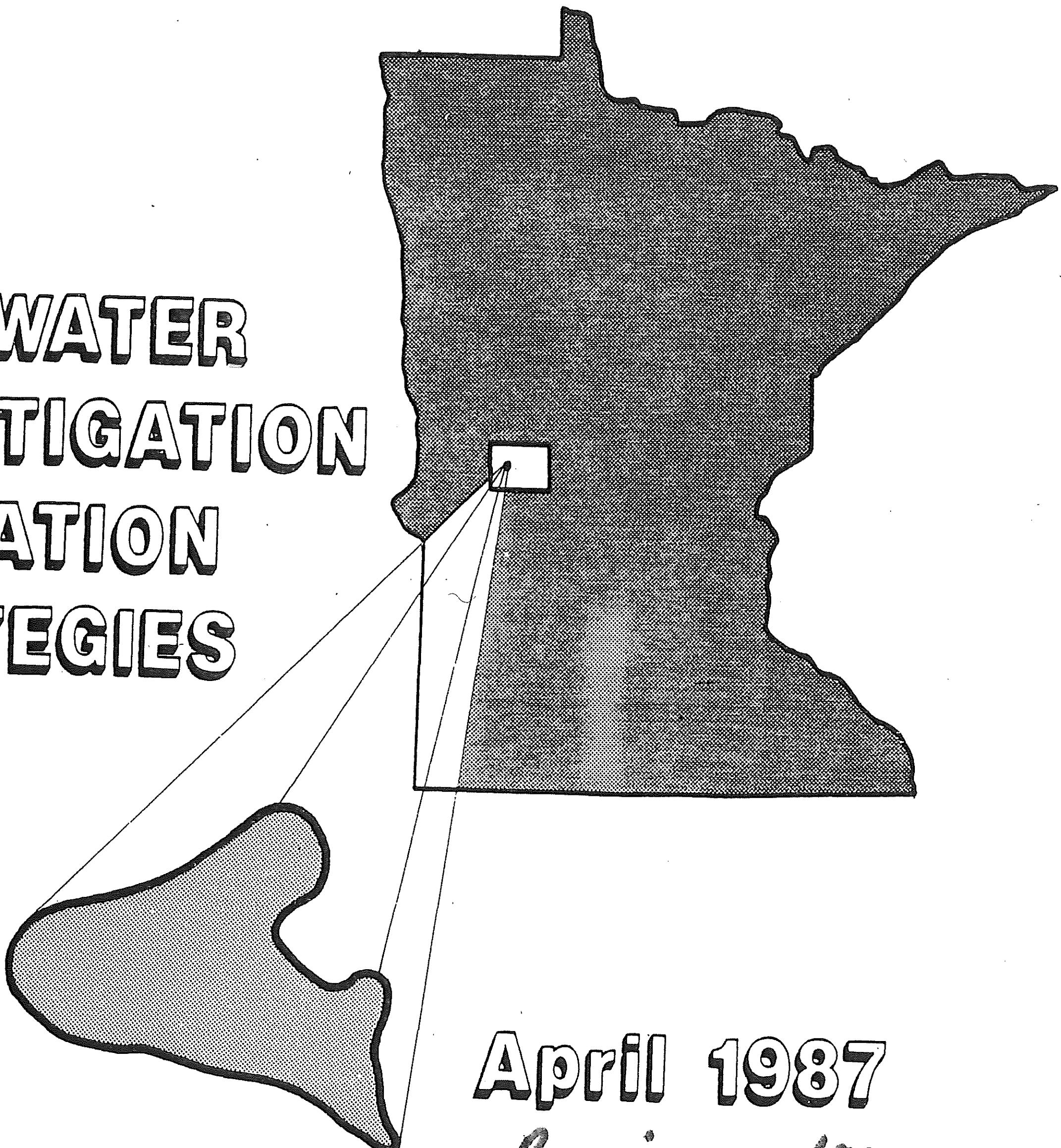
MOON LAKE

(Douglas County, 21-226)



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

MOON LAKE

BASIN #21-226

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

This report was prepared under a Hazard Mitigation Assistance Grant from the Federal Emergency Management Agency with matching funds from the Department of Natural Resources, Division of Waters. This report would not have been possible without the special assistance of Dennis Nagle, Douglas County Zoning Administrator and Richard Howe, (R.L.S.) Douglas County Surveyor.

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INTRODUCTION

Moon Lake is located in northwestern Douglas County, Minnesota, approximately 155 miles northwest of the Twin Cities metropolitan area. The lake is about 10 miles northwest of the City of Alexandria, and most of its area is within Section 28 of Township 129 North, Range 39 West (Plate 1).

Moon 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.

Moon Lake is situated within glacial drift of the Alexandria Moraine Association. The lake level began to rise during the 1970's and by 1975, the county and local lake residents started to become concerned. By October 9, 1986, the lake was 1.79' above the Ordinary High Water Level (OHW elevation 1365.1'; NGVD, 1929)[1] to elevation 1366.89' flooding many low elevation structures and forcing other residents to move their structures to a higher elevation.

The Department of Natural Resources issued Permit 87-1050 on October 20, 1986, to Douglas County which authorized the installation of a drop structure and drainage system. Through the permit, the county is allowed to lower the lake to 1.5' below the Ordinary High Water elevation (OHW elevation 1365.1'). As of April 28, 1987, Moon Lake has been lowered to elevation 1364.61' or .49' below the OHW and is continuing towards elevation 1363.6'. The Department of Natural Resources decided to continue with this report even though an artificial drainage outlet is in place because the outlet is not efficient enough to prevent future bounces to the lake. In addition, this report contains information relevant to a long-term management strategy for the lake.

