; ground elevation 1383.3'. A 3.4' cottonwood stump (approximately 140 years old) was recorded at a ground elevation of 1383.4'.

The best available evident points to an NOHW level between elevations 1382.7' and 1384.4'. The elevation of 1382.7' equates to the lower "toe of the lake bank" elevation referred to on the previous page. The line of oak trees referred to above indicates the higher level (1384.4'). Of the 39 trees recorded at Oscar Lake a total of 15 trees were used as being the best NOHW indicator trees. The trees growing in the lake basin below the toe of the lake bank (1382.7') were not used. In the same manner the trees growing at too high

[2] According to Minnesota Statutes Section 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.

an elevation were eliminated from consideration. An average of the remaining 15 trees growing near the lake basin and above the level of the toe of the lake bank were utilized to determine the NOHW level.

From the examination of the bed and banks of Oscar Lake and of the vegetation found on the shores and banks of the lake and from review and study of existing records, map files and historic data, the predominance of evidence normally supports an Ordinary High Water level for Oscar Lake at elevation 1383.1, NGVD 1929. However, a public hearing was held during October, 1986, and the Administrative Law Judge recommended the OHW to be elevation 1381.0'. The Commissioner of the Minnesota Department of Natural Resources found exceptions to the report but elected not to pursue the matter further. On May 13, 1987, he issued a Commissioners Order stating the OHW for Oscar Lake is 1381.0 feet above mean sea level, NGVD, 1929.

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 (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 vegetation provide little evidence as to the lakes 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. What we have seen so far is that Oscar Lake level fluctuations are closely related to how much or how little precipitation falls at the lake. Precipitation patterns have historically 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, or 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), to reflect current antecedent conditions, and a recently recorded known lake level. 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. It should be noted that this modeling does not produce a set of simulated historic levels but instead estimate potential future needs based on a fixed, recently observed level.

The in-house water budget computer model "WATBUD" computes net monthly inflow and outflow volumes and then 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 groundwater seepage rate may be an inflow or outflow and together with the rainfall-runoff coefficient are used as calibration parameters to provide a balanced water budget.

At Oscar Lake, due to lack of sufficient water level data, the WATBUD model calibration parameters from the Moon Lake study were used. The recently recorded initial lake level of 1379.0' was used with monthly time series precipitation data from the Alexandria precipitation record (1891 to 1986) to compute the specific one and five year period anticipated lake level series.

The modeling results indicate that there is a one-percent probability the lake level would rise above elevation 1380.2' on December 1, 1987 and a one-percent probability the lake will exceed elevation 1380.8' on December 31, 1991. These elevations are still below the run-out of the basin. Conversely, probabilities exist which state the likelihood the lake elevation may fall. There is a one-percent probability the lake may fall below elevation 1376.5' by December 1, 1987 and a one-percent probability the lake may fall below elevation 1372.4' on December 31, 1991. The modeling results also suggest a 50-percent probability (a 50/50 chance) that the lake will be at elevation 1378.4' on December 1, 1987 and 1376.9' in approximately 5-years.

The above-noted modeling concerned itself with longer periods of total precipitation and did not attempt to determine the impacts of major storm events which occur relatively quick and are not cyclical. 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 increase was also computed for the 24 hour and 10 day duration 100-year storm events. Assuming the same initial condition lake elevation of 1379.0', the 100-year 24 hour duration event of 5.6 inches of precipitation would result in a lake level increase of 1.0 foot to elevation 1380.0' and the 100-year 10 day runoff of 6.5 inches would result in a lake level increase of 1.7 feet to elevation 1380.7'.

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 Oscar Lake. These base data were collected in April of 1987, when the lake was at elevation 1379.45'. While the potential maximum elevation of Oscar Lake is unknown, it was felt surveying structures within an approximate 5-6' vertical elevation above elevation 1379.45' 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 7 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
N½, Sec. 24, Twp. 122, R. 29
Lot 2

Floor Elevation : 1383.37'
Ground Elevation: 1380.45'

Basement : Yes
Walkout : Yes

Assessed Market Value
Building Value : $25,300.00
Land : $15,200.00

Total Value : $40,500.00

STRUCTURE PHOTO PROVIDED

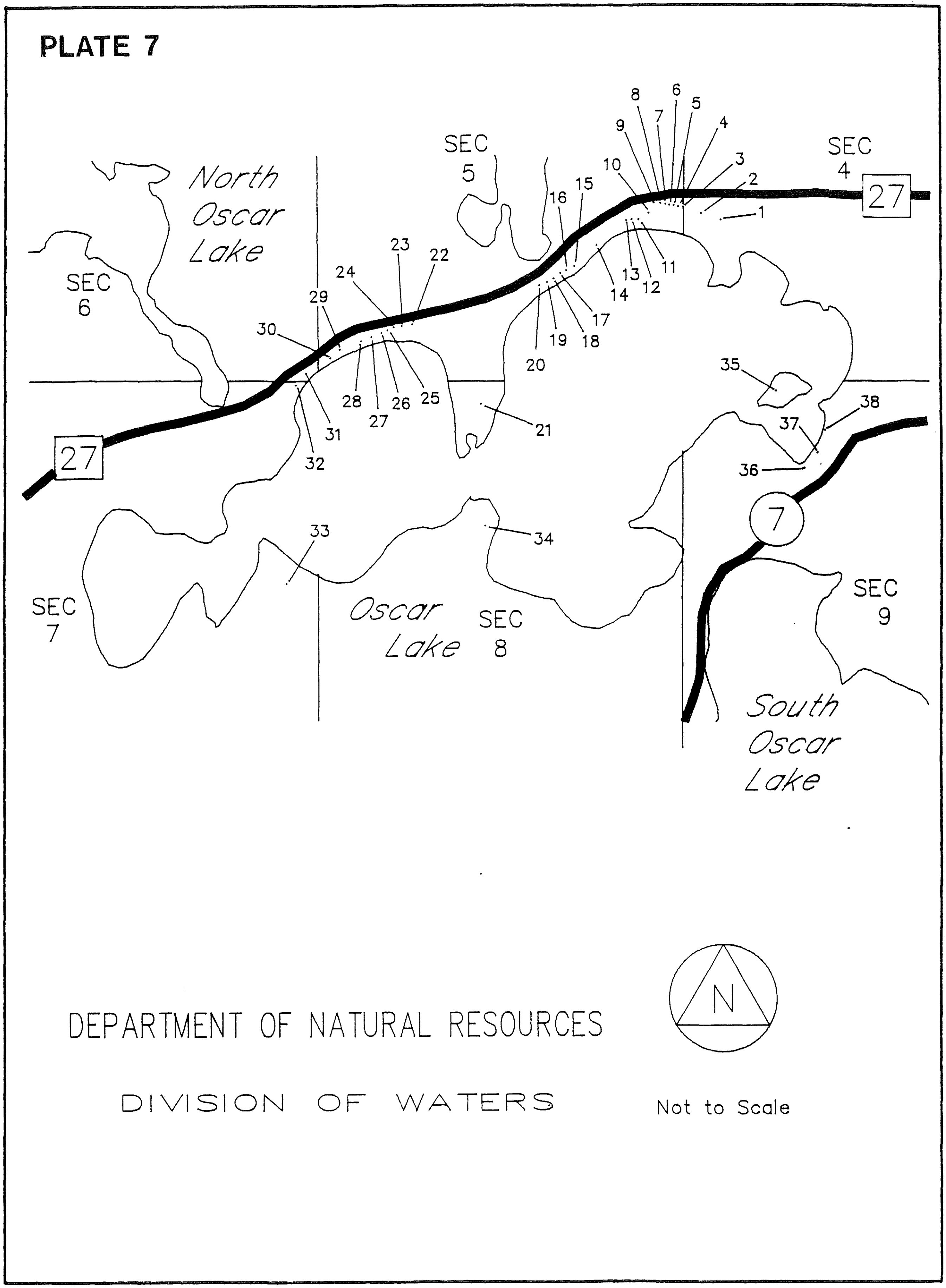


PLATE 7
North Oscar Lake
Oscar Lake
South Oscar Lake
SEC 4
SEC 5
SEC 6
SEC 7
SEC 8
SEC 9
27
27
7
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2
3
4
5
6
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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS
N
Not to Scale

Potential structural losses for Oscar Lake 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 1379.45' and 1388.45' would be $267,341.
>
> 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 1388.45', an estimated $267,339 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 (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 references should be given to the discussion on anticipated future lake levels on pages 18 and 19 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 (losses prevented). Table 2 was provided to show the estimated losses which could occur should the lake continue to rise.

Again, potential loss figures provided here were from generalized assumptions and the intent was to not provide exact projected damages for individual structures. Potential damages per individual structure would have to be determined after a site-specific investigation. Pages 31-35 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	Walkout Level	Ground Level at Base of Crawlspace or Basement[3]	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 1379.45 presently flooded[1]	12	$ 500	N/A	N/A	N/A				
	13	500	N/A	N/A	N/A				
	14	500	N/A	N/A	N/A				
	17	500	N/A	N/A	N/A				
	18	500	N/A	N/A	N/A				
	20	500	N/A	N/A	N/A				
	22	500	N/A	N/A	N/A				
	23	500	N/A	N/A	N/A				
	24	500	N/A	N/A	N/A				
	25	500	N/A	N/A	N/A				
	26	500	N/A	N/A	N/A				
	28	500	N/A	N/A	N/A				
	29	Omitted	N/A	N/A	N/A				
	30	500	N/A	N/A	N/A				
	37	500	N/A	N/A	N/A				
	38	500	N/A	N/A	N/A				
New damages between elevations 1379.46 and 1380.45	27	$ 4,763	1381.95	N/A	1379.95				
	31[5]	41,537	1386.45	1378.70	N/A				
	16[5]	38,017	1387.55	1379.25	N/A				
	15[5]	39,136	1387.35	1379.45	N/A				
	19	27,964	1386.65	1380.05	N/A	$188,285	$ 41,109	$188,285	$ 41,109
	10	500	N/A	N/A	N/A				
	11	11,031	1383.05	N/A	1380.05				
	1	3,328	1380.25	N/A	N/A				
	34[6]	22,509	1386.11	1378.61	N/A				
New damages between elevations 1380.46 and 1381.45	No new structures at this elevation	N/A	N/A	N/A	N/A	N/A	$ 96,611	$188,285	$137,720
New damages between elevations 1381.46 and 1382.45	2	$ 2,500	1384.36	N/A	1382.36	$ 2,500	$ 625	$190,785	$138.345
New damages between elevations 1382.46 and 1383.45	No new structures at this elevation	N/A	N/A	N/A	N/A	N/A	$ 8,273	$190,785	$146,618

	Structure Number as shown on Location Map	Market Value of Building[3]	First Floor Level	Walkout Level	Ground level at base of Crawlspace or Basement[3]	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 Damage[4]
New damages between elevations 1383.46 and 1384.45	32	$ 1,120	1383.85	N/A	N/A	$ 1,120	$ 2,995	$191,905	$149,613
New damages between elevations 1384.46 and 1385.45	36	$ 8,290	1385.18	N/A	N/A	$ 8,290	$ 8,290	$200,195	$157,903
New damages between elevations 1385.46 and 1386.45	33	$ 3,427	1385.61	N/A	N/A	$ 3,427	$ 19,438	$203,622	$177,341
New damages between elevation 1386.46 and 1387.45	4	$ 1,344	1386.84	N/A	N/A				
	3	7,997	1386.93	N/A	N/A				
	6	5,712	1387.10	N/A	N/A				
	5	9,996	1387.11	N/A	N/A	$ 36,009	$ 52,784	$239,631	$230,125
	35	4,720	1387.16	N/A	N/A				
	21	6,240	1387.45	N/A	N/A				
New damages between elevation 1387.46 and 1388.45	7	$ 5,712	1387.74	N/A	N/A				
	9	11,094	1388.30	N/A	N/A	$ 27,710	$ 37,214	$267,341	$267,339
	8	10,904	1388.37	N/A	N/A				

1 Oscar Lake's water surface elevation was 1379.45' in April of 1987, which was the time the structure elevation data were collected.
2 1987 assessed market value supplied by County Assessor.
3 Estimated crawlspace/block foundations to the nearest foot based on structure photos.
4 A) Estimated damage 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 to 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 there figures do not include any allowance for contents damage because of the uncertainty 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 These structures presently are protected by a dike in front. Based on the photos, flooding would occur with the next foot of water.
6 Walkout level is a tuck-under garage.

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 Oscar Lake can purchase flood insurance through Douglas County's eligibility in the National Flood Insurance Program (NFIP). Actually, all property owners and renters in the unincorporated areas of Douglas 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 Douglas County's Flood Hazard Boundary Map dated December 2, 1977 indicates a flood hazard delineation has not been provided for Oscar Lake. The significance of a lack of a flood hazard delineation will be discussed in greater detail below and on Pages 30-31 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;
- The 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.

Table 3 identifies the amount of flood insurance coverage available via the National Flood Insurance Program. Douglas County has been in the Emergency Program (or phase) of the NFIP since March 16, 1974. As Table 3 shows, $35,000 of coverage is available for a residential structure and $10,000 for its contents in the Emergency Program. Presently, under the Emergency Program, flood insurance premiums are standardized for the unincorporated areas of the County, and everyone would pay the same flood insurance premium regardless of risk.

Douglas County is presently in the process of converting to the Regular Program or phase of of the NFIP. The process involves FEMA's publishing a Flood Insurance Rate Map (FIRM) which will replace the current Flood Hazard Boundary Map. In addition, to qualify for the increase amounts of flood coverage available in the Regular Program the County will have to adopt the FIRM into its regulatory program and regulate the identified flood prone areas accordingly.

The County, State and FEMA have all tentatively agreed that the current Flood Hazard Boundary Map will be converted to a Flood Insurance Rate Map with no additions or modifications to the flood plain areas already identified. This being the case, the FIRM will not show a flood delineation for Oscar Lake because none is now shown on the Flood Hazard Boundary Map. Ideally, a FIRM will identify flood delineations with associated risk factors (e.g., 100-year floodplain, 500-year floodplain, etc.). This is extremely difficult on landlocked basins because of all the uncertainties of starting water level conditions, inter-relationships or surface and ground water flow and other factors. So the Oscar Lake area will likely not show a flood delineation on the FIRM but flood insurance will remain available to adjacent landowners at Zone "C" or the cheapest of all flood insurance premiums. It is anticipated that Douglas County will convert to the Regular Program on or about October 1, 1988.

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 of 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 Oscar 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 Oscar Lake.

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 18 and 19 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 Oscar Lake. If the lake should continue to rise, a dampening effect would occur as the lake reaches its runout elevation at elevation 1382.1'. If the cause is the lake reacting only to long-term, above normal precipitation, then the assumption would be as the lake rises 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 Oscar Lake 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 at a starting lake elevation of 1379.0' Oscar Lake would bounce 1.0' upward during a 100-year, 24 hour rainfall event and 1.7' upward to elevation 1380.7' for a 100-year, 10-day rainfall event. Landowners should refer to Appendix D which provides actual lowest floor elevations for adjacent shoreland development. It is the author's recommendation that, at a minimum, any landowner with a structure within 2 or 3 feet of the lake's current water level should purchase 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 Oscar Lake. 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 finishing materials on walls and floors and most contents. A basement was defined, though, as a space subgrade on all four sides. 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. Douglas 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 Hazard Boundary Map for Douglas County does not show a flood delineation (i.e., Zone A) for Oscar Lake. Additionally, Douglas County's existing floodplain ordinance was based upon a special flood delineation study in and immediately adjacent to the City of Alexandria and does not address the Oscar Lake area. This means that: 1) technically, Douglas County does not now have to apply the provisions of its flood plain ordinance to new development bordering Oscar Lake; 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 on Oscar Lake.

The obvious question is what prudent course of action should Douglas County take when regulating new development adjacent to Oscar Lake? Douglas 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 a 100-year flood level, all new structures and additions/modification/substantial repairs of existing construction must be elevated with the lowest floor (including basement) to 3' above the Ordinary High Water level. The highest <u>recorded</u> water level is at 1379.45', and it must be noted that the <u>ordinary</u> high water elevation (OHW) has been established at 1381.0'. The ordinary high water level represents a water level that has been maintained in the (historic) past for a sufficient period of time to leave evidence upon the landscape. Therefore, by definition the highest known water level in this particular case must at least be equal to the OHW which has been set at 1381.0'. The regulatory elevation for Oscar Lake is then 1381.0' + 3" = 1384.0", NGVD 1929. In addition, physical evidence indicates that surface water level has been at approximately elevation 1384.0' which further justifies this elevation as the flood protection elevation.

- 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 elevation 1384.0'; and

- 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 above elevation 1384.0'.

The basic issues as to whether a flood delineation should be added to the County's Flood Insurance Rate Map (FIRM) when it is published 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 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 Oscar Lake?

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 will adequately regulate new development on Oscar Lake with the adoption of one additional provision requiring an elevated road access for new development. Strictly using the 100-year, 10-day rainfall event with a starting water elevation of or near the OHW of 1381.0' would cause the lake level to rise only to elevation 1382.7'. Evidence shows the lake was at or near 1384.0' in the past and the Department feels this is by far the most prudent long-term regulatory elevation to use.

Adding a flood delineation on the County's FIRM would primarily act then 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 1382.45'. The Department of Natural Resources strongly encourages a local flood protection level for Oscar Lake of 1384.0' at a minimum.

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 8 and 9 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 emergency protection measures.

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 elevation 1382.45' (or to a higher elevation if the County wishes to adopt one).

The reader is requested to pay special attention to the discussion of levees and filling around structures on Plates 8 and 9 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

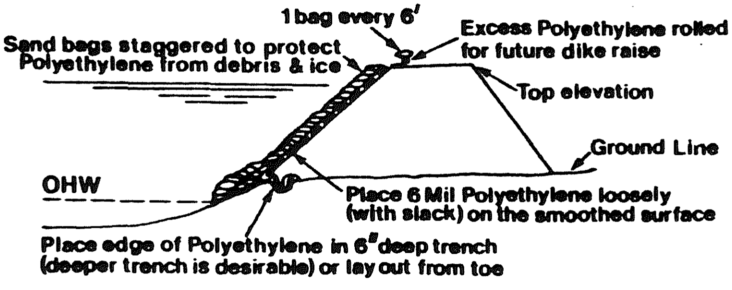
PLATE 8
FLOOD PROTECTION MEASURES

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

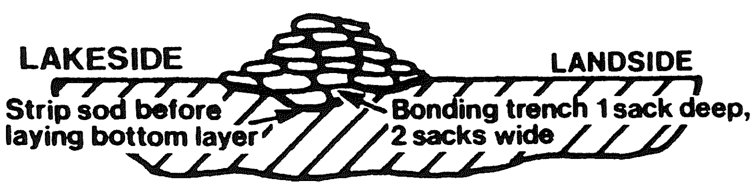
- Interior Drainage: Pumping will always be required for removal of seepage and rainfall behind the levee. The amount of pumping depends on the foundation soils, the levee material and the drainage area behind the levee.