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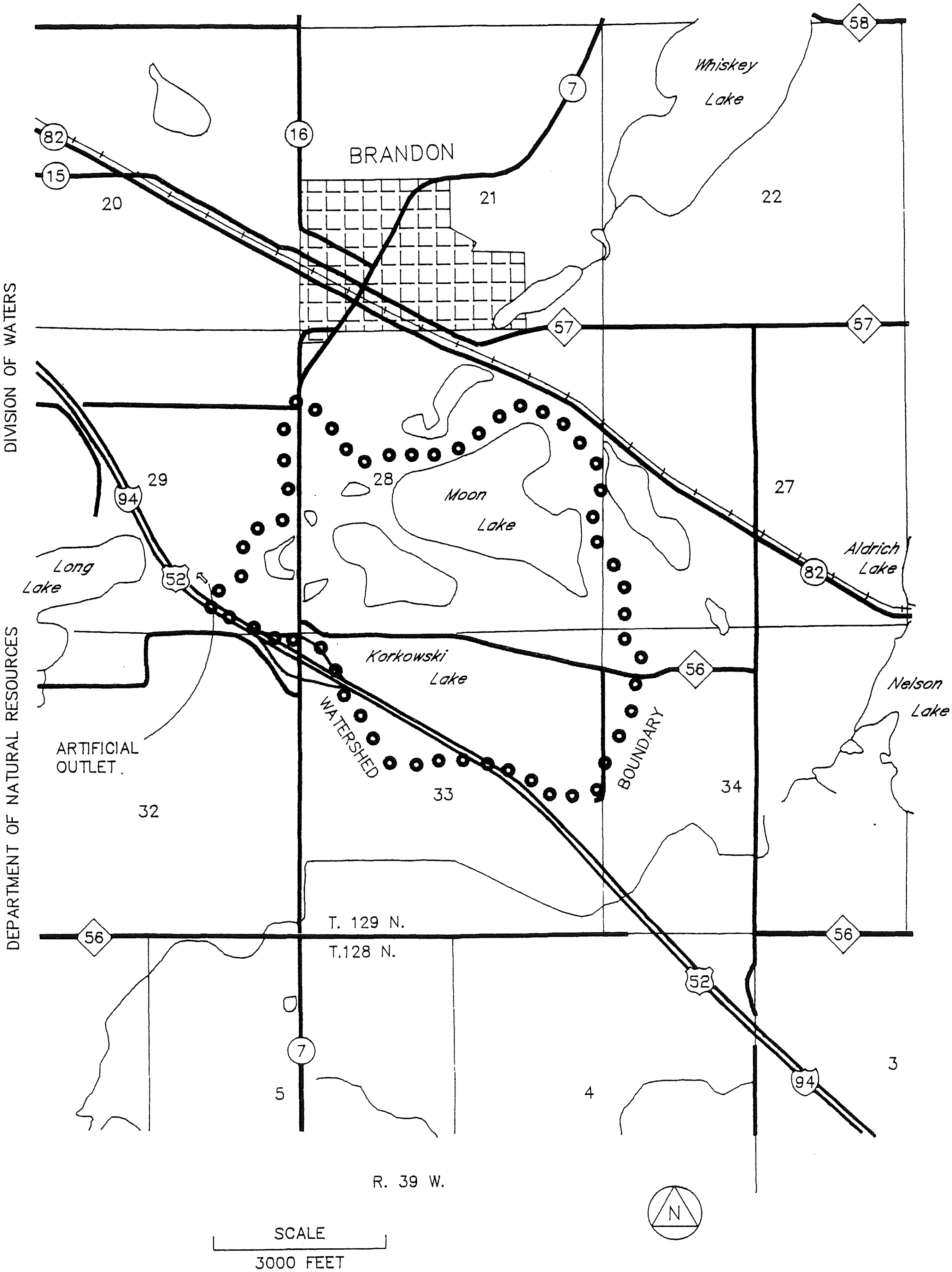
[1]National Geodetic Vertical Datum of 1929 is used for all elevations included in this report.

PLATE 1



58
Whiskey Lake
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4
R. 39 W.
N
SCALE
3000 FEET

SUMMARY AND CONCLUSIONS/RECOMMENDATIONS

Water Level Data (See Part 1)

-In April of 1987 Moon Lake was at elevation 1364.61', an elevation 0.49' below the lake's ordinary high water elevation of 1365.1'. Moon 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 Moon 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 1368.61', 7 additional structures would be flooded with 1986 assessed market values totalling $69,789. At this elevation, it is estimated a minimum $115,108 of damage would occur.

-Methodologies <u>do not</u> exist which can predict what Moon 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 1363.6'.

-Methodologies <u>do</u> 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 Moon Lake will: 1) rise above elevation 1363.7' on December 1, 1987; or 2) will exceed elevation 1363.7' on December 31, 1991. Conversely, there is a one-percent probability the lake will: 1) fall below elevation 1362.2' by December 1, 1987; or 2) fall below elevation 1361.2' on December 31, 1991. There is a 50% probability (a 50/50 chance) that Moon Lake will be at elevation 1363.3' on December 1, 1987 and elevation 1363.2' in December of 1991.

-Moon Lake will continue to react to significant short-term storm event such as the 100-year, 24 hour or 100-year, 10 day rainfall events. The 100-year, 10 day rainfall event will cause a 1.5' bounce to the lake assuming a starting water surface elevation of 1363.6' (the artificial runout elevation). A series of significant storms over a summer period would cause significant increases to the lake level even with the in-place artificial outlet.

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 Moon 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) Even though Moon Lake has a permit for a drainage outlet, the lake is technically considered a landlocked basin. The reason it is considered a landlocked basin is due to the fact that the drainage outlet is artificial and is only 12 inches in diameter and does not allow the lake to lower itself very quickly. The county's shoreland regulations require new development to be constructed at an elevation of 3 feet above the highest known water level (3' + 1366.89' = 1369.89'). However, since the lake does have a small artificial outlet, the Department feels that a more realistic elevation of 3 feet above the Ordinary High Water level would be acceptable (3' + 1365.1' = 1368.1'). Further justification for the recommended flood protection elevation of 1368.1' is the fact that the highest elevation for which there is some physical evidence for a historical water level is 1368.2'. This lowest floor or flood protection elevation of 1368.1' will insure that all new development is above Moon Lake's runout elevation and above the reasonably conceivable future high water level; and

2) For all new construction a provision should be added which requires an elevated road access to the recommended flood protection elevation of 1368.1'.

-The County should develop a strategy to address the inundation of sewage treatment systems and wells, the abandonment of flooded structures,and, with the receding water levels, the reoccupancy of previously flooded/significantly damaged structures (i.e., must the structure be made compliant/elevated or floodproofed prior to reoccupancy?). 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 the potential floodplain or elevating a structure at its existing site on fill to a minimum recommended flood protection elevation as established by the County. 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

Moon Lake is located within glacial drift of the Alexandria moraine association. The drift consists of morainal deposits of the Wadena Lobe, including gray calcareous till, ice contact sands and gravels, and buried outwash sands and gravels, which are mantled by younger gray calcareous drift of the Des Moines Lobe. The older moraine was overridden by ice of the Des Moines Lobe while there was still ice in the moraine. The lakes in the area were formed when the ice melted away and the overlying material collapsed into depressions formed by the melting ice. The glacial drift is approximately 300 ft. thick, and is underlain by pre-Cambrian crystalline bedrock.

A large gravel pit adjacent to the south end of Mud Lake (near the SE corner of Moon Lake) shows extensive deposits of outwash sands and gravels associated with older Wadena lobe glaciation, mantled by 3-15 ft. of Des Moines Lobe till (Plate 2). The material exposed in the gravel pit is uncollapsed, but Moon Lake and nearby lakes are ice block depressions, so their bottoms and sides are likely lined with till. Below the till is likely to be the same type of sand and gravel exposed in the pit.

A gravel pit located near the public access on the northwest shore of Moon Lake has sands and gravels association with more recent Des Moines Lobe glaciation overlain by till. The contact between the till and the sand and gravel is sharp and dips toward the lake. It appears that the till has collapsed into the lake basin.

Driller's logs from wells in Brandon (just to the north of Moon Lake) and along County Road 7 just west of Moon Lake show 100-150 ft. of till. The wells obtain water from buried outwash at these depths.

Three test borings were drilled around Moon Lake in 1984 (Plate 2). Boring #1 at the public access encountered 50 ft. of sand and gravel. An observation well was installed in this boring. Borings #2 (at the SE corner of Moon Lake) and #3 (west of Korkowski Lake) both showed 50 ft. of clay till.

SOILS

The soils surrounding the lake are primarily loam of the Langhei Series. The soils formed under grasses in calcareous loam or clay loam glacial till, and consists of deep, undulating to very steep, somewhat excessively drained, moderately permeable soils.

HYDROGEOLOGIC SETTING

The regional direction of ground water flow is from east to west. On a local scale, Mud Lake is higher than Moon Lake, which is in turn higher than Loves Lake, so the framework exists for east to west ground water flow through Moon Lake. Net ground water inflow to Moon Lake must be the controlling factor in the last decade's lake level rise, since the drainage basin of the lake is far too small for precipitation and surface water inflow alone to have accounted for the change in lake level.

The observation well at the Moon Lake public access consistently shows a water level 25 ft. below the level of Moon Lake, indicating a strong tendency for seepage out of the lake at this location. This is somewhat surprising since only sand and gravel was encountered during the drilling of the well. The till which has collapsed into the lake presumably forms a relatively impermeable barrier between the lake and the underlying and adjacent permeable materials. Mini-piezometer measurements confirmed a strong gradient indicating seepage out of the lake at this location. Ground water inflow is occurring on the lake, but the precise location is not known. There are areas of the lake near the eastern shore which do not freeze completely in the winter - a phenomenon which would be explained by ground water inflow.

In conclusion, increased net ground water inflow to Moon Lake resulting from rising ground water levels associated with above normal precipitation over the last 10 years has caused the lake level to rise. Ground water outflow from the lake is occurring along the eastern shore. Attempts to lower the lake level should take the net ground water inflow into account. Lowering the lake level will almost certainly increase the ground water inflow and reduce the ground water outflow.