- 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.

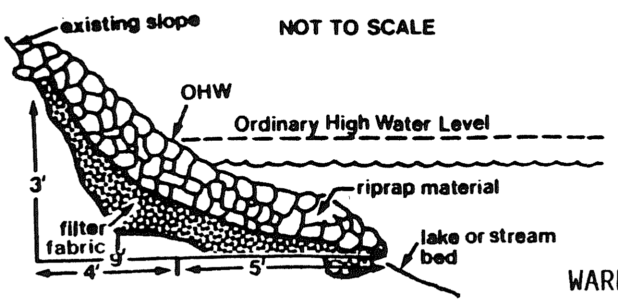
- Site Preparation: Remove topsoil and vegetation. Dig a bonding trench to key in the levee to the foundation.
- Construction Materials and Placement: Sand or predominantly sandy or gravelly material should be used. Woven plastic sandbags are preferred if the levee is long term, as burlap bags will deteriorate 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.

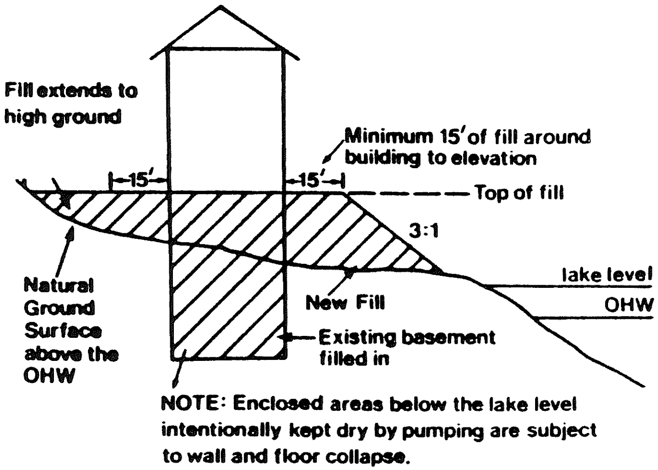
PLATE 9

FLOOD PROTECTION MEASURES

TYPE OF PROTECTION

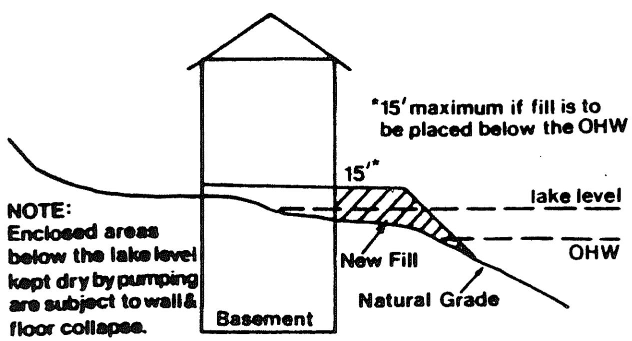
GENERAL DESIGN CONSIDERATIONS

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.

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.

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 Oscar Lake. 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. Oscar Lake has been identified as a public water (Basin 257) in the Protected Waters Inventory for Douglas County and, thus, falls under the jurisdiction of Minnesota Statutes Section 105.42.

A common response to rising lake levels is to: 1) artificially control the 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 elevation 1381.0', the Ordinary High Water Elevation (OHW) for Oscar Lake (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 <u>below the OHW</u> to protect a structure; or

- Placement of any shoreline protection measure which <u>does not</u> 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.
  (Minnesota Statutes Sections 105.41 and/or 105.42).

A DNR permit would be required: 1) to lower the lake below 1381.0'; or 2) to control the lake at an elevation above 1381.0', when:

1) Water is <u>pumped</u> 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 is 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 Oscar Lake should contact the DNR area hydrologist in Fergus Falls at: DNR-Division of Waters, 1221 Fir Avenue East, Fergus Falls, MN 56537, Phone: (218) 739-7576.

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 Oscar Lake. 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 of and have used to alleviate flooding problems in Minnesota. Some of these funding sources have been used more successfully than others, while potential funding sources (i.e. programs) are still under consideration at the state and federal level.

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. It must be noted that all federal assistance will be premised upon an acceptable <u>local sponsor</u> and <u>non-federal</u> 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

Until the 1987 Legislative Session, there were no ongoing statewide financial assistance programs designed specifically to alleviate flooding problems. Prior to 1987, the state had acted with emergency funds with cost-sharing projects to respond to high water problems. An example 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).

During the 1987 Leigslative Session, the Department of Natural Resources sponsored a bill to cost-share local flood loss reduction programs. As proposed and passed, the State Flood Loss Reduction Act can cost-share up to a 50/50 match with a local government sponsor to implement flood loss mitigation measures (both structural and non-structural). The primary benefit is that increased state funding levels are now available for advance mitigation measures on a priority basis. The legislation would consider funding projects which alleviate lake flooding problems. Applications will be available from the respective DNR area hydrologists on or about November 15, 1987. Technical guidance will be available to assist in formulating and evaluating damage reduction strategies.

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 too 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. Section 1362 applications become more competitive as 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 West 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 of Natural Resource'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 Douglas 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

Watershed Districts

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 Soil and Water 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 or 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 Soil and Water Resources
90 West Plato Blvd.
St. Paul, MN 55107
Phone: (612) 296-2840

APPENDIX A

SOIL TYPES AND CHARACTERISTICS

OSCAR
LITTLE LAKE OSCAR
LITTLE LAKE OSCAR
Kron
Lakes
Lewis
Lake
BLACKWEL
water
water

SOIL SURVEY FOR OSCAR LAKE - DOUGLAS COUNTY

MAP SYMBOL	SOIL CLASSIFICATION	% SLOPE
BaB2	Barnes loam, eroded	2-6
Cc	Cathro muck	
DaA	Darnen loam	1-4
Fa	Flom silty clay loam	
FmC2	Forman clay loam, eroded	6-12
FoB	Forman-Aastad clay loams	1-5
GoA	Gonvick loam	1-3
La	Lake beaches, sandy	
Lb	Lake beaches, loamy	
LeF	Langhei loam	18-40
LgD2	Langhei-Barnes loams, eroded	12-18
LkD2	Langhei-Waukon loams, eroded	12-18
LkE	Langhei-Waukon loams	18-24
Mh	Marsh	
Qu	Quam mucky silty clay loam	
SIB	Sinai clay	2-6
SvA	Sverdrup loam, thick solum	0-3
Up	Urness mucky silt loam, peaty subsoil variant	0-3
VaA	Vallers clay loam	0-3
WaB	Waukon loam	2-6
WaB2	Waukon loam, eroded	2-6
WaC	Waukon loam	6-12
WaC2	Waukon loam, eroded	6-12
WaD	Waukon loam	12-18
WaE	Waukon loam	18-24
WcB	Waukon clay loam	2-6
WcC2	Waukon clay loam, eroded	6-12
WIB2	Waukon-Langhei loams, eroded	2-6
WIC2	Waukon-Langhei loams, eroded	6-12
WsC2	Waukon-Langhei-Sioux complex, eroded	6-12

SOIL SURVEY FOR OSCAR LAKE - DOUGLAS COUNTY

Barnes loam, 2 to 6 percent slopes, eroded (BaB2).

This is an undulating soil that occurs on side slopes. The areas vary in size and shape. This soil has complex slopes that are 50 to 200 feet long and are concave and convex. In a few areas the slopes are more uniform than is normal. This soil has the profile described as representative for the series. The present surface layer consists of the original surface layer mixed with moderate amounts of material from the subsoil as a result of erosion.

Included in mapping were small areas of somewhat excessively drained Langhei soils and moderately well drained Aastad and Darnen soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, areas of gravelly soils, spots where stones are on the surface, and a few areas that have a surface layer of sandy loam. Other inclusions were areas of Barnes soils that are adjacent to areas of Sinai soils and that have a surface layer of silty clay loam. In addition, areas of Barnes soils that are slightly eroded were included.

Nearly all of this soil is used for cultivated crops. A few small areas are in pasture. This soils is suited to all crops commonly grown in the county. Water runs off this soil at a medium rate, and the hazard of erosion is moderate.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Cathro muck (Cc).

This soil is nearly level. It occupies depressions, potholes, and drainageways. The areas vary in size and shape. All soils areas are flooded in spring, and most areas are flooded or wet throughout the year.

Included in mapping were small areas of the Seeleyville soils and Cathro muck, sandy subsoil variant. Also included were small areas that are calcareous and a few areas where the organic material is less decomposed than typical.

Most areas of this soil are undrained and are covered with marsh vegetation that consists of sedges, rushes, reeds, and in some areas, willows. These areas are well suited to wildlife habitat. They provide some food and cover for furbearers and upland game. If drained, this soil is used for hay or pasture, and a few areas are cropped. If adequately drained, this soil is suited to all crops commonly grown in the county, but small grains often lodge and corn and soybeans may not reach maturity. Soil blowing is a hazard on bare fields.

Darnen loam, 1 to 4 percent slopes (DaA).

This soil occurs as long, narrow strips along the base of the stronger slopes. In places it is delta-shaped at the mouth of waterways in the morainic upland areas.

Included in mapping were small areas of Barnes, Aastad, and Flom soils. In some places the black surface layer is thicker than normal, and in others it is silt loam. Most areas of this soil are in permanent pasture, because this soil is associated with more strongly sloping soils. Most of the areas are small and are farmed along with the adjacent soils. This soil is suited to all the crops commonly grown in the county.

The main management need is control of erosion in the larger areas.

Flom silty clay loam (0 to 3 percent slopes) (Fa).

This soil is in shallow, circular or oblong depressions and in swales and drainageways on the till plains and in morainic upland areas. It is wet after spring runoff or after rain in summer.

Included in mapping were small areas of Vallers, Darnen, and Aastad soils. Also included were areas where the surface layer is thicker than normal and some areas where the surface layer is limy.

This soil is not suited to cultivation unless drained. If adequately drained, it is suited to all the crops commonly grown in the county. Open ditches provide adequate drainage in most years, but a tile system is needed for complete drainage.

The main management needs are drainage and maintenance of fertility and tilth.

Forman clay loam, 6 to 12 percent slopes, eroded (FmC2).

This soil is sloping and rolling. The slopes are fairly uniform and 100 to 300 feet long. This soil occurs along waterways and drainageways and around sloughs. It is moderately eroded, and tillage has mixed material from the subsoil with the original surface layer. As a result, the surface layer is less friable. This soil has the profile described as representative for the series.

Included in mapping were small areas of Flom and Quam soils and of lighter colored soils that are calcareous. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are slightly eroded.

Nearly all of this soil is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. It is sticky when wet. Water runs off this soil at a medium to rapid rate, and the hazard of erosion is moderately severe.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Forman-Aastad clay loams, 1 to 5 percent slopes (FoB).

The soils of this complex occur on the till plains and morainic uplands. The areas vary in size and shape. Forman soils make up about 40 to 80 percent of the area, and Aastad soils, 20 to 60 percent. Forman soils occur on the rises, but Aastad soils have smooth, nearly level slopes. The Forman and Aastad soils in this unit occur in a pattern too complex to separate.

Included in mapping were small areas of poorly drained Flom soils and calcareous Vallers soils.

The soils in this unit are used for cultivated crops and pasture. They are suited to all crops commonly grown in the county.

The main management needs are practices that improve fertility and tilth.

Gonvick loam, 1 to 3 percent slopes (GoA).

This soil is nearly level. It is on the till plains and morainic uplands. The areas vary in size and shape. This soil occurs in close association with Waukon, Flom, and Quam soils. It is on slightly convey positions downslope from Waukon soils or upslope from Flom and Quam soils.

Included in mapping were small areas of well-drained Waukon, poorly drained Flom, and very poorly drained Quam soils. Also included were small calcareous areas and areas that are more strongly sloping. Other inclusions were areas where the surface layer is lighter colored and areas where the surface layer and subsoil are finer textured.

This soil is well suited to crops and there are few limitations to its use. Most areas are used for crops, but a few are used for woodland or pasture. All crops common in the county can be grown.

The main management need is maintenance of fertility and tilth.

Lake beaches, sandy (La).

This land type occurs as rims along the edge of present or former lakes. The surface texture includes sand, sandy loam, and loamy sand. Most of these areas are nearly level and have a water table near the surface. They generally have a vegetative cover that consists of grass and willows and other trees. In some areas this soil has slopes of 3 to 6 percent. These areas are droughty and were formed as the ice expanded and pushed the beach material into ridges and as the lake level lowered. On most lakes these areas are being used for homes, cabins, and campsites.

Drainage is poor in the level to nearly level areas and excessive in the sloping areas. The fertility and available water capacity are low. Some of these areas that are on small lakes or that were former lakes are farmed or are used for pasture.

Lake beaches, loamy (Lb).

This land type is along the edge of present lakes and the borders of former lakes. The soil material lacks distinct layers. The surface texture is generally loam but in places sandy loam. The soil generally is deep, black loam or sandy loam.

Most areas are nearly level, but because of gradual lowering of the level of the lakes during the time when the material was deposited there are some areas where the slopes are as much as 3 to 5 percent.

This soil is poorly drained in the level areas to well drained in the sloping areas. The natural fertility is moderate, and the available water capacity is medium.

This land generally is too wet to be cropped. Most of this soil is used for pasture, wildlife habitat, or woodland. The higher lying areas are used for cabins and campsites.

Langhei loam, 18 to 40 percent slopes (LeF).

This soil is adjacent to streams, waterways, sloughs, or lakes on the till plains and in morainic upland areas. Waterways dissect the area and make the cross slopes irregular. Slope ranges from 100 to 300 feet in length. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Barnes, Darnen, and Flom soils. Also included were small areas of less sloping soils and areas of gravelly soils. Also included were areas that are moderately eroded.

Most of this soil is under grass vegetation. A few areas are cultivated. The soil is well suited to grassland. Water runs off very rapidly.

The main management needs are practices that control erosion and conserve moisture.

Langhei-Barnes loams, 12 to 18 percent slopes, eroded (LgD2).

These soils are hilly. The areas vary in size and shape and have complex topography. Slopes are 75 to 250 feet long. Langhei soils make up 60 to 80 percent of the area, and Barnes soils, 20 to 40 percent. The Langhei soil has the profile described as representative for the series. The Barnes soil, in most places has a profile that differs from the one described as representative for the Barnes series in being thinner. Barnes soils are on the more uniform parts of the slope, and Langhei soils are on the exposed knobs, ridges, and knolls. The soils in this unit have been moderately eroded, and the surface layer is a mixture of the original surface layer and moderate amounts of material from the subsoil. This mixing gives the surface layer of the Barnes soils a dark brownish color and the Langhei soils a grayish color when dry. The Barnes and Langhei soils in this unit occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of the moderately well drained Aastad and Darnen soils and the poorly drained Flom and Vallers soils. Also included were small areas of soils that are more strongly sloping, small areas that are less sloping, areas of gravelly soils, areas of severely eroded soils, and areas that are stony on the surface. Also included were some areas that are only slightly eroded.

These soils are used for cultivated crops and pasture and are suited to all crops commonly grown in the county. The Langhei soils are less suited to crops than the Barnes soils because of the nutrient imbalance caused by the high content of lime. Surface runoff is rapid, and the hazard of erosion is severe.

The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Langhei-Waukon loams, 12 to 28 percent slopes, eroded (LkD2).

The soils of this complex are hilly. The areas are interspersed with many draws, potholes, drainageways, and lakes. The areas vary in size and shape and have complex topography. Slopes are 75 to 250 feet long. Langhei soils make up 50 to 70 percent of the area, and Waukon soils, 30 to 50 percent. Langhei soils are dark grayish brown in color when moist and are light gray in color when dry. They occur on the knobs, knolls, and ridges. Waukon soils occur on the less exposed parts of the slope. The Langhei and Waukon soils in this unit occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of the moderately well drained Gonvick soils and the poorly drained Flom and Vallers soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, areas of scattered stones and areas that are slightly eroded.

These soils are used for cultivated crops, pasture, and woodland. They are suited to all crops commonly grown in the county. Water runs off at a rapid rate, and the hazard of erosion is severe.

The main management needs are practices that control erosion, improve fertility and tilth; and conserve moisture.

Langhei-Waukon loams, 18 to 24 percent slopes (LkE).

The soils in this complex are generally adjacent to streams, waterways, sloughs, or lakes. Waterways dissect the area, making the cross slope very irregular. Langhei soils make up 60 to 80 percent of the area, and Waukon soils, 20 to 40 percent. The Langhei soils are dark grayish brown in color when moist and light gray when dry. They occur on the knobs, knolls, and ridges. The Waukon soils occur on the less exposed parts of the slope. The Langhei and Waukon soils of this mapping unit occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small ares of the moderately well drained Gonvick soils and poorly drained Flom soils.

These soils are generally used for pasture or woodland, but a few areas are cultivated. They should be kept in permanent vegetation. The hazard of erosion is very severe.

Marsh

Marsh (0 to 1 percent slopes) (Mh) is a land type that occurs in shallow ponds and sloughs and in depressions that contain water throughout most of the year. Some of these areas go dry late in summer or during periods of drought, but most areas are wet all year. The vegetation consists of cattails, rushes, sedges, and other water-tolerant plants. The soil in these areas consists of mineral material, calcareous mucky lake sediments, or organic soil material.

Marsh is excellent for wildlife habitat. It provides nesting, mating, and escape areas for waterfowl, furbearers, and upland game. Most of these areas can be improved for wildlife production by controlling the water level, by increasing nesting and courting areas for ducks, and by fencing out livestock.

Many of these areas are impracticable to drain because of nearby streams or lakes.

Quam mucky silty clay loam (0 to 2 percent slopes) (Qu).

This soil occupies circular or oblong depressions and potholes that are variable in size. All soils areas are flooded in spring, and most areas are flooded throughout the entire year.

Included in mapping were small areas of Vallers, Urness, and Cathro soils, areas where the soil does not have a mucky surface layer, and areas where the black soil material is more than 48 inches thick. A few areas that are calcareous throughout the profile are shown on the map by spot symbols.

If undrained, this soil is covered with marsh vegetation that consists of sedges, reeds, rushes, or willows. The undrained areas are well suited as wildlife habitat. They provide food, cover, and nesting for waterfowl, furbearers, and upland game. Many of these areas can be improved for wildlife habitat by exposing or creating additional areas of open water. If drained, this soil is used for crops, pasture, and hay, depending on the kind of drainage system installed. If adequately drained, this soil is suited to all crops commonly grown in the county. Small grains tend to lodge, and corn and soybeans may not reach maturity every year. This soil may be drained by open ditches or tile. The main management needs are drainage and maintenance of fertility and tilth.

Sinai clay, 2 to 6 percent slopes (SIB).

This soil is gently sloping and undulating. It has slopes that are fairly uniform and 100 to 350 feet long. It lies in areas that break away from nearly level Sinai soils and in sloping areas that break away from Fulda or Dovray soils. This soil has the profile described as representative for the series.

Included in mapping were small areas of Dovray and Fulda soils and soils that are lighter colored and are calcareous to the surface. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are moderately eroded.

Nearly all the acreage is used for cultivated crops. A few areas are in pasture. This soil is suited to all crops commonly grown in the county. This soil is sticky when wet and hard when dry. Water runs off at a moderate rate. The hazard of erosion is moderate. The main management needs are practices that control erosion and improve fertility and tilth.

Sverdrup loam, thick solum, 0 to 3 percent slopes (SvA).

This soil is on outwash plains. The areas are variable in size and shape, and a few areas are quite large. The profile differs from the one described as representative for the series in being 22 to 36 inches deep to sand.

Included in mapping were small areas of well drained Sverdrup soils, moderately well drained Clontarf soils, and poorly drained Dassel soils. Also included were small areas of more strongly sloping soils.

Nearly all the acreage is used for cultivated crops. A few small areas are in pasture. Drought is a hazard during prolonged dry periods. Soil blowing is also a hazard on bare fields during winter and spring. This soil is suited to irrigation, and field crops and vegetables can be irrigated. The main management needs are practices that control erosion, improve fertility, and conserve moisture.

Urness mucky silty clay loam (0 to 2 percent slopes) (Up).

This soil is in shallow lake basins and potholes. Included in mapping were small areas of Vallers and Quam soils along the edges of the soil areas.

This soil is flooded in spring and often throughout the entire year. The undrained areas are well suited as wildlife habitat. They provide nesting, mating, and escape cover for waterfowl, furbearers, and upland game. If drained, this soil is used for crops, pasture, and hay. Open ditches or tile are used for drainage. If adequately drained, it is suited to all crops commonly grown in the county. Small grains tend to lodge, and corn and soybeans often do not reach maturity. This soil is well suited to silage corn. The main management needs are maintaining the drainage system, controlling soil blowing, and maintaining fertility.

Vallers clay loam, 0 to 3 percent slopes (VaA).

This soil occurs around the edges of depressions and in drainageways on the till plains and morainic uplands. The areas are variable in size and shape.

Included in mapping were small areas of Flom and Quam soils, a few areas in which the profile contains gravel bands, and areas of more strongly sloping soils. Also included were areas where the soil profile has less mottling and a few areas of soil that lacks a distinct horizon of lime accumulation.

If this soil is adequately drained, it is suited to all crops commonly grown in the county. Drainage can be improved with open ditches or tile. The nutrient imbalance can be improved by proper fertilization. The main management needs are practices that improve the drainage and improve tilth and fertility.

Waukon loam, 2 to 6 percent slopes (WaB).

This undulating soil occurs on the till plains and morainic uplands. The areas vary in size and shape. The slopes are irregular and complex and 80 to 200 feet long. This soil has the profile described as representative for the series.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also, included were small areas of more strongly sloping soils, small areas of less sloping soils, and eroded areas.

This soil is used for cultivated crops, woodland, and pasture. This soil is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon loam, 2 to 6 percent slopes, eroded (WaB2).

This soil is undulating and moderately eroded. The areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow. Tillage and the removal of trees have mixed material from the subsoil with the original surface layer. As a result, the surface layer is browner and less friable and contains less organic matter.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of less sloping soils, of more strongly sloping soils, and of gravel.

This soil is used for crops, and a few small areas are in pasture. This soil is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon loam, 6 to 12 percent slopes (WaC).

This rolling soil occurs on the till plains and morainic uplands. Areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, and gravelly areas.

This soil is used for cultivated crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility, and tilth, and conserve moisture.

Waukon loam, 6 to 12 percent slopes, eroded (WaC2).

This rolling soil occurs in areas that vary in size and shape. Slopes are irregular and complex and are 80 to 200 feet long. This soil is moderately eroded. Its profile differs from the one described as representative for the series in being thinner. Tillage and the removal of trees have mixed material from the subsoil with the original surface layer. As a result, the present surface layer is browner and less friable and contains less organic matter.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas where there are surface stones.

This soil is used for crops, and a few areas are in pasture. It is suited to all crops commonly grown in the county. Water runs off at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon loam, 12 to 18 percent slopes (WaD).

This soil is hilly. It occurs on the till plains and morainic uplands. The areas vary in size and shape. Slopes are irregular and complex and 80 to 250 feet long. This soil occurs along drainageways and around sloughs. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Langhei, Gonvick, Flom, and Quam soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, eroded areas, and areas where there are surface stones.

This soil is used for cultivated crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off at a rapid rate. The hazard of erosion is severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon loam, 18 to 24 percent slopes (WaE).

This soil occurs along draws and waterways and around sloughs or lakes on morainic uplands. The areas vary in size and shape. Slopes are irregular, commonly cut up by draws, and 100 to 250 feet long. The profile differs from the one described as representative for the series in being thinner.

Included in mapping were small areas of Langhei, Gonvick, and Darnen soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded areas, and areas where there are surface stones.

This soil is used for woodland and pasture. A few areas are used for crops. Water runs off very rapidly. The hazard of erosion is very severe. The main management needs are practices that control erosion and conserve moisture.

Waukon clay loam, 2 to 6 percent slopes (WcB).

This soil is undulating. It occurs on the morainic uplands. The areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in having a clay loam surface layer and subsoil.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, and moderately eroded areas.

This soil is used for crops, woodland, and pasture. It is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon clay loam, 6 to 12 percent slopes, eroded (WcC2).

This soil is rolling. It occurs on the morainic uplands. The areas vary in size and shape. Slopes are irregular and complex and 80 to 200 feet long. The profile differs from the one described as representative for the series in having a clay loam surface layer and subsoil.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, and moderately eroded areas of Waukon soil.

This soil is used for crops, woodland, and pasture. This soil is suited to all crops commonly grown in the county. Water runs off at a medium rate. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon-Langhei loams, 2 to 6 percent slopes, eroded (WlB2).

The soils in this complex are undulating. The areas vary in size and shape. Slopes are complex, may be concave or convex, and are 50 to 200 feet long. Waukon soil makes up 70 to 80 percent of each area and is on the more uniform parts of the side slopes. Langhei soil makes up 20 to 30 percent of each area and is on the more exposed knobs, knolls, and ridges. The surface layer of the Langhei soil is lighter colored than that of the Waukon soil. These soils occur in such an intricate pattern that it is not practical to map them separately. They are moderately eroded, and the present surface layer is a mixture of the original surface layer and moderate amounts of material from the subsoil.

Included in mapping were small areas of Gonvick, Flom, and Vallers soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, some gravelly areas, and areas where there are surface stones. Also included were some areas that are only slightly eroded.

This complex is used for cultivated crops, pasture, and woodland. It is suited to all crops commonly grown in the county. The Langhei soil is less well suited to crops than the Waukon soil because of a nutrient imbalance caused by their high content of lime. Surface runoff is medium. The hazard of erosion is moderate. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon-Langhei loams, 6 to 12 percent slopes, eroded (WlC2).

The soils in this complex are rolling. The areas vary in size and shape. Slopes are complex, may be concave or convex, and are 50 to 200 feet long. Waukon soil makes up 50 to 70 percent of each area and is on the more uniform parts of the side slopes. Langhei soil makes up 30 to 50 percent of each area and is on the more exposed knobs, knolls, and ridges. The Langhei soil has a lither colored surface layer than the Waukon soil. The soils in this complex are moderately eroded, and the present surface layer is a mixture of the original surface layer with moderate amounts of material from the subsoil. These soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of Gonvick, Darnen, Flom, and Vallers soils. Also included were small areas of more strongly sloping soils, small areas of less sloping soils, gravelly areas, and areas where there are surface stones. Also included were areas that are only slightly eroded.

These soils are used for cultivated crops, pasture, and woodland. They are suited to all crops commonly grown in the county. The Langhei soil is less well suited to crops than the Waukon soil because of a nutrient imbalance caused by the high content of lime. Surface runoff is medium to rapid. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

Waukon-Langhei-Sioux complex, 6 to 12 percent slopes, eroded (WsC2).

The soils in this complex are rolling. The areas vary in size and shape. Slopes are irregular and complex and 75 to 250 feet long. Waukon loam makes up 40 to 60 percent of each area; Langhei loam, 30 to 40 percent; and Sioux loamy coarse sand, 20 to 30 percent. The Sioux soil makes up the gravelly areas, the Langhei soil makes up the light-gray areas on the exposed knobs and knolls, and the Waukon soil makes up the dark-gray to black areas on the smooth parts of the side slopes. The soils in this complex are moderately eroded, and the present surface layer is a mixture of the original surface layer with moderate amounts of material from the subsoil. These soils occur in such an intricate pattern that it is not practical to map them separately.

Included in mapping were small areas of Gonvick, Flom, and Quam soils. Also included were areas that are only slightly eroded and areas where there are many surface stones. Also included were small areas of less sloping soils and small areas of more strongly sloping soils.

These soils are used for crops, woodland, and pasture. They are suited to all crops commonly grown in the county. The Sioux soil is less well suited to crops than the Waukon soil because of drought and lower fertility and the Langhei soil is less well suited because of lower fertility. Water runs off at a medium to rapid rate. The hazard of erosion is moderately severe. The main management needs are practices that control erosion, improve fertility and tilth, and conserve moisture.

For more detailed information, see the Soil Conservation Service Soil Survey of Douglas County, Minnesota dated January, 1975.

APPENDIX B

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

PIC DATA

PHYSICAL CHARACTERISTICS FOR LAKE: OSCAR

Lake Type: Marginal Lake
Dominant Forest/Soil Type: DECID/SAND
Size of Lake: 1,018 Acres
Shorelength: 7.3 Miles
Maximum Depth: 19.0
Median Depth: 7.0

Secchi Disk Reading (water clarity): 3.0 feet
Lake Contour Map Number: C1589 (available at cost from Documents Division)
(Phone: 612-297-3000)

DEVELOPMENT CHARACTERISTICS FOR LAKE: OSCAR

Shoreland Zoning Classification: Recreational Development
Public Accesses in 1983: 0

Development	Seasonal Homes	Permanent Homes	Total Homes
1967	17	22	39
1982	41	23	64

DNR SECTION OF FISHERIES INFORMATION FOR LAKE OSCAR

Water Chemistry   Survey Date: 7/14/78

Water Color: Greenish-Brown
Cause of Water Color: Agricultural Runoff
Secchi Disk: 5.0
% Littoral: 80

Lake Description

Surface Water Area: 630
Management Class: WALLEYE-CENTRARCHID
Ecological Type: CENTRARCHID

Accessibility: State owned access in 0.5 on North end of lake.

Area Fisheries Supervisor: Francis Ask
Route 3
Glenwood, MN 56334
(612) 634-4573

NET CATCH DATA

GILL NETS   No. of Sets: 8   Gill Net Survey Date: 7/14/78

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
White Sucker	5	0.5	8.50	0.44
Carp	9	1.1	36.50	4.56
Black Bullhead	11	1.4	5.75	0.72
Brown Bullhead	5	0.6	2.50	0.31
Yellow Bullhead	15	1.9	12.75	1.59
Northern Pike	17	2.1	49.00	6.13
Yellow Perch	27	3.4	1.88	0.24
Walleye	30	3.8	90.00	11.25
Largemouth Bass	1	0.1	0.25	0.03
Pumpkinseed Sunfish	4	0.5	0.50	0.06
Bluegill Sunfish	2	0.3	0.25	0.03
Black Crappie	111	13.9	16.00	2.00

TRAP NETS   No. of Sets: 11   Trap Survey Date: 7/14/78

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
White Sucker	5	0.5	8.50	0.77
Carp	17	1.5	69.25	6.30
Black Bullhead	4	0.4	2.00	0.18
Brown Bullhead	4	0.4	1.75	0.16
Yellow Bullhead	49	4.5	46.75	4.25
Northern Pike	3	0.3	9.50	0.86
Yellow Perch	2	0.2	0.25	0.02
Walleye	3	0.3	9.75	0.89
Largemouth Bass	2	0.2	4.75	0.43
Pumpkinseed Sunfish	16	1.5	1.80	0.16
Bluegill Sunfish	125	11.4	19.38	1.76
Black Crappie	71	6.5	15.25	1.39

FISH STOCKING DATA

Year	Species	Size	# Released
1970	Northern Pike	ADULT	180
1970	Northern Pike	FINGERLING	27.750
1970	Walleye	FRY	200,000
1971	Northern Pike	ADULT	75
1971	Northern Pike	FINGERLING	42,000
1971	Largemouth Bass	FINGERLING	5,625
1972	Northern Pike	ADULT	79
1972	Walleye	FRY	300,000
1972	Northern Pike	FINGERLING	58,560
1972	Largemouth Bass	FINGERLING	4,592
1973	Northern Pike	FINGERLING	19,590
1973	Walleye	FRY	920,000
1973	Walleye	FINGERLING	5,040
1974	Northern Pike	FINGERLING	10,320
1974	Walleye	FINGERLING	16,370

FISH STOCKING DATA (CONT'D)

Year	Species	Size	# Released
1975	Northern Pike	FINGERLING	23,400
1975	Walleye	FRY	240,000
1976	Walleye	FRY	920,000
1976	Northern Pike	FINGERLING	5,050
1977	Walleye	FRY	920,000
1978	Walleye	FRY	920,000
1978	Walleye	FINGERLING	45,240
1978	Northern Pike	FINGERLING	750
1979	Northern Pike	ADULT	510
1979	Northern Pike	YEARLING	2,346
1979	Walleye	FINGERLING	13,730
1979	Walleye	YEARLING	100
1979	Northern Pike	FINGERLING	75,520
1980	Walleye	FINGERLING	13,470
1982	Walleye	FINGERLING	14,592
1982	Walleye	YEARLING	60
1984	Walleye	FINGERLING	28,615
1985	Muskellunge	FINGERLING	250

PERMIT DATA FOR LAKE OSCAR

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

Permit Types	Number Issued	Number Denied
Public (Protected) Waters Permits		
Pipeline	1	0
Sand blanket	2	0
Excavation	1	0
Shore protection	1	0
General Appropriation Permits		
Temporary projects	1	0

APPENDIX C

CLIMATOLOGICAL DATA

Alexandria, MN Monthly Precipitation

####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
112	1886	m	m	m	m	m	m	m	m	3.29	1.25	0.95	0.70	m
112	1887	m	m	m	m	m	m	m	m	1.10	1.07	0.56	1.19	m
112	1888	0.72	0.37	0.60	1.78	3.86	2.26	9.08	1.85	3.23	1.03	0.35	0.10	25.23
112	1889	0.93	0.56	1.26	1.97	1.79	1.64	2.66	2.04	2.36	0.14	0.43	1.20	16.98
112	1891	0.22	1.10	1.11	1.27	2.90	3.39	3.45	3.70	2.47	0.78	0.57	1.16	22.12
112	1892	0.18	0.79	0.96	2.01	4.76	2.46	3.76	5.39	0.24	0.10	0.58	0.42	21.65
112	1893	1.38	1.40	2.10	4.20	3.44	3.29	2.77	5.64	2.20	0.67	0.52	0.78	28.39
112	1894	0.45	0.01	2.18	4.58	2.25	3.75	0.60	1.59	1.16	2.52	0.36	0.10	19.55
112	1895	1.13	0.62	0.00	2.47	1.80	4.98	2.14	2.09	1.98	0.06	0.84	0.08	18.19
112	1896	0.66	0.69	2.01	9.23	5.15	2.77	1.84	1.08	3.04	3.01	1.75	0.55	31.78
112	1897	2.15	1.39	1.51	1.57	0.59	5.50	8.19	2.12	3.73	1.36	0.73	0.13	28.97
112	1898	0.10	0.91	1.59	0.81	3.21	4.51	4.01	2.03	1.94	3.25	0.41	0.09	22.86
112	1899	1.16	0.39	0.52	1.17	5.60	5.71	2.32	9.86	0.91	2.29	0.73	0.40	31.06
112	1900	0.29	0.21	0.54	0.28	0.18	0.49	1.87	16.52	2.96	2.39	0.63	0.51	26.87
112	1901	0.19	0.17	1.01	1.97	0.85	4.56	2.44	1.37	2.43	1.16	0.08	0.21	16.44
112	1902	0.16	0.11	0.46	1.38	5.79	3.07	3.32	3.07	0.43	0.81	0.32	1.36	20.28
112	1903	0.13	0.46	1.85	2.94	2.75	0.90	7.18	2.70	3.39	2.86	0.03	0.40	25.59
112	1904	0.40	0.60	1.70	1.80	3.33	3.60	2.78	1.77	2.97	3.24	0.00	0.49	22.68
112	1905	0.63	0.21	0.90	2.75	5.12	7.02	5.72	1.91	2.82	2.71	2.93	0.00	32.72
112	1906	1.16	0.24	0.61	2.16	4.32	5.52	2.76	5.15	3.18	2.69	1.29	0.99	30.07
112	1907	0.93	0.52	0.92	0.47	2.27	3.08	2.68	2.57	1.95	1.23	0.28	0.32	17.22
112	1908	0.17	0.50	1.67	1.38	7.25	6.98	0.92	3.48	2.47	1.37	1.44	0.78	28.41
112	1909	1.44	1.21	0.10	0.83	4.49	2.72	1.13	1.38	2.64	1.30	1.23	1.03	19.50
112	1910	0.47	0.90	0.07	3.03	1.07	1.65	3.78	3.08	1.98	1.47	0.38	0.48	18.36
112	1911	0.60	0.36	0.36	1.78	2.54	3.08	4.21	5.81	3.86	3.63	0.96	0.67	27.85
112	1912	0.56	0.15	0.26	2.47	7.20	1.20	5.38	4.33	2.06	0.00	0.17	0.30	24.08
112	1913	0.68	0.16	0.42	1.71	4.59	2.46	5.98	5.31	1.66	1.64	1.17	0.07	25.85
112	1914	0.78	0.51	0.88	1.95	1.87	9.35	3.55	2.45	4.56	2.97	0.20	0.36	29.43
112	1915	0.54	1.04	0.48	1.01	3.85	6.77	7.09	1.32	3.31	3.85	1.45	0.96	31.67
112	1916	1.42	0.44	3.04	1.49	4.39	6.09	3.37	6.71	3.88	0.85	0.04	1.16	32.88
112	1917	1.20	0.82	1.42	3.11	0.54	1.36	4.06	1.92	2.00	0.93	0.10	0.68	18.14
112	1918	0.68	0.03	0.62	1.93	3.60	1.20	2.80	1.20	0.30	1.63	1.74	1.38	17.11
112	1919	0.25	2.74	1.15	2.46	2.78	3.98	3.54	2.09	0.80	0.75	2.00	0.09	22.63
112	1920	0.75	0.00	2.11	1.49	5.53	8.07	2.33	1.39	3.49	1.01	0.00	0.80	26.97
112	1921	0.40	0.44	0.81	1.70	2.86	3.02	5.91	1.41	6.45	0.91	0.26	0.00	24.17
112	1922	0.32	1.02	0.91	1.28	3.74	2.23	0.57	0.60	1.55	0.00	5.41	0.15	17.78
112	1923	0.42	0.14	0.05	1.16	2.38	5.32	1.47	1.45	1.32	0.00	0.35	0.20	14.26
112	1924	0.00	0.08	0.99	1.92	1.00	5.06	1.82	4.35	4.22	2.20	0.00	0.10	21.74
112	1925	0.00	0.01	0.82	2.10	1.28	7.75	3.67	1.99	1.85	0.36	1.08	0.12	21.03
112	1926	0.08	0.93	0.57	0.00	1.69	1.51	3.51	5.26	2.48	1.64	0.24	0.17	18.08
112	1927	0.56	0.20	0.86	1.43	1.92	3.90	2.87	2.13	2.91	1.58	0.97	2.45	21.78