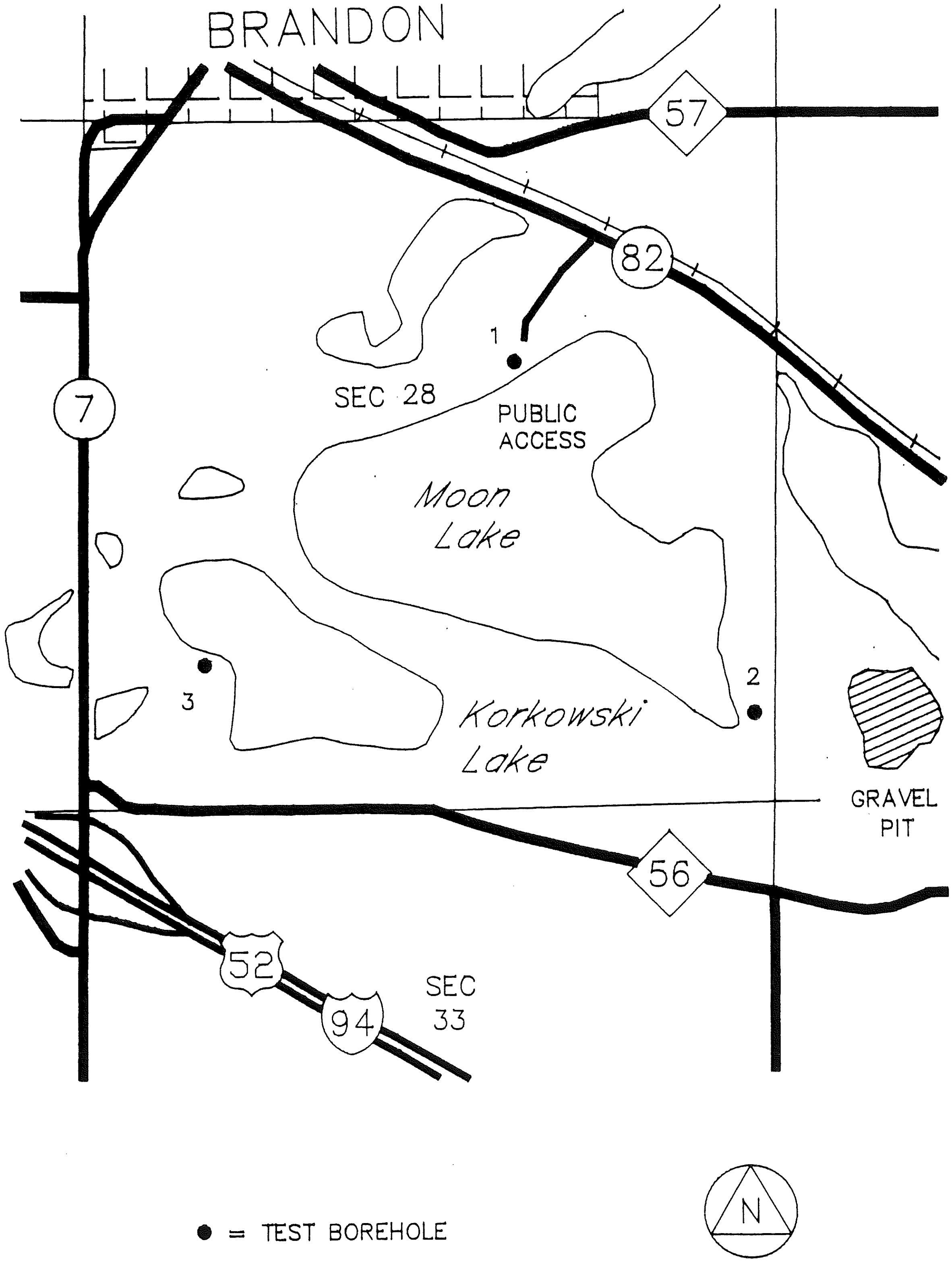


PLATE 2 : TEST BORE LOCATIONS

WATERSHED

The total watershed area for Moon Lake (including Korkowski Lake) is approximately 790 acres (Plate 1 on Page ii). The watershed of 790 acres minus the two lakes water surface areas of about 171 acres equals 619 acres or a total watershed area to lake area ratio of about 3½ to 1.

This watershed to lake area ratio of about 3½ to 1 is generally considered adequate to maintain lake levels during periods of normal precipitation. 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 was not surprising to see a rise in the lake water level.

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

On September 10, 1986, Douglas County applied for a permit to lower the water level of Moon Lake. On October 20, 1986, the Minnesota Department of Natural Resources issued Permit 87-1050 to Douglas County. The permit authorized the County to install a drop inlet water level control structure with the runout control elevation at 1363.6'. The drop structure consists of a vertical stand pipe with a 12" corrugated plastic draintile approximately 1700' in length. The draintile outlets into an existing 30" reinforced concrete pipe under Interstate 94 to Long Lake (21-230) and a series of wetlands.

WATER QUALITY

Water quality information for Moon Lake exists only for 1987. This mid-summer Department of Natural Resources Lake Survey shows the lake to be strongly stratified and anoxic at depth. Conductivity and pH measurements are typical of a lake with a small surface watershed. Water clarity is very good (Secchi disk depth in mid-summer: 13.0 feet) and indicates that the lake can be classifed as a mesotrophic hardwater lake.

Moon Lake has experienced recent water level increases and water quality issues of flooded septic systems and pastures were not addressed in the survey.

FISH AND WILDLIFE

A 1987 Fisheries Lake Survey Report indicates that Moon Lake, in ecological and management terms, is a Centrarchid (largemouth bass/panfish) lake. The fish population of the lake includes northern pike, walleye, largemouth bass, black crappie, pumpkinseed, bluegill, yellow perch, white sucker and black bullhead. Although the survey indicates many of the fish are small to average in size, some larger fish were taken. In general, Moon Lake is a good recreational fishing lake with spawning conditions favorable for largemouth bass, pumpkinseeds and bluegills.

The Department of Natural Resources has not performed a wildlife field survey for Moon Lake. However, the lake and its riparian area 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 a great 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, muskrats, 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

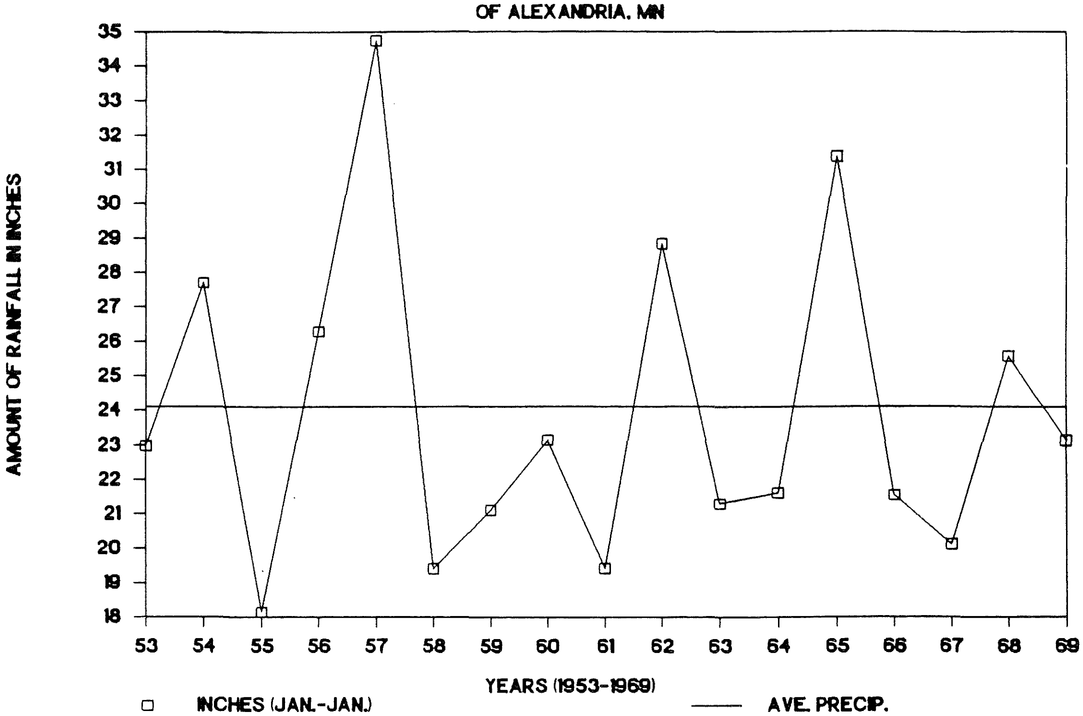
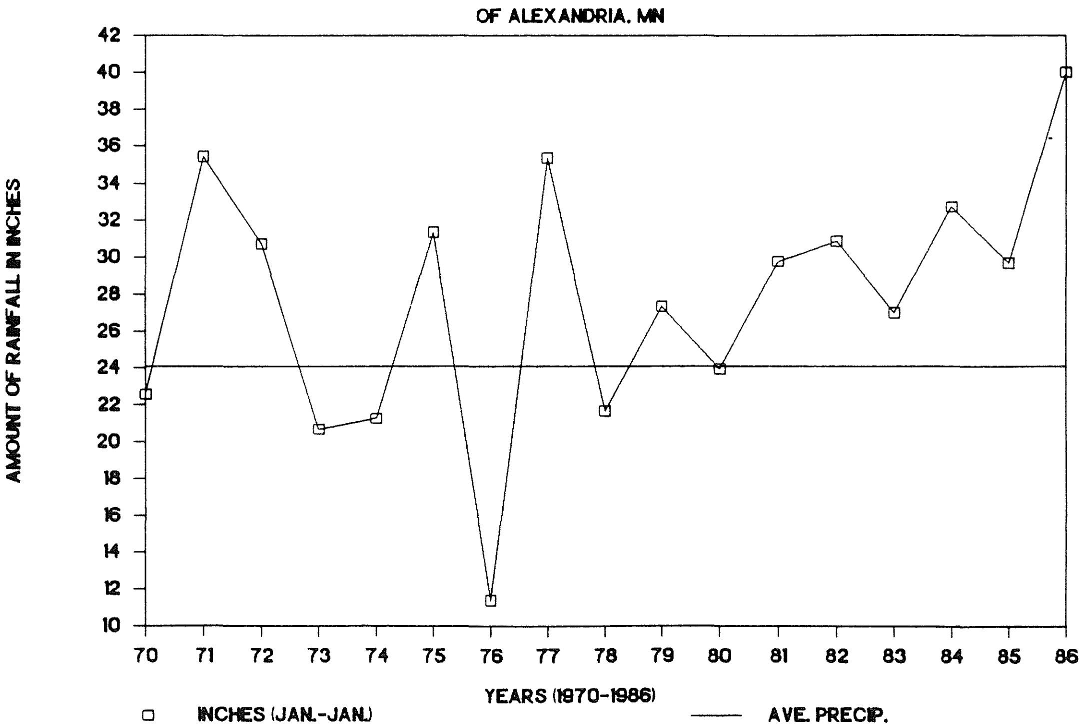


PLATE 4 ANNUAL PRECIPITATION



WATER LEVEL HISTORY

The Department of Natural Resources' Moon Lake file contains a number of fairly reliable surface water elevations dating from presettlement times through April 28, 1987 (See Chart 1 below and Table 1 on the following page). The available precipitation and lake level data indicate a correlation between the area's annual precipitation and the lake's water level. From 1982 through 1986 (last 5 years), the area has received an additional 37.35 inches of precipitation over the normal annual precipitation of 24.59 inches. The water level of the lake (1366.89') on October 9, 1986, was about 1.79' above the lake's Natural Ordinary High Water mark (1365.1') and was presumably due to several years of above normal precipitation.

The Minnesota Department of Natural Resources issued the County Permit 87-1050 which authorized the lowering of Moon Lake to 1.5 feet below the Ordinary High Water Mark. The control outlet began lowering the lake during October, 1986. By April 28, 1987, the lake has been lowered from elevation 1366.89' to 1364.61' or .49' below the Ordinary High Water Level. The lake will continue to drop until elevation 1363.6' is reached.

It should also be noted that the precipitation patterns in this area are characterized by alternating wet and dry periods of varied duration (Plates 5 and 6). These long-term precipitation variations could continue into the future and Moon Lake's water surface elevation will respond accordingly. Because above normal periods of precipitation of longer duration than the current period (recent years) have occurred in the past, the current period may continue for several more years.