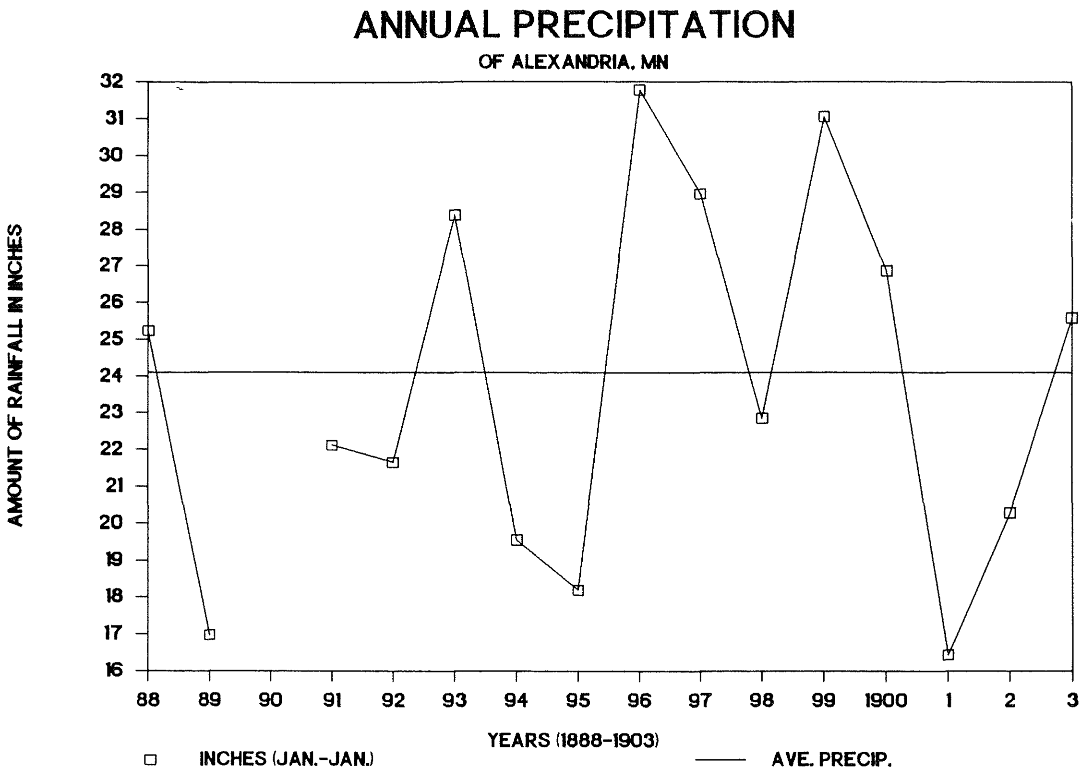
####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
112	1928	0.22	0.00	0.00	0.77	0.14	2.16	6.50	4.37	1.82	2.16	0.62	0.89	19.65
112	1929	0.19	0.50	1.38	2.32	1.81	0.85	2.78	3.10	3.95	2.02	0.38	0.11	19.39
112	1930	0.42	0.21	0.60	1.38	6.85	1.66	2.80	2.30	0.92	0.66	3.79	0.02	21.61
112	1931	0.00	0.35	0.59	1.29	1.83	5.23	2.21	2.71	1.21	2.12	1.78	0.00	19.32
112	1932	0.42	0.04	0.08	1.36	2.00	1.54	2.53	2.69	0.63	1.64	0.33	0.02	13.28
112	1933	0.14	0.06	0.38	1.66	4.77	2.67	2.62	3.09	0.81	0.60e	0.16	0.25	17.21
112	1934	0.06	0.00	0.16	0.59	0.63	4.81	1.41	1.43	2.78	2.51	0.21	0.42	15.01
112	1935	0.51	0.19	0.98	3.26	2.21	3.98	4.51	5.07	0.46	0.18	0.16	0.15	21.66
112	1936	0.07	0.97	0.20	1.12	1.93	0.62	1.01	1.90	2.01	0.05	0.30	0.28	10.46
112	1937	0.97	0.71	0.30	4.94	4.43	2.28	3.42	3.18	0.61	0.69	0.14	0.06	21.73
112	1938	0.07	0.06	0.94	1.97	6.62	1.93	2.12	2.46	3.00	0.27	0.94	0.20	20.58
112	1939	1.11	0.34	0.12	1.55	2.90	6.28	2.24	2.53	0.68	1.73	0.00	0.12	19.60
112	1940	m	m	m	m	1.93	2.25	1.84	m	m	3.28	1.86	0.52	m
112	1941	0.91	0.39	0.56	5.22	3.48	6.41	1.32	7.36	4.34	2.50	0.02	0.19	32.70
112	1942	0.05	0.16	1.69	1.95	5.41	4.83	1.01	4.98	3.42	0.94	0.15	0.76	25.35
112	1943	0.68	1.29	1.59	0.94	3.12	7.27	2.40	3.22	0.60	1.83	1.01	0.03	23.98
112	1944	0.45	0.25	0.86	2.06	5.11	3.44	4.23	1.37	2.26	0.25	1.22	0.10	21.60
112	1945	0.39	1.08	1.48	1.78	3.33	1.77	8.12	2.63	2.90	0.36	0.96	0.72	25.52
112	1946	0.12	1.49	0.85	1.28	2.16	5.20	3.67	1.70	2.24	3.89	0.85	0.84	24.29
112	1947	0.14	0.16	0.99	4.51	2.69	3.67	1.70	2.35	1.62	1.64	2.77	0.09	22.33
112	1948	0.41	1.42	0.79	3.29	0.73	5.17	3.34	3.34	2.18	1.06	0.78	0.21	22.72
112	1949	1.74	0.32	0.55	0.54	1.94	5.30	5.12	2.14	1.23	2.94	0.96	0.93	23.71
112	1950	1.24	0.12	1.83	2.21	4.60	2.69	3.04	0.94	3.88	1.59	0.77	0.76	23.67
112	1951	0.56	0.69	2.74	2.30	2.88	6.22	2.79	2.87	1.36	2.90	1.67	2.01	28.99
112	1952	1.27	1.21	1.41	0.53	1.89	4.10	3.88	4.74	0.49	0.06	0.76	0.29	20.63
112	1953	0.40	0.80	0.94	3.42	2.05	5.34	1.01	5.77	0.54	0.71	0.91	1.09	22.98
112	1954	0.84	1.12	1.47	3.38	2.84	2.94	4.23	5.89	3.78	1.03	0.14	0.04	27.70
112	1955	0.38	1.40	0.41	1.80	1.47	2.08	3.29	3.47	1.38	0.46	0.63	1.37	18.14
112	1956	1.17	0.34	0.94	2.75	3.03	3.46	3.22	5.81	0.62	1.34	3.03	0.57	26.28
112	1957	0.15	0.55	1.59	1.73	4.28	7.48	4.56	8.23	3.17	1.49	0.93	0.59	34.75
112	1958	0.62	0.23	0.29	2.73	1.59	2.64	2.01	3.58	2.09	0.65	2.79	0.17	19.39
112	1959	0.10	0.31	0.16	0.65	7.23	2.57	1.98	3.05	2.21	1.54	0.41	0.89	21.10
112	1960	0.41	0.08	0.59	2.49	2.08	4.42	2.40	6.33	1.51	1.20	0.92	0.71	23.14
112	1961	0.07	0.05	0.29	2.05	2.24	2.46	3.90	2.60	3.31	1.01	0.65	0.79	19.42
112	1962	0.63	1.16	0.78	1.02	6.71	2.06	9.68	2.05	3.81	0.43	0.35	0.17	28.85
112	1963	0.40	0.32	1.26	2.16	3.01	4.03	2.65	2.13	2.55	1.25	0.58	0.96	21.30
112	1964	0.29	0.05	1.16	2.56	0.58	3.77	0.95	7.53	3.51	0.19	0.55	0.48	21.62
112	1965	0.47	0.55	2.62	2.93	5.66	2.76	5.47	2.14	5.43	1.19	1.41	0.74	31.37
112	1966	0.62	1.06	1.42	1.99	1.41	3.40	2.01	4.76	0.43	3.00	0.88	0.56	21.54
112	1967	2.06	0.82	0.21	3.30	0.88	6.67	1.01	1.91	0.89	1.10	0.11	1.16	20.12
112	1968	0.59	0.14	0.71	4.86	2.48	3.17	2.05	2.57	1.89	4.12	0.41	2.58	25.57
112	1969	2.54	0.60	0.37	2.92	3.38	1.74	3.14	0.18	2.68	3.73	0.69	1.16	23.13
112	1970	0.34	0.31	1.20	4.82	1.84	3.35	1.23	0.36	0.85	4.74	3.18	0.36	22.58

####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
112	1971	1.10	2.17	0.57	1.16	3.02	5.49	4.78	3.73	3.10	7.77	1.98	0.56	35.43
112	1972	1.20	0.72	2.15	2.35	5.89	2.88	7.95	2.51	0.43	1.78	1.22	1.65	30.73
112	1973	0.20	0.44	1.31	1.19	2.92	1.67	2.87	4.22	1.68	1.86	1.62	0.69	20.67
112	1974	0.10	0.88	1.42	1.68	3.20	3.49	2.01	2.64	2.23	2.62	0.72	0.29	21.28
112	1975	4.16	0.76	2.13	2.46	2.24	7.98	1.05	4.59	2.37	1.20	2.31	0.10	31.35
112	1976	1.01	0.66	1.51	0.96	0.27	3.74	1.66	0.46	0.64	0.02	0.17	0.29	11.39
112	1977	0.73	1.04	3.03	2.55	4.77	2.87	3.41	3.79	4.60	2.82	4.06	1.69	35.36
112	1978	0.14	0.29	0.48	1.75	3.32	7.37	1.38	0.92	4.99	0.10	0.38	0.54	21.66
112	1979	1.06	1.57	1.69	1.05	1.64	7.01	2.22	4.13	1.42	5.00	0.50	0.06	27.35
112	1980	1.44	0.44	1.02	0.00	2.88	4.97	2.52	5.05	4.06	1.29	0.04	0.24	23.95
112	1981	0.51	0.92	0.38	3.44	3.39	7.36	4.12	3.99	0.75	3.41	0.77	0.74	29.78
112	1982	2.22	0.30	2.46	2.82	2.85	3.01	4.54	2.51	2.44	2.98	2.10	2.64	30.87
112	1983	1.02	0.15	2.52	0.58	1.11	4.94	3.50	5.63	2.23	1.72	2.95	0.63	26.98
112	1984	0.87	0.82	2.52	2.87	2.57	6.79	2.28	4.61	2.06	8.19	0.04	0.63	32.73
112	1985	0.84	0.24	2.11	2.08	4.58	3.19	3.29	3.15	5.40	1.04	2.42	1.35	29.69
112	1986	0.99	1.09	1.03	6.51	3.56	7.94	4.98	7.28	4.38	0.20	1.96	0.11	40.03

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

All data was 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 at (612) 296-4214.


ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
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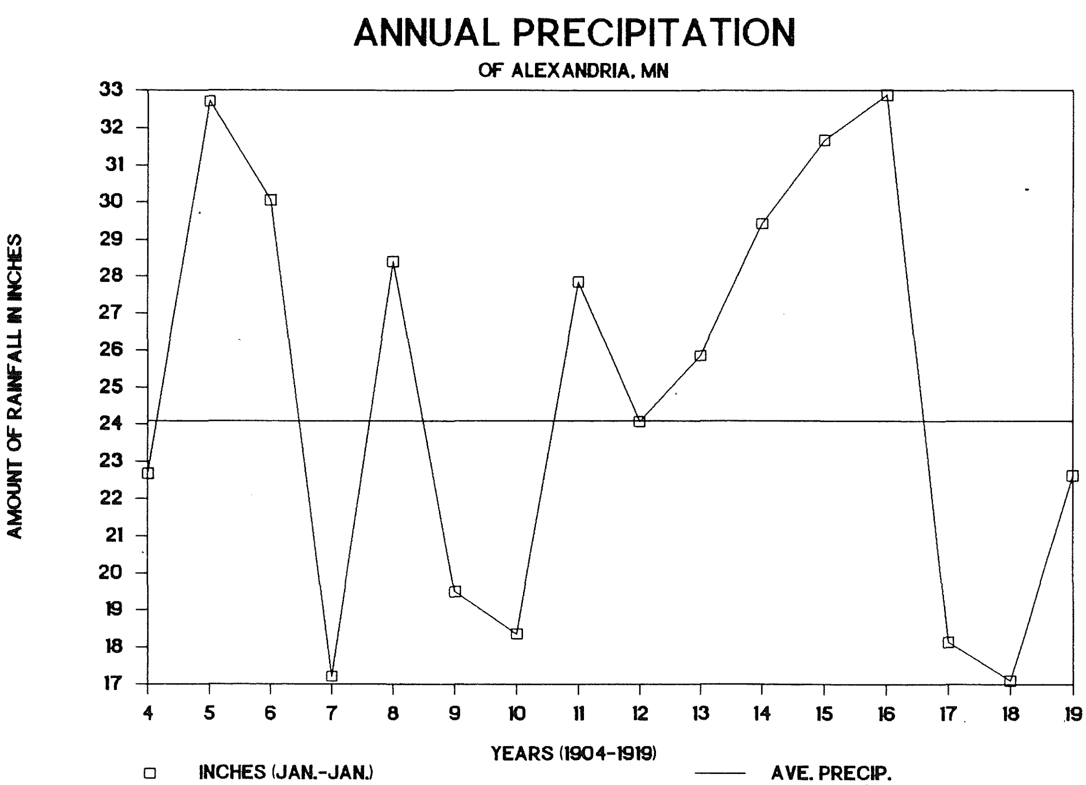
YEARS (1888-1903)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
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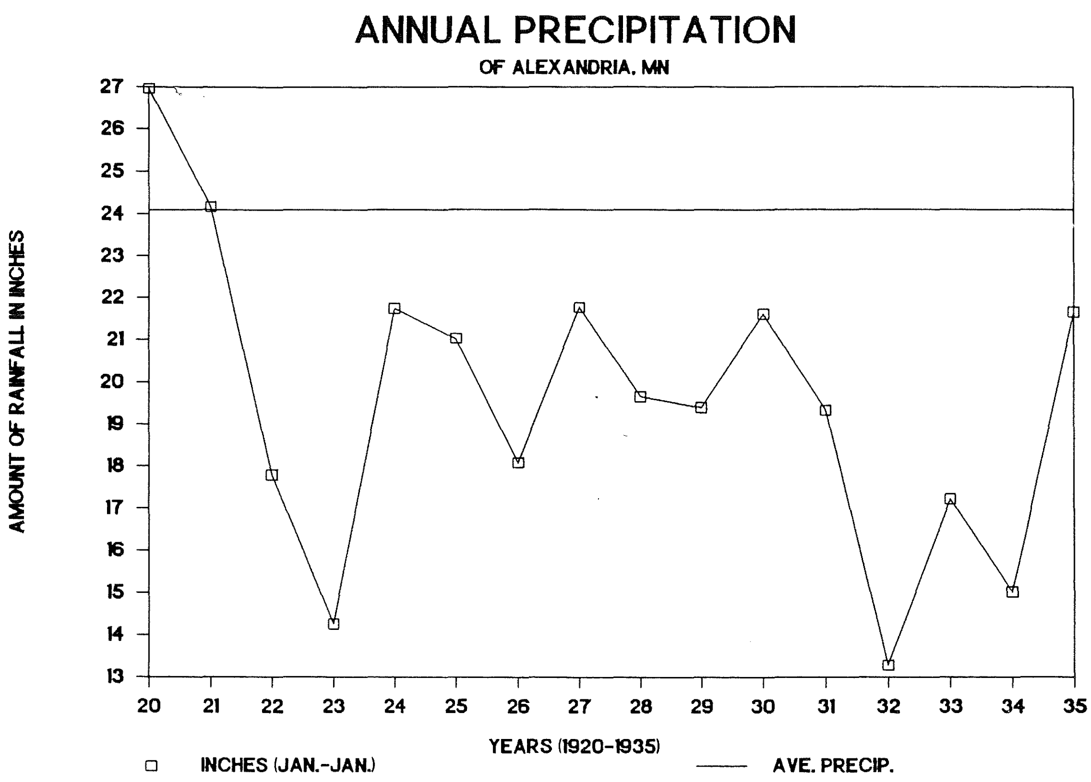
YEARS (1904-1919)
INCHES (JAN.-JAN.)
AVE. PRECIP.



ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
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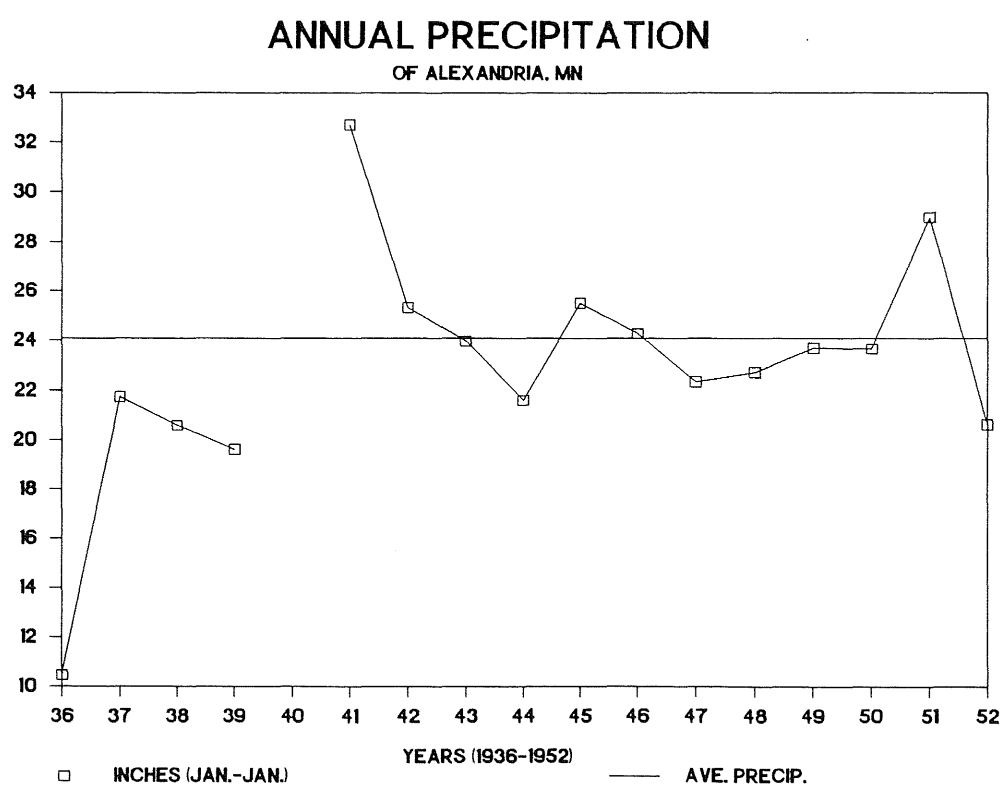
YEARS (1920-1935)
INCHES (JAN.-JAN.)
AVE. PRECIP.



ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
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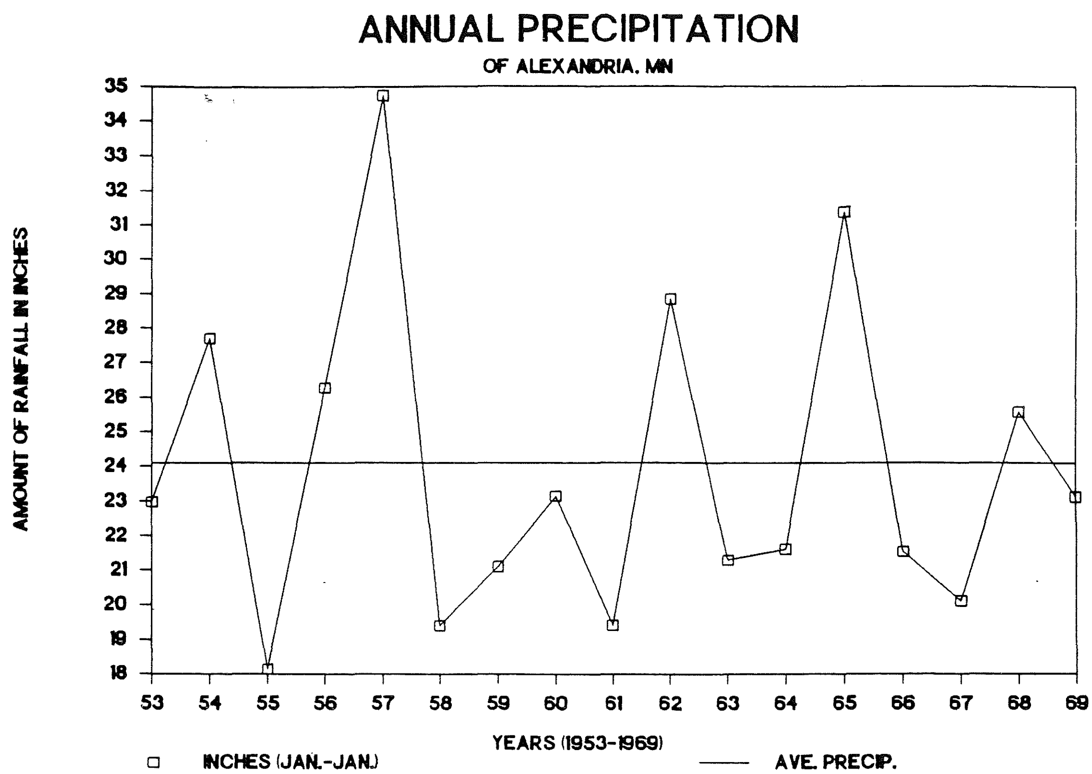
YEARS (1936-1952)
INCHES (JAN.-JAN.)
AVE. PRECIP.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OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
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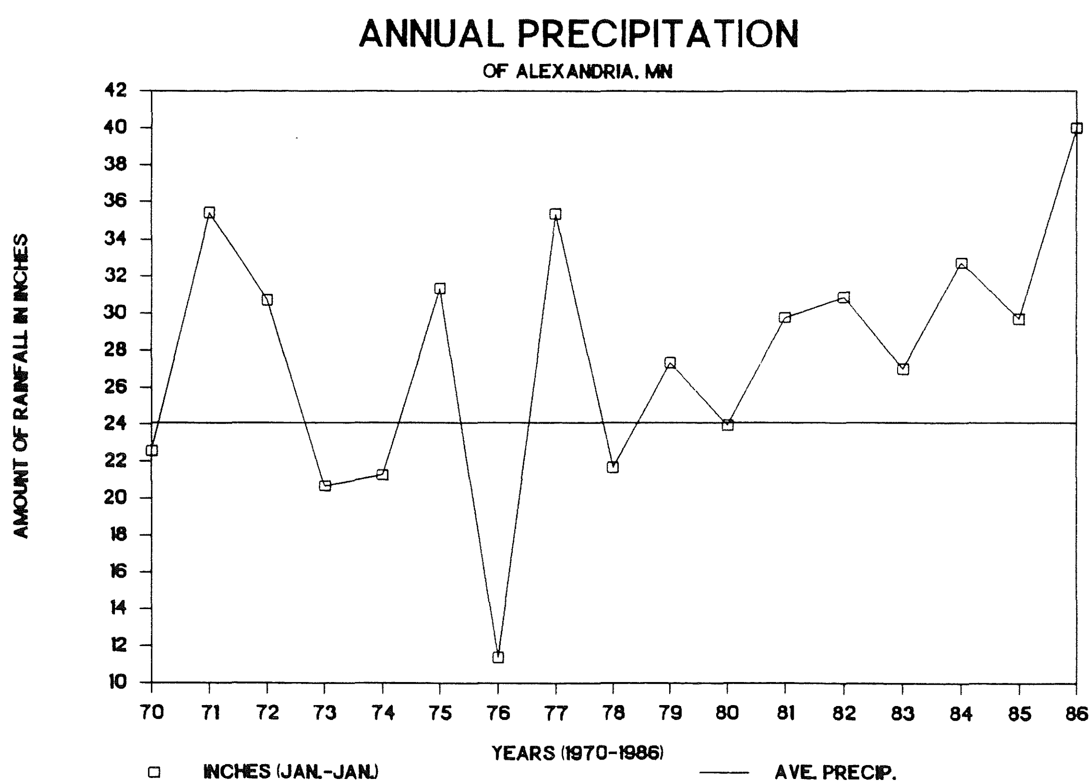
YEARS (1953-1969)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
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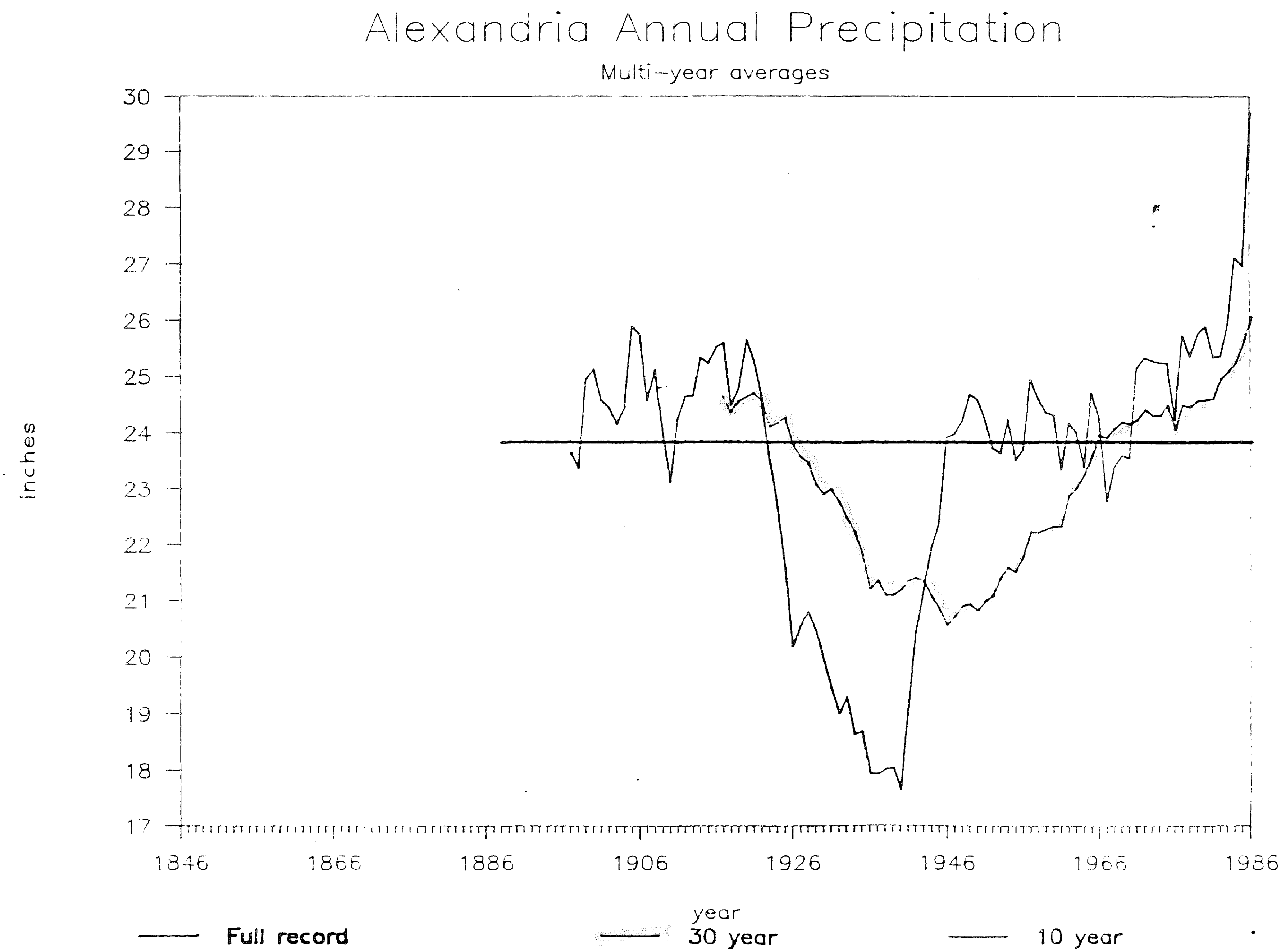
YEARS (1970-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.



Alexandria Annual Precipitation
Multi-year averages
inches
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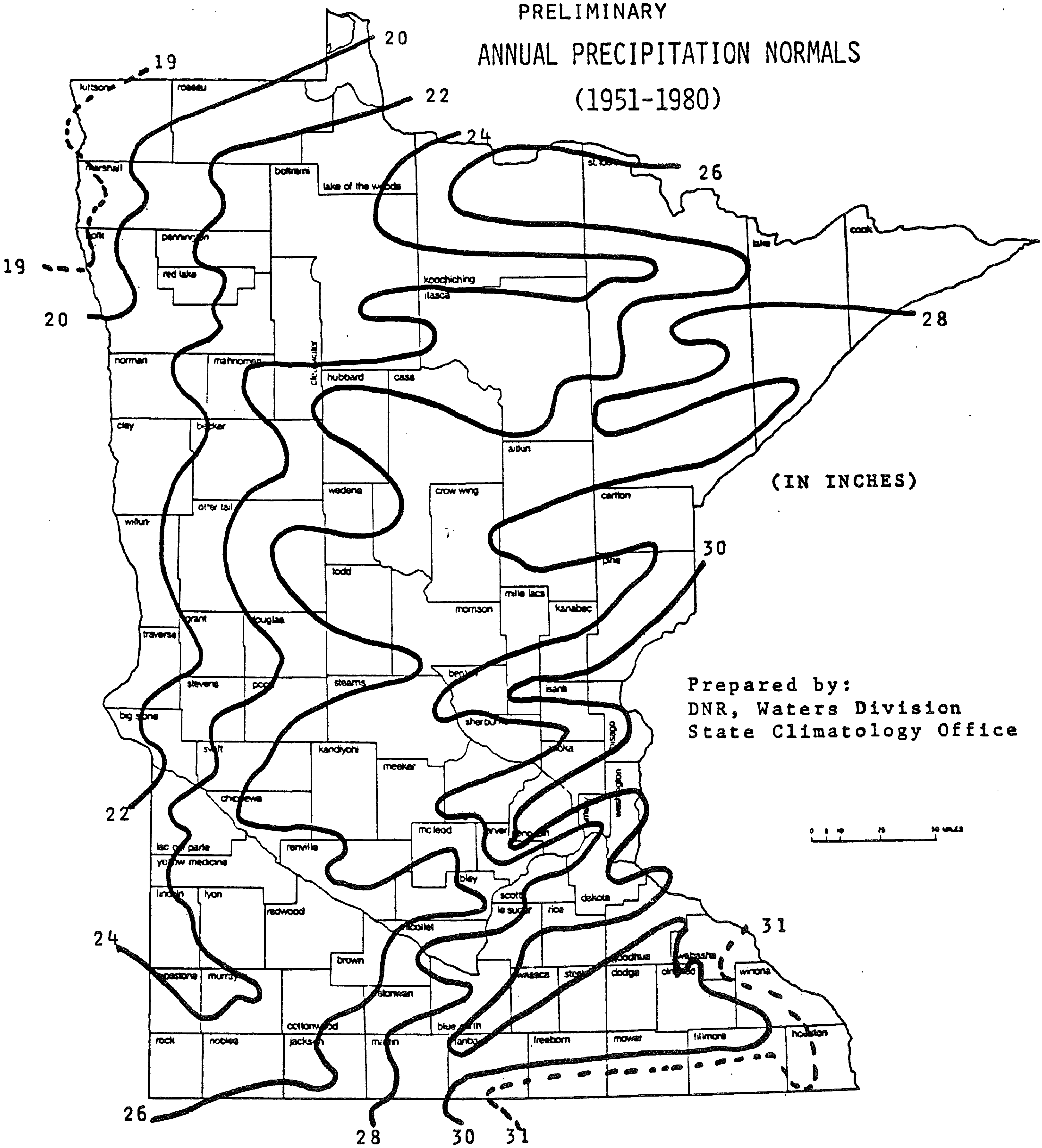
1846
1866
1886
1906
1926
1946
1966
1986
year
Full record
30 year
10 year

PRELIMINARY

ANNUAL PRECIPITATION NORMALS

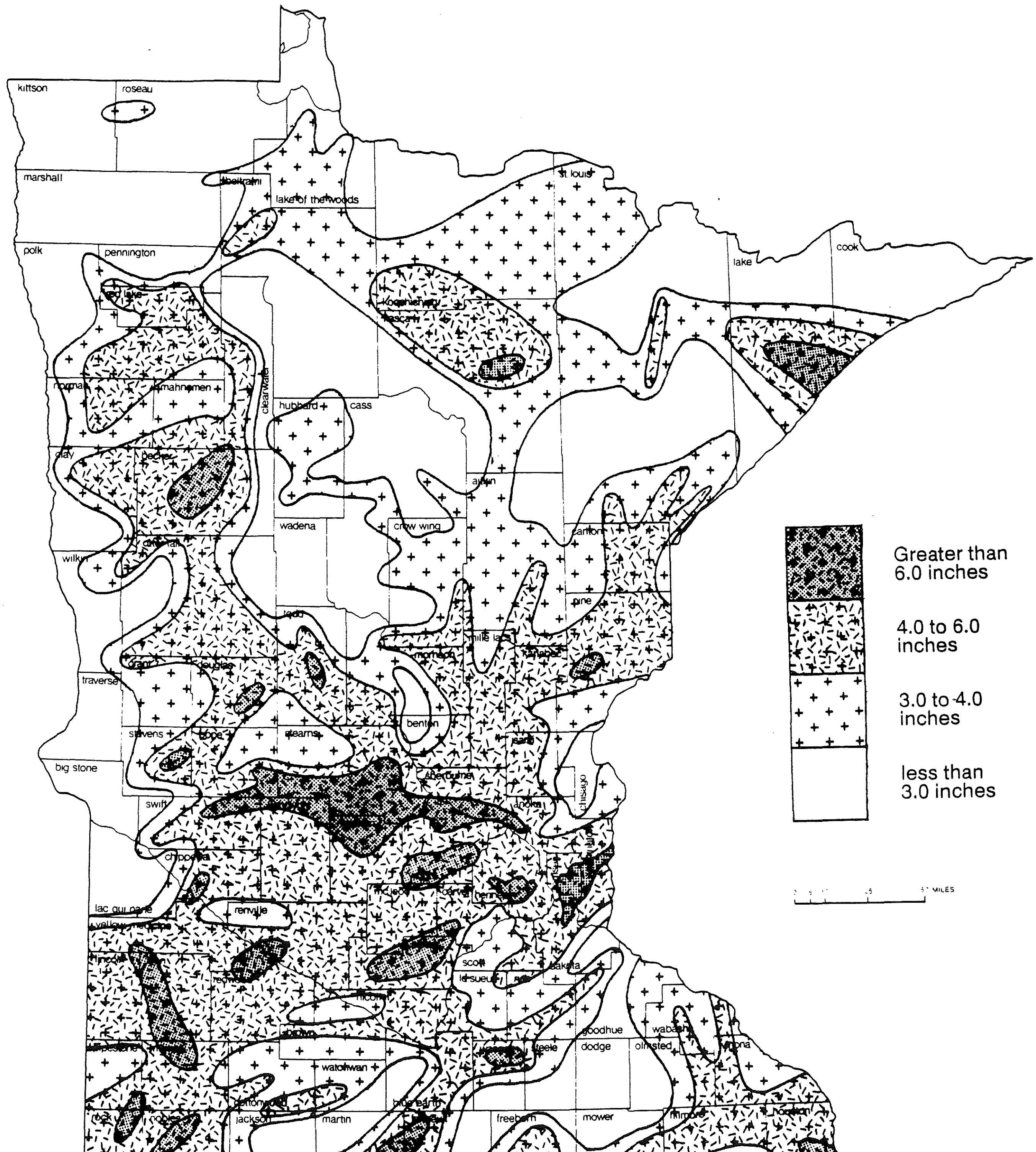
(1951-1980)