Chart 1

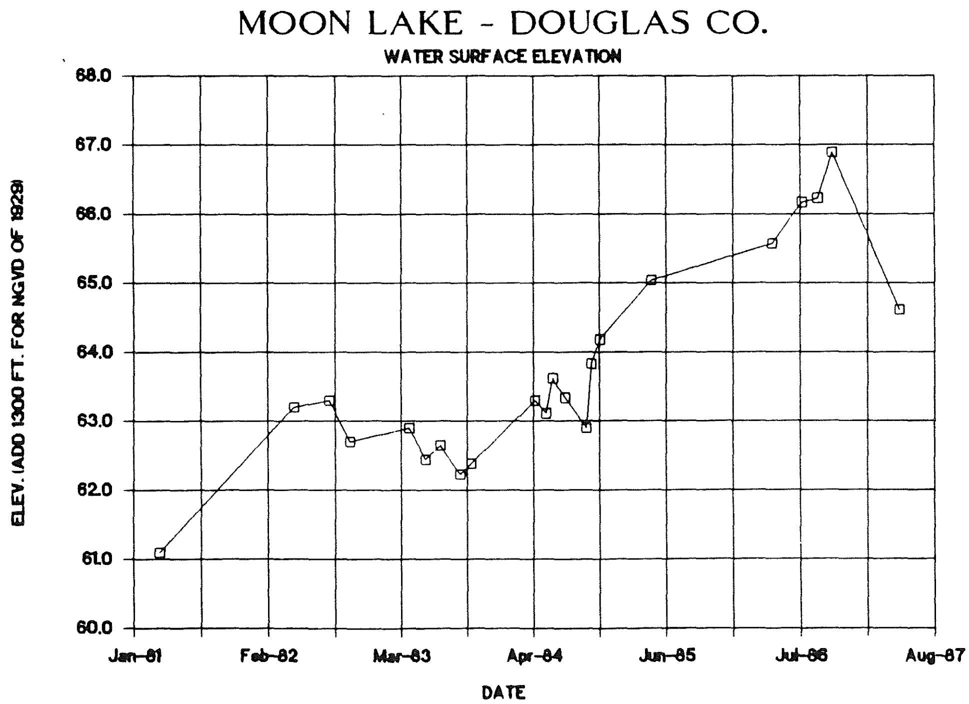
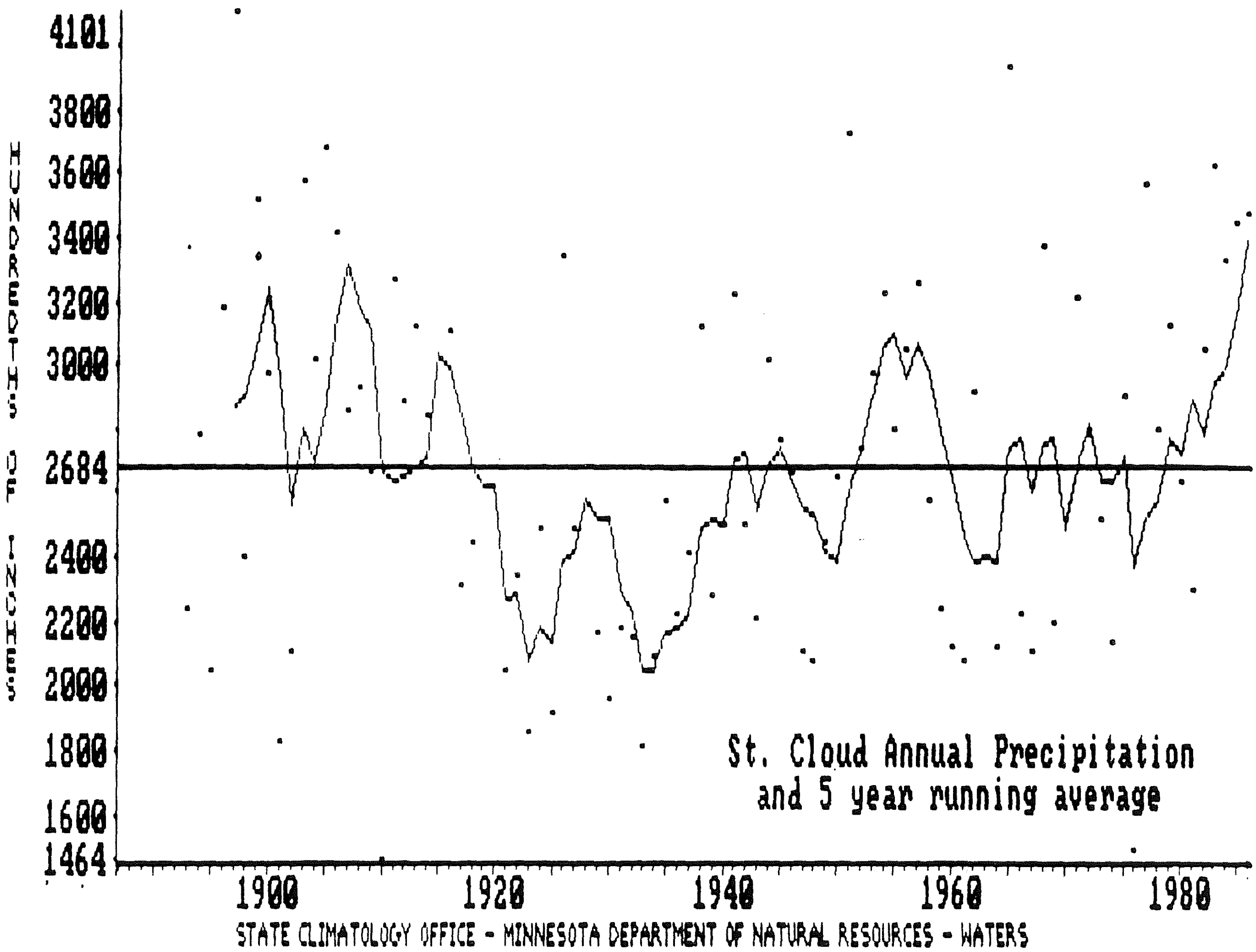