(IN INCHES)

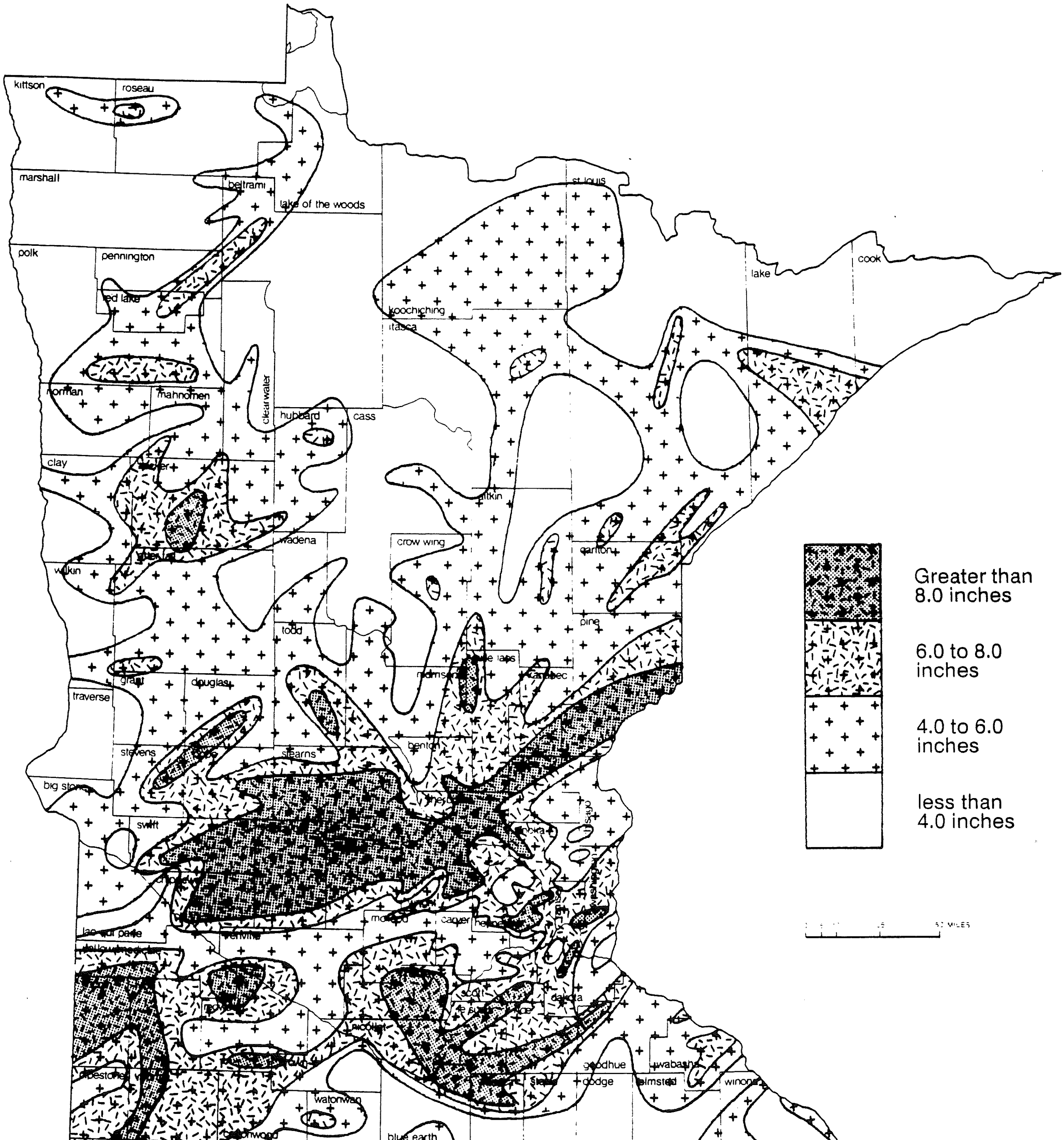
Prepared by:
DNR, Waters Division
State Climatology Office

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



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

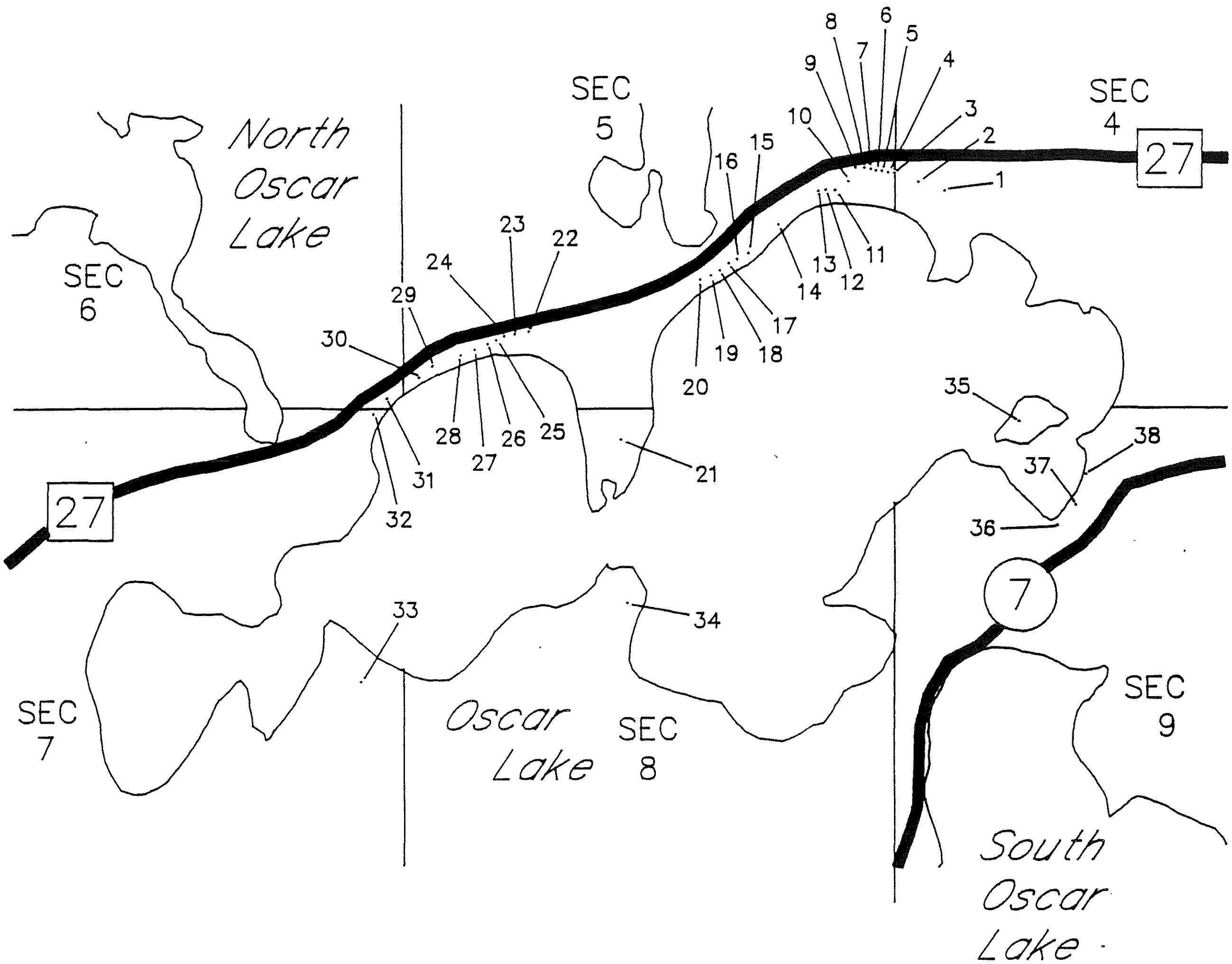
AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1982 - 1986 (5 YEARS)

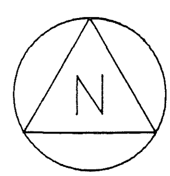


Prepared by: DNR, Division of Waters, State Climatology Office

APPENDIX D

FACT SHEET FOR EACH POTENTIALLY DAMAGED STRUCTURE





DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATERS

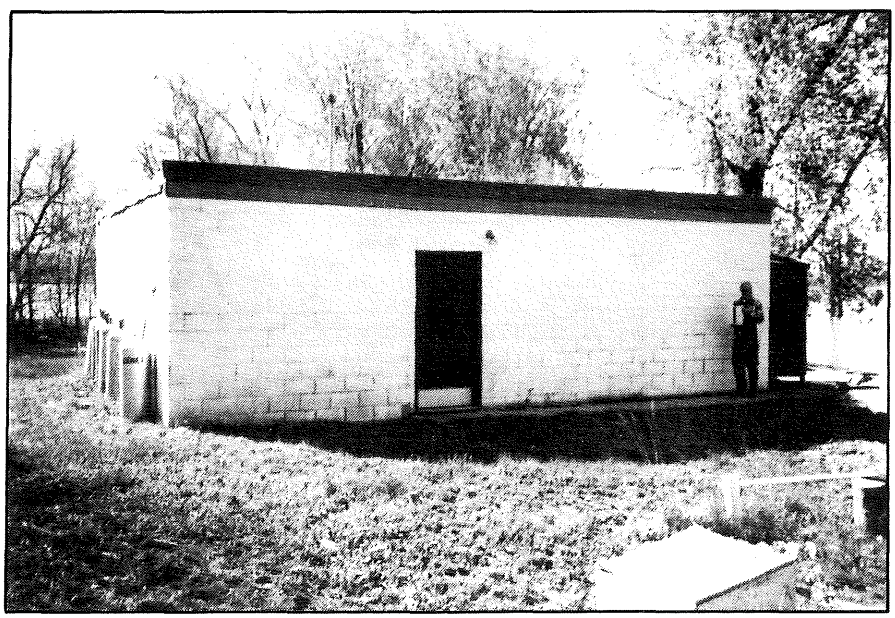
Not to Scale

OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	1
Name:	John J. and Judy A. Ahrens
Address:	Route 1, Kensington, MN 56345 (Resort)
Assessment Number:	18-0121-000
Walkout/1sFl Elev.:	1380.25
Basement:	No
Walkout:	No

Market Value

Buildings:	$3,328



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 2
Name: John J and Judy A., Ahrens
Address: Route 1, Kensington, MN 56345 (Resort)

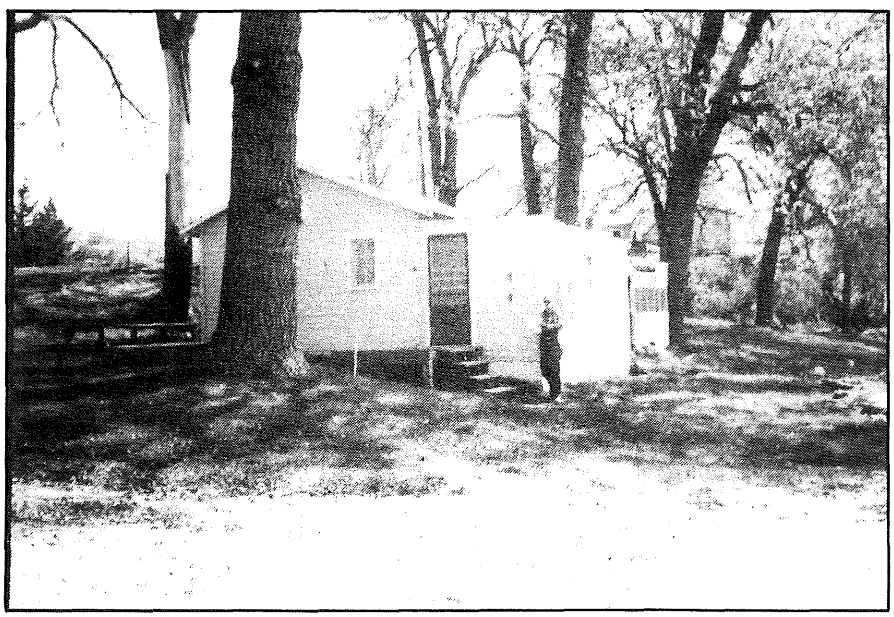
Assessment Number: 18-0121-000

Walkout/1sFl Elev.: 1384.36

Basement: No
Walkout: No

Market Value

Buildings: $2,500



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 3
Name: John J. and Judy A. Ahrens
Address: Route 1, Kensington, MN 56345 (Resort)

Assessment Number: 18-0176-000

Walkout/1sFl Elev.: 1386.93

Basement: No
Walkout: No

Market Value

Buildings: $7,997

OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	4
Name:	John J. and Judy A. Ahrens
Address:	Route 1, Kensington, MN 56345 (Resort)
Assessment Number:	18-0176-000
Walkout/1sFl Elev.:	1386.84
Basement:	No
Walkout:	No

Market Value

Buildings:	$1,344

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 5
Name: John J. and Judy A. Ahrens
Address: Route 1, Kensington, MN 56345 (Resort)

Assessment Number: 18-0176-000

Walkout/1sFl Elev.: 1387.11

Basement: No
Walkout: No

Market Value

Buildings: $9,996

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 6
Name: John J. and Judy A. Ahrens
Address: Route 1, Kensington, MN 56345 (Resort)

Assessment Number: 18-0176-000

Walkout/1sFl Elev.: 1387.10

Basement: No
Walkout: No

Market Value

Buildings: $5,712

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 7
Name: John J. and Judy A. Ahrens
Address: Route 1, Kensington, MN 56345 (Resort)

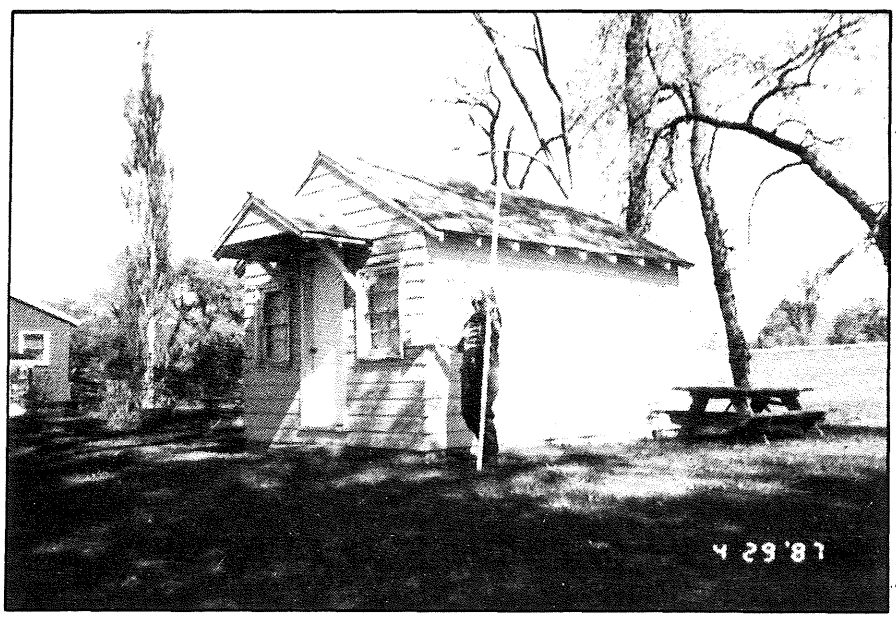
Assessment Number: 18-0176-000

Walkout/1sFl Elev.: 1387.74

Basement: No
Walkout: No

Market Value

Buildings: $5,712

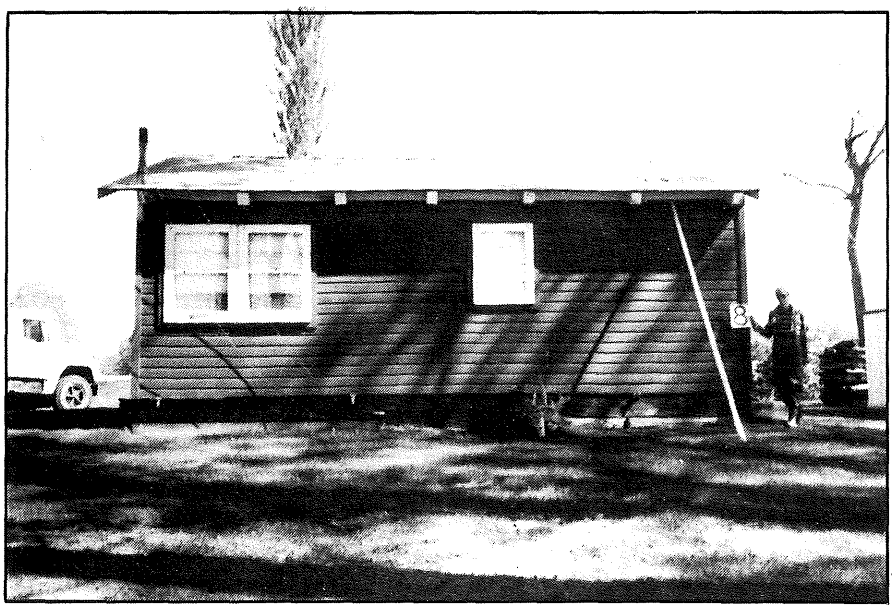


OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	8
Name:	Gerald E. and Dorothy A. Teig
Address:	7421 - 15th Avenue S., Richfield, MN 55423
Assessment Number:	18-0175-000
Walkout/1sFl Elev.:	1388.37
Basement:	No
Walkout:	No

Market Value

Buildings:	$10,904



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 9
Name: Frederick R. Tomaseck
Address: 1565 Knowles Avenue, Los Angeles, CA 90063

Assessment Number: 18-0174-000

Walkout/1sFl Elev.: 1388.30

Basement: No
Walkout: No

Market Value

Buildings: $11,094

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 10
Name: Verle and Norma Anderson
Address: 19768 Tyler Street W., Elk River, MN 55330

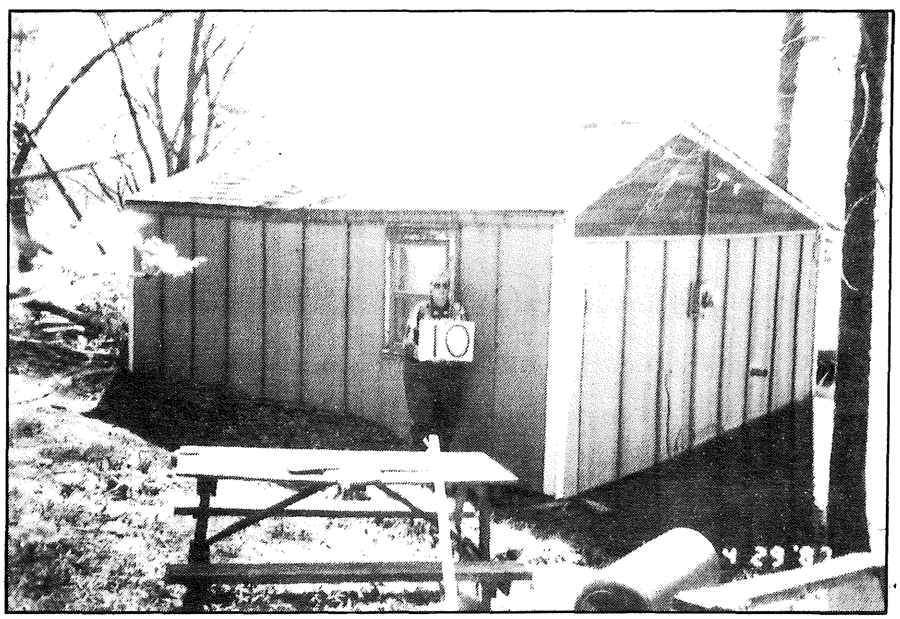
Assessment Number: 18-0158-000

Walkout/1sFl Elev.: 1379.85

Basement: No
Walkout: No

Market Value

Buildings: $500



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 11
Name: Wesley and Florence Brosh
Address: Box 113, Lowry, MN 56349

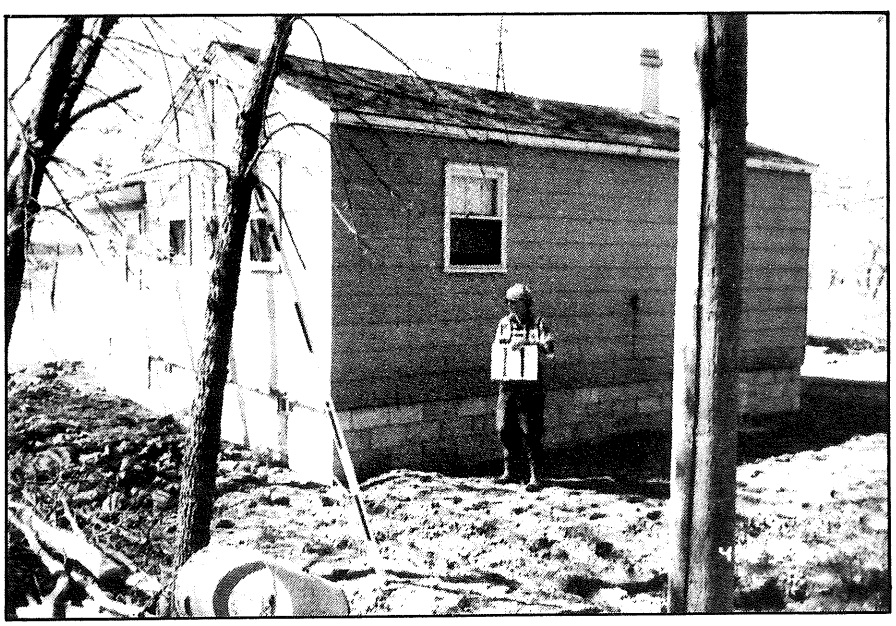
Assessment Number: 18-0159-000

Walkout/1sFl Elev.: 1383.05

Basement: No
Walkout: No

Market Value

Buildings: $11,031



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 12
Name: Edward J. and Reita J. Formanek
Address: 237 Fleming Avenue, Council Bluffs, IA 51501

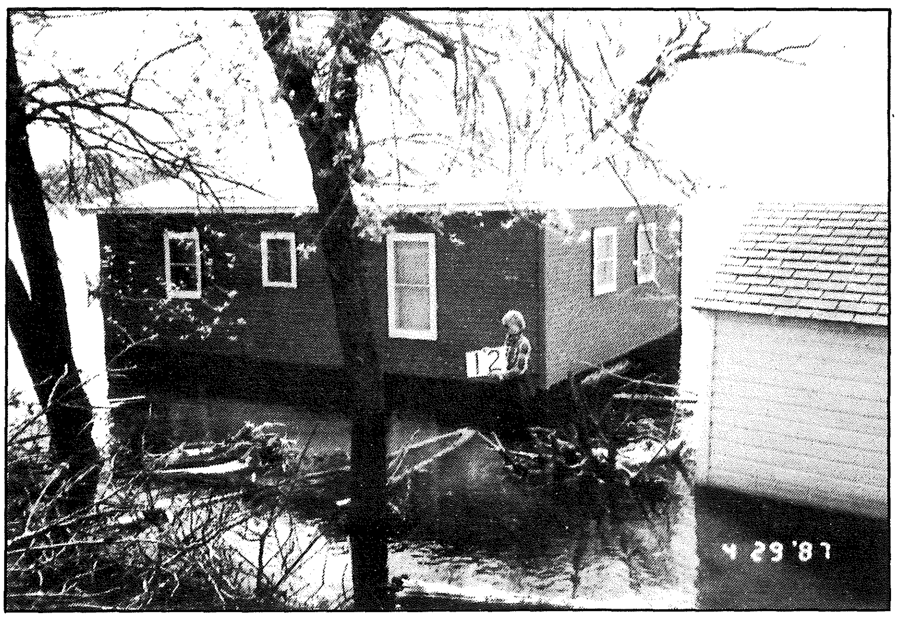
Assessment Number: 18-0162-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 13
Name: JoAnn L. Lueck
Address: Route 2, Kensington, MN 56343

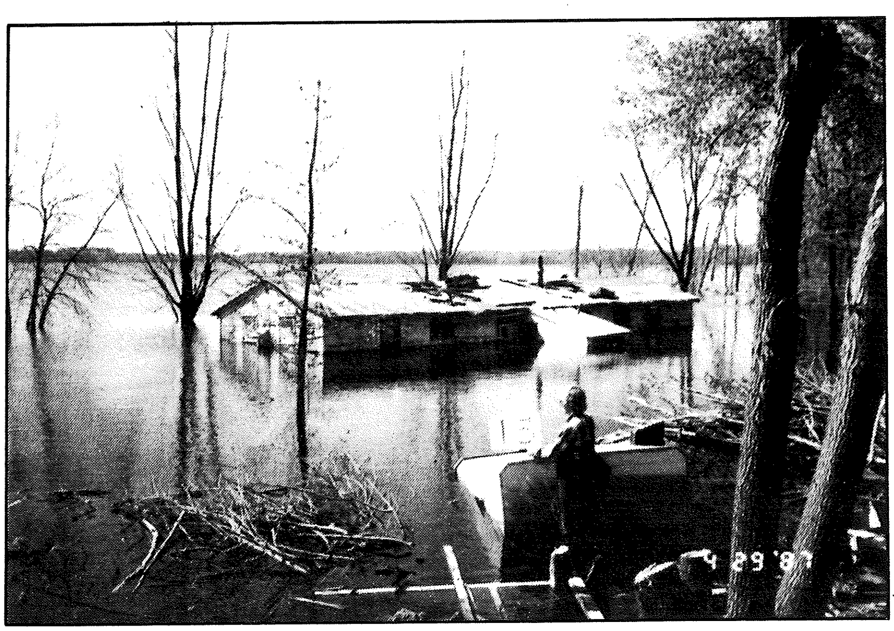
Assessment Number: 18-0164-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 14
Name: Jean E. Bloom
Address: 756 E. Hawthorne, St. Paul, MN 55106

Assessment Number: 18-0140-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 15
Name: Morgan Larson
Address: Route 1, Box 153, Kensington, MN 56343

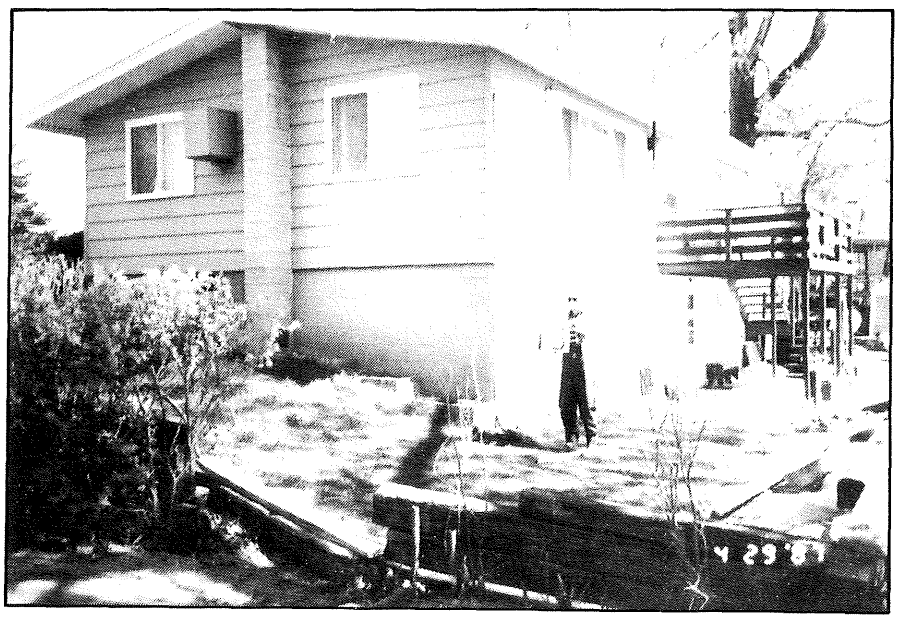
Assessment Number: 18-0146-000

Walkout/1sFl Elev.: 1379.45

Basement: Yes
Walkout: Yes

Market Value

Buildings: $39,136



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 16
Name: Elroy H. and Frances J. Kattre
Address: 1813 Aga Drive, Apt. 101, Alexandria, MN 56308

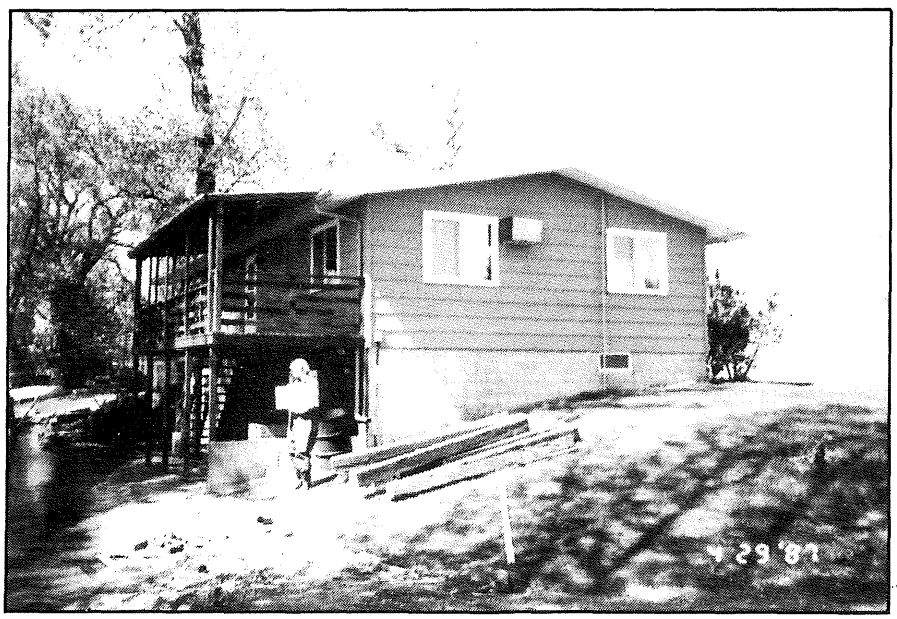
Assessment Number: 18-0148-000

Walkout/1sFl Elev.: 1379.25

Basement: Yes
Walkout: Yes

Market Value

Buildings: $38,017



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 17
Name: Patrick W. and Judith M. Ryan
Address: 395 Beacon Avenue, St. Paul, MN 55104

Assessment Number: 18-0149-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 18
Name: David Vanek
Address: 110 - 19th Avenue North, Hopkins, MN 55343

Assessment Number: 18-0150-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 19
Name: Korby J. and Elizabeth Peltola
Address: 200 Viking Drive, Mankato, MN 56001

Assessment Number: 18-0151-000

Walkout/1sFl Elev.: 1380.05

Basement: Yes
Walkout: Yes

Market Value

Buildings: $27,964

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 20
Name: Frederick Lorenz
Address: Kensington, MN 56343

Assessment Number: 18-0152-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

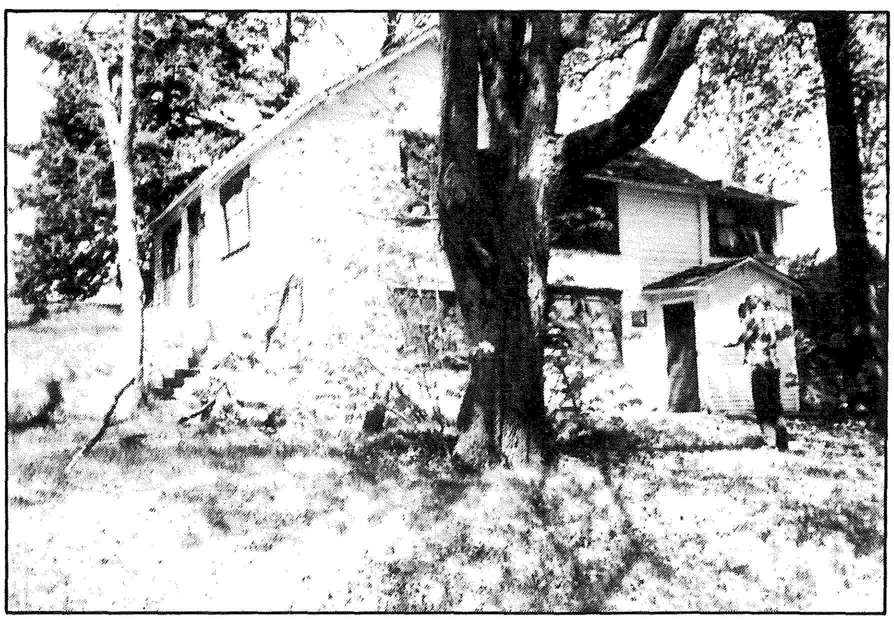
Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	21
Name:	Erwin E. Hildebrandt
Address:	Route 1, Box 29, Kensington, MN 56343
Assessment Number:	18-0248-000
Walkout/1sFl Elev.:	1387.45
Basement:	Yes
Walkout:	Yes

Market Value

Buildings:	$6,240



OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	22
Name:	Elvin and Myrtle J. Huseby
Address:	320 - 6th Avenue, Granite Falls, MN 56241
Assessment Number:	18-0135-000
Walkout/1sFl Elev.:	1st Floor Elevation Underwater
Basement:	No
Walkout:	No

Market Value

Buildings:	$500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 23
Name: Richard J. and Erma J. Admave
Address: 405 S. Ridge, South Souix Falls, NE 68776

Assessment Number: 18-0134-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 24
Name: Clifford and Joann Van Vickle
Address: Route 1, Kensington, MN 56343

Assessment Number: 18-0136-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 25
Name: Clifford and Joann Van Vickle
Address: Route 1, Kensington, MN 56343

Assessment Number: 118-0137-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 26
Name: Almira Kill
Address: Route 1, Kensington, MN 56343

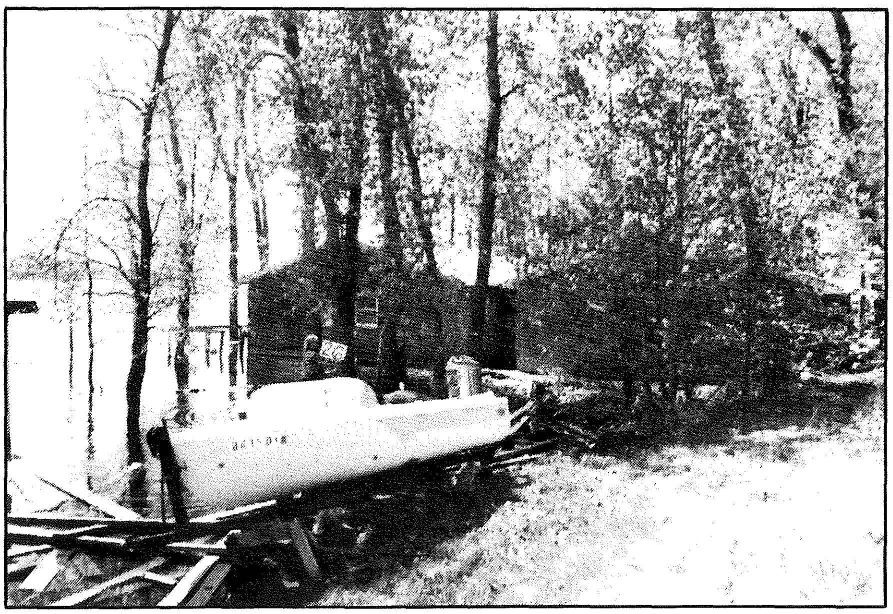
Assessment Number: 18-0196-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 27
Name: Arthur Christensen
Address: Route 2, Box 317, Lucan, MN 56255