Table 1

WATER LEVEL HISTORY

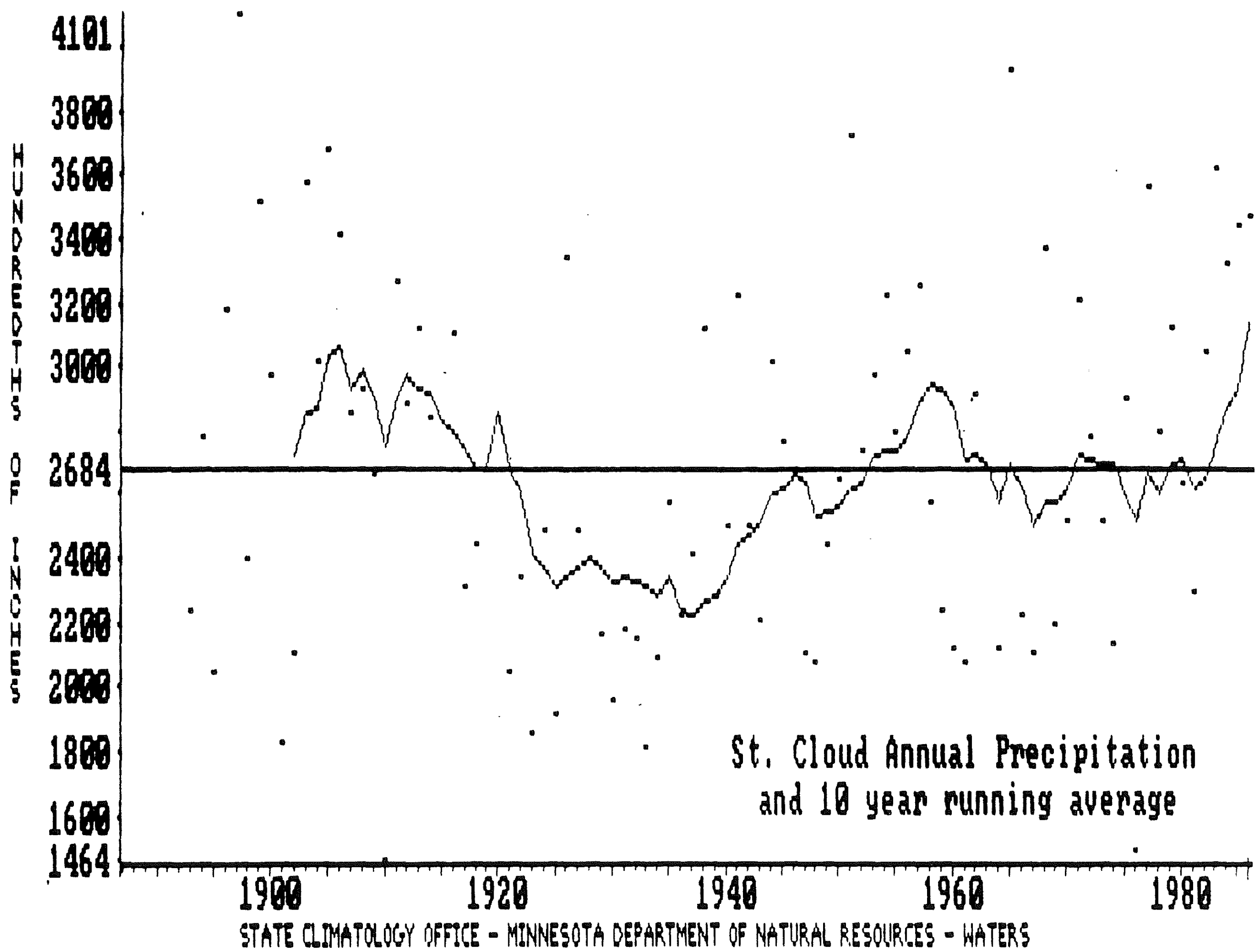
Date	Water Level	Source
Presettlement	1368.20	Physical Evidence
August, 1860	1360±	Estimated From Govt. Land Office Survey Data
1920±	1366.50	Resident Observation
9/14/38	1353.00	Aerial Photo Estimates
5/27/51	1356.00	Aerial Photo Estimates
8/9/55	1360.00	Aerial Photo Estimates
8/6/58	1355.00	Aerial Photo Estimates
9/3/65	1355.00	Estimated
9/17/70	1356.30	Estimated
6/8/76	1359.37	DOW Field Survey
4/1/81	1361.10	DOW Field Survey
5/5/82	1363.20	Gauge
8/19/82	1363.30	Gauge
10/20/82	1362.70	Gauge
4/19/83	1362.90	Gauge
6/8/83	1362.44	Gauge
7/21/83	1362.65	Gauge
9/19/83	1362.23	Gauge
10/24/83	1362.38	Gauge
5/3/84	1363.30	Gauge
6/5/84	1363.11	Gauge
6/25/84	1363.62	Gauge
8/1/84	1363.34	Gauge
10/5/84	1362.90	Gauge
10/19/84	1363.83	Gauge
11/14/84	1364.18	Gauge
4/17/85	1365.04	Gauge
4/16/86	1365.57	Gauge
7/11/86	1366.17	Gauge
8/27/86	1366.23	Gauge
10/9/86	1366.89	Gauge
4/28/87	1364.61	Gauge

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.

ORDINARY HIGH WATER LEVEL (OHW)

The Ordinary High Water level (OHW)[2] for Moon Lake has been determined by the Department of Natural Resources, Division of Waters in accordance with Minnesota Statute § 105.37, Subdivision 16. OHW data was obtained from field surveys completed on August 28, 1986, and the subsequent analysis indicated the OHW to be at elevation 1365.1'.

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 such as cattails will follow lake levels as they rise and fall and therefore 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

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[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.

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 Moon Lake level fluctuations have been 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) and, to reflect current antecedent conditions a known autumn, 1986 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 estimates potential future levels 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 Moon Lake the WATBUD model was calibrated for the period May, 1984 through August, 1986 using monthly precipitation from Alexandria and pan evaporation data from Morris. The initial lake level of 1363.6', the control elevation of the recently constructed outlet, was used with monthly time series precipitation data from 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 1363.7' on December 1, 1987 and a one-percent probability the lake will exceed elevation 1363.7' on December 31, 1991. Conversely, probabilities exist which state the likelihood the lake elevation may fall. There is a one-percent probability the lake may fall below elevation 1362.2' by December 1, 1987 and a one-percent probability the lake may fall below elevation 1361.2' on December 31, 1991. The modeling results also suggest a 50-percent probability (a 50/50 chance) that the lake will be at elevation 1363.3' on December 1, 1987 and 1363.2' 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 major 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 starting water surface lake elevation of 1363.6', the 100-year, 24 hour duration event of 5.6 inches of precipitation would result in a lake level increase of 1.3 feet to elevation 1364.9' and the 100-year, 10 day runoff of 6.5 inches would result in a lake level increase of 1.5 feet to elevation 1365.1'.