Assessment Number: 18-0195-000

Walkout/1sFl Elev.: 1381.95

Basement: No
Walkout: No

Market Value

Buildings: $4,763

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 28
Name: Eugene W. Pearson
Address: 2207 Stinson Blvd. N.E., Minneapolis, MN 55418

Assessment Number: 18-0194-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 29
Name: Gilbert M. and Ethel I. Kruschke
Address: 2813 - 142nd Avenue N.W., Andover, MN 55304

Assessment Number: 18-0192-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

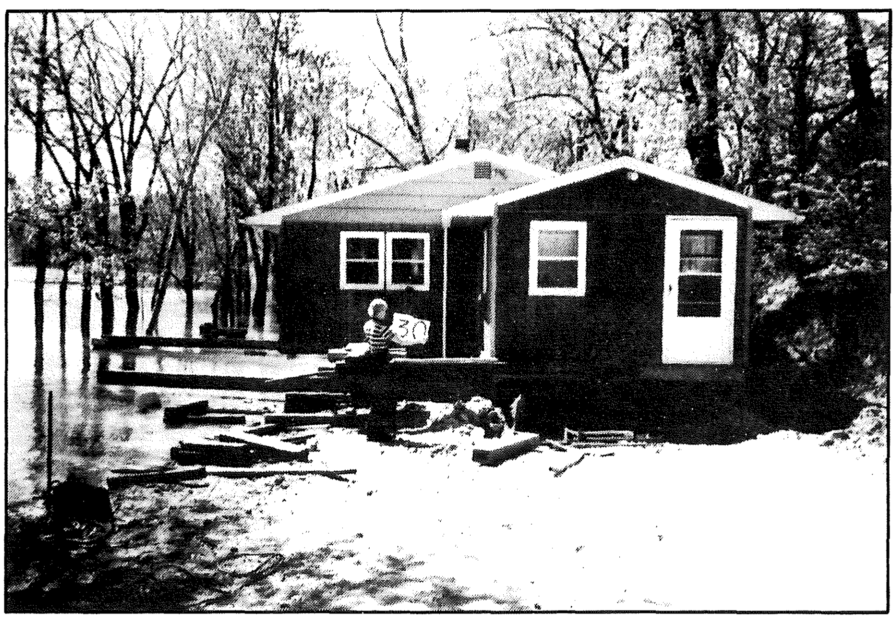
Buildings: Omitted

OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	30
Name:	Gilbert M. and Ethel I. Kruschke
Address:	2813 - 142nd Avenue N.W., Andover, MN 55304
Assessment Number:	18-0192-000
Walkout/1sFl Elev.:	1st Floor Elevation Underwater
Basement:	No
Walkout:	No

Market Value

Buildings:	$500

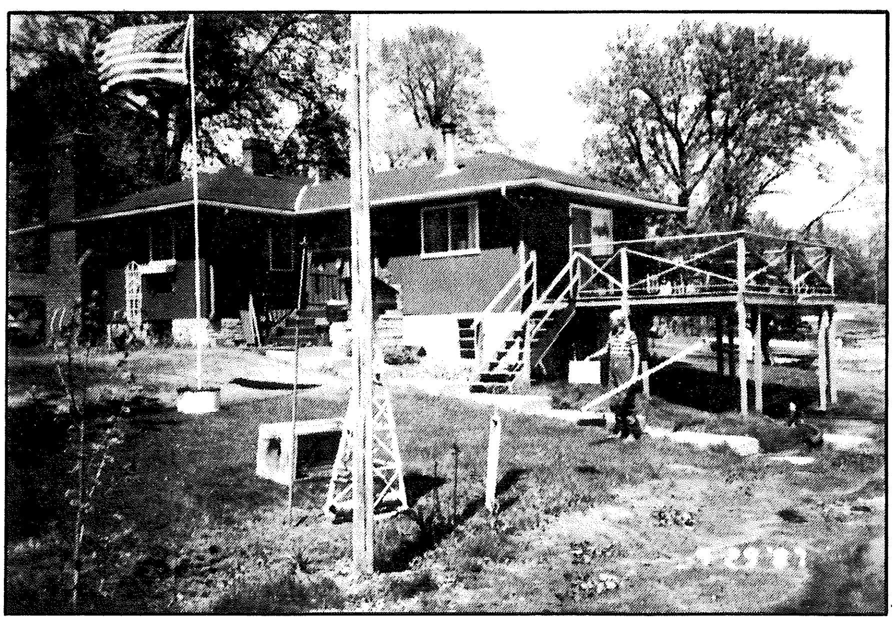


OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	31
Name:	LeRoy Anderson et. al.
Address:	Route 1, Box 172, Kensington, MN 56343
Assessment Number:	18-0212-000
Walkout/1sFl Elev.:	1378.70
Basement:	Yes
Walkout:	Yes

Market Value

Buildings:	$41,537



OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	32
Name:	Einar T. and Ione T. Bakke
Address:	Route 1, Kensington, MN 56343
Assessment Number:	18-0245-000
Walkout/1sFl Elev.:	1383.85
Basement:	No
Walkout:	No

Market Value

Buildings:	$1,120

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 33
Name: David L. Fahlin et. al.
Address: Route 2, Box 152, Kensington, MN 56343

Assessment Number: 18-0238-000

Walkout/1sFl Elev.: 1385.61

Basement: No
Walkout: No

Market Value

Buildings: $3,427

OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	34
Name:	James W. Goit
Address:	2928 Dean Blvd., Minneapolis, MN 55416
Assessment Number:	18-0249-000
Walkout/1sFl Elev.:	1378.61
Basement:	No
Walkout:	No

Market Value

Buildings:	$22,509

OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 35
Name: Elwin S. and Linda Stauffer
Address: 8901 Hilltop Drive, St. Bonifacius, MN 55375

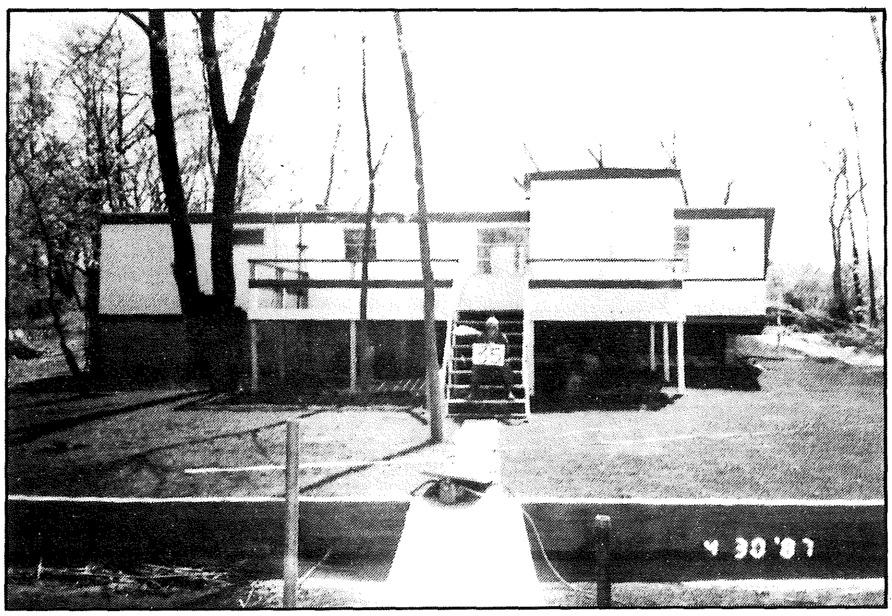
Assessment Number: 18-0261-000

Walkout/1sFl Elev.: 1387.16

Basement: No
Walkout: No

Market Value

Buildings: $4,720



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 36
Name: Jerald K. and Mary J. Williamson
Address: RR Box 15, Louisberg, MN 56254

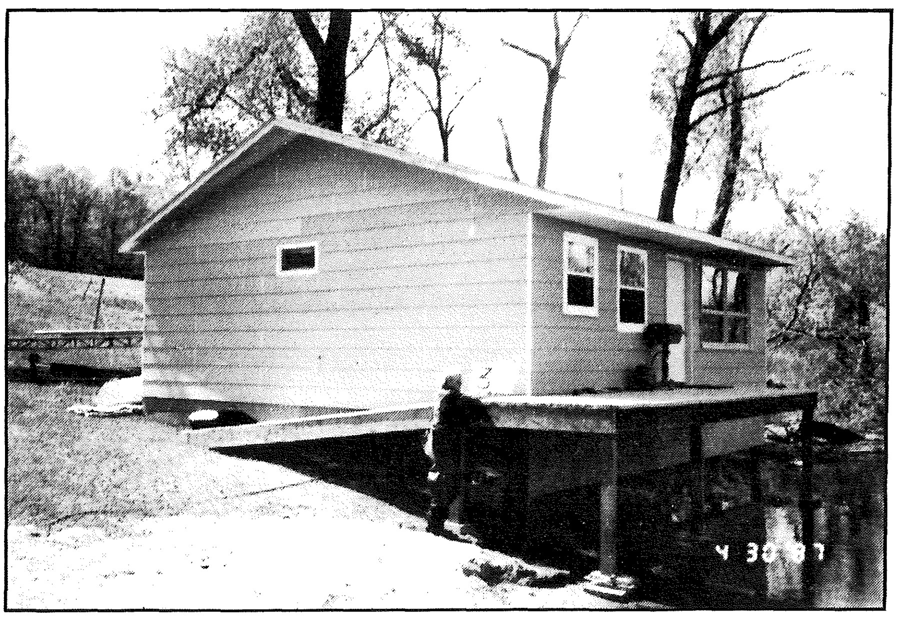
Assessment Number: 18-0280-000

Walkout/1sFl Elev.: 1385.18

Basement: No
Walkout: No

Market Value

Buildings: $8,290

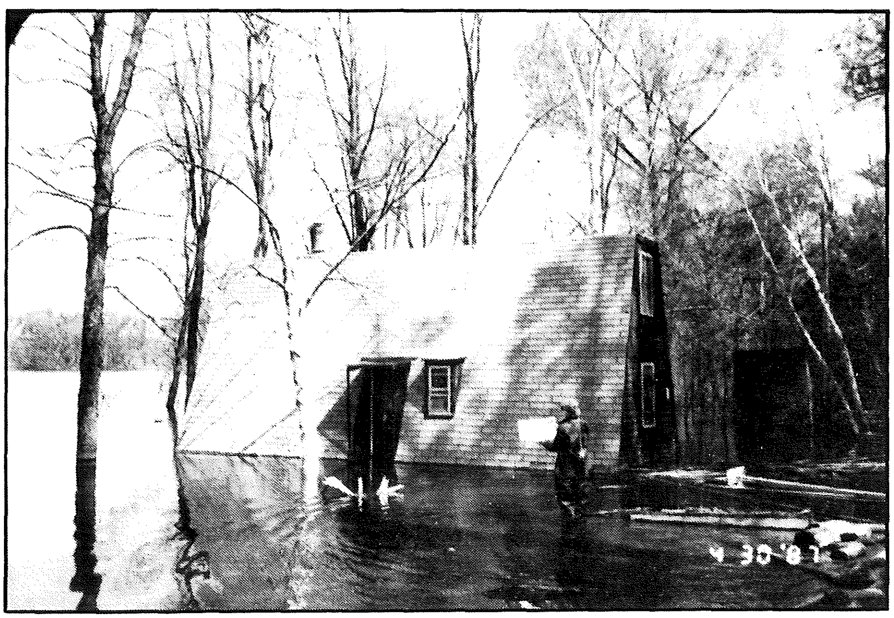


OSCAR LAKE - DOUGLAS COUNTY

Structure Number:	37
Name:	Robert J. and Karen R. Colin
Address:	20133 - 156th Street, Elk River, MN 55330
Assessment Number:	18-0279-000
Walkout/1sFl Elev.:	1st Floor Elevation Underwater
Basement:	No
Walkout:	No

Market Value

Buildings:	$500



OSCAR LAKE - DOUGLAS COUNTY

Structure Number: 38
Name: Donald E. and Marilyn J. Filipek
Address: 3661 - 37th Avenue S., Minneapolis, MN 55406

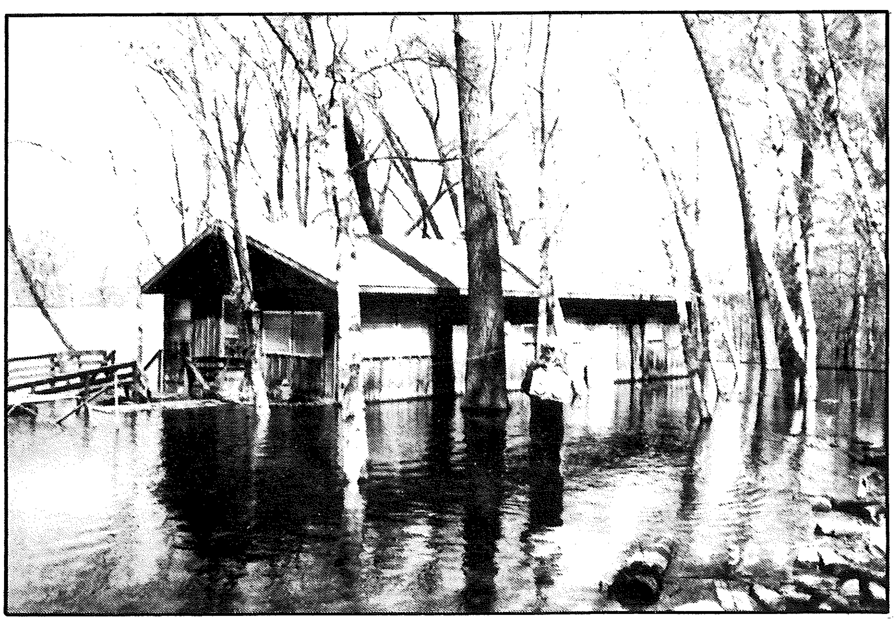
Assessment Number: 18-0277-000

Walkout/1sFl Elev.: 1st Floor Elevation Underwater

Basement: No
Walkout: No

Market Value

Buildings: $500



APPENDIX E

GEOLOGIC MAP OF MINNESOTA

Minnesota Geological Survey
University of Minnesota
Matt Walton, Director

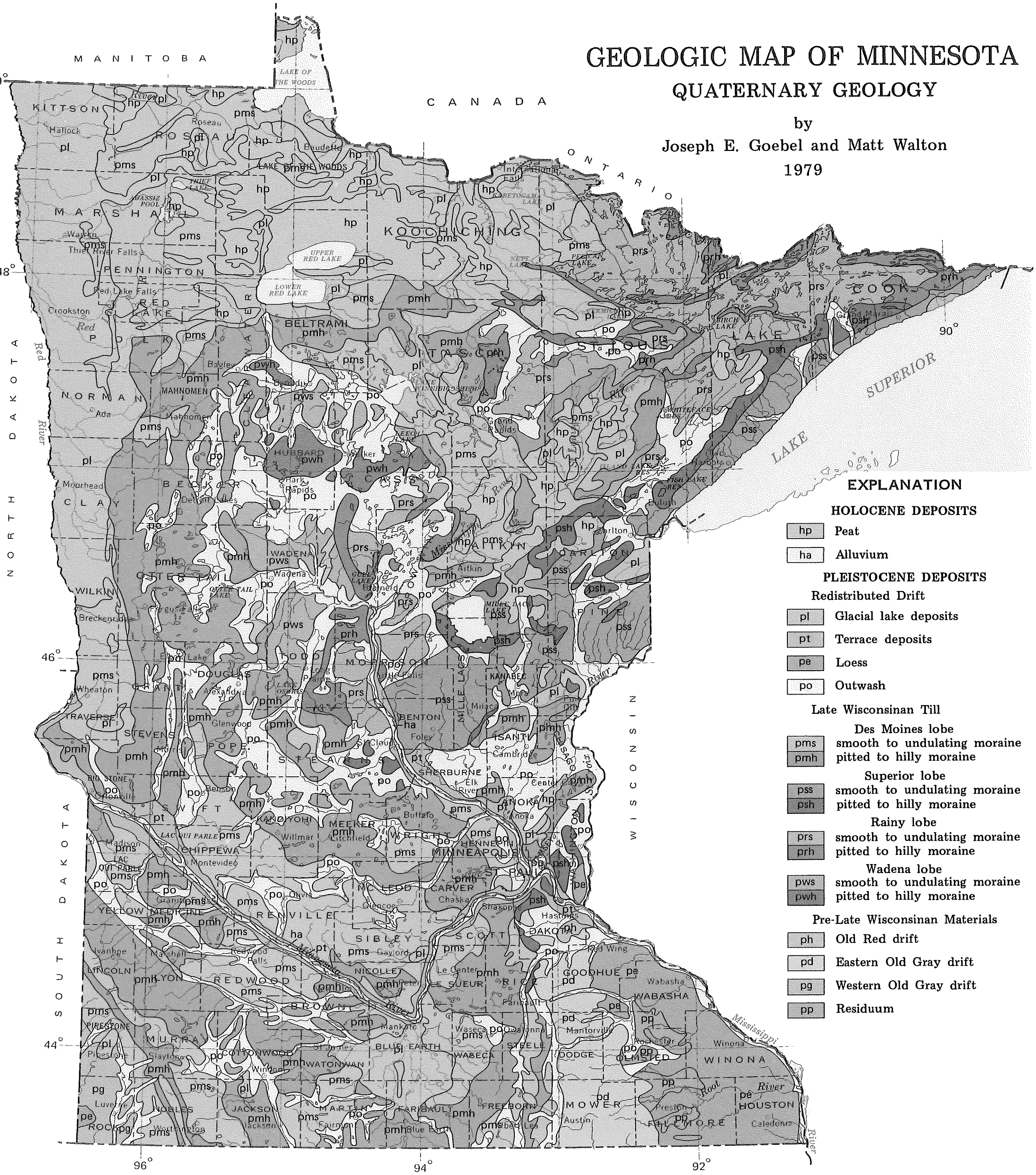
GEOLOGIC MAP OF MINNESOTA

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

Published with the support of the Legislative Commission on Minnesota Resources

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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