The above analyses show that the major storm events, and not the long-term precipitation series discussed above, will have the most detrimental impact on increasing water levels. This is a direct effect of the recently constructed outlet. A single 100-year, 24 hour event can cause a 1.5' bounce in the lake's level. A management plan must consider the potential for a number of these significant storm events over a period of time such as summer (April-September). If multiple storm events were to occur over a summer, with only a restricted outlet in place, a long-term flooding situation could occur.

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 Moon Lake. These base data were collected in April of 1987, when the lake was at elevation 1364.61'. While the potential maximum elevation of Moon Lake is unknown, it was felt surveying structures within an approximate 5-6' vertical elevation above elevation 1364.61' 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 : 1367.36'
Ground Elevation: 1364.36'

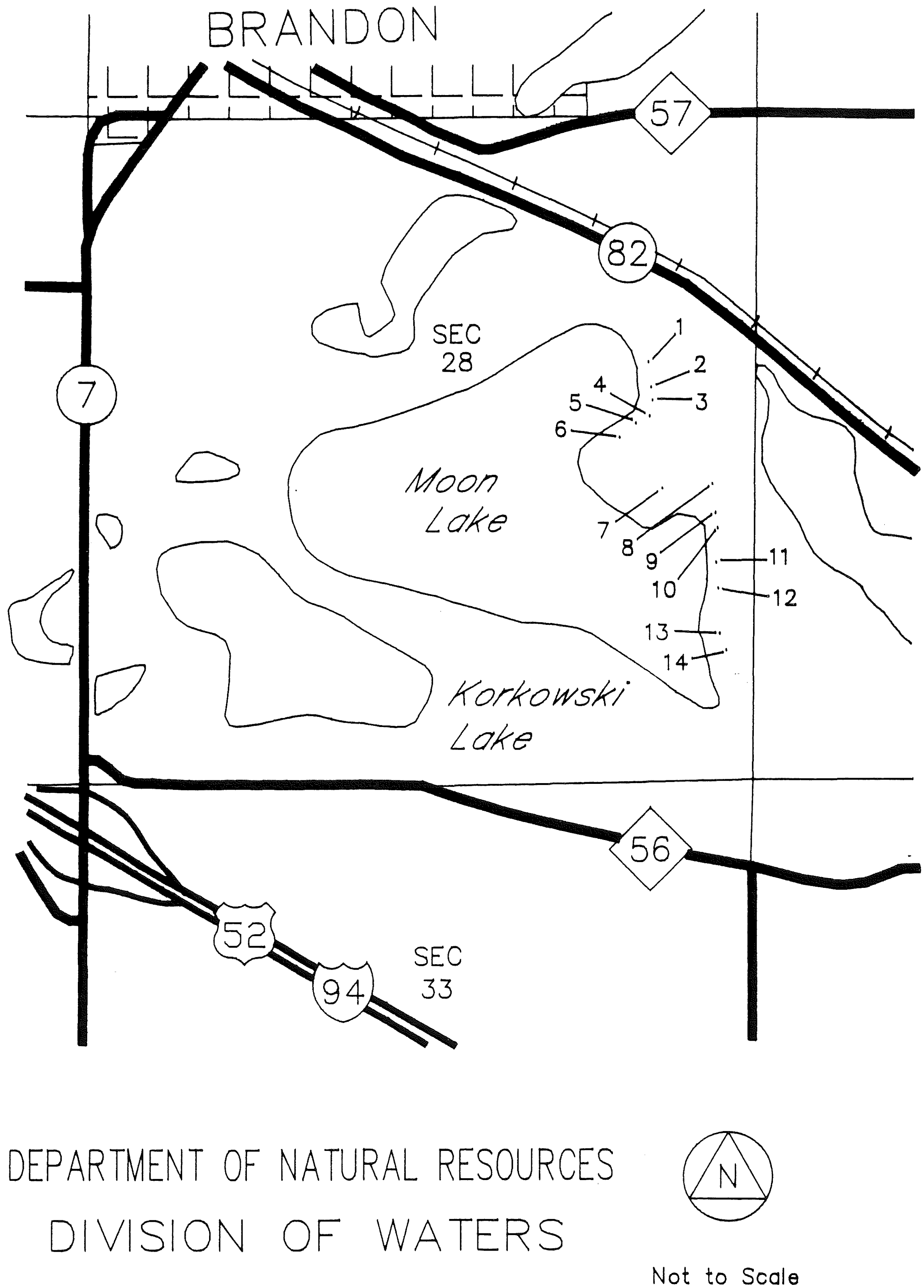
Basement : Yes
Walkout : Yes

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

Total Value : $40,500.00

STRUCTURE PHOTO PROVIDED

PLATE 7



DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS

Not to Scale

Potential structural losses for Moon Lake can be viewed from two different viewpoints:

<u>First</u> - 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 1364.61' and 1368.61' would be $69,789.

<u>Second</u> - 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 and this figure includes the additional damages to structures that were already under water at the time of the survey. At elevation 1368.61', an estimated $115,108 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 17 and 18 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 30-34 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 at or below elevation 1364.61 presently flooded[1]	4[5]	$ 500	N/A	N/A	N/A				
	5[5]	500	N/A	N/A	N/A				
	7	15,183	1366.61	N/A	1364.61				
	2	12,265	1366.61	N/A	1364.61				
	1	11,159	1366.96	N/A	1364.61				
	11	9,218	1368.31	N/A	1364.61				
	10	12,603	1366.61	N/A	1364.61				
New damages between elevation 1364.62 and 1365.61	6	12,909	1367.71	N/A	1364.71	$ 12,909	$ 3,227	$ 12,909	$ 3,227
New damages between elevation 1365.62 and 1366.61	12	8,878	1367.91	N/A	1365.91	$ 19,610	$ 34,940	$ 32,519	$ 38,167
	3	500	1365.94	N/A	N/A				
	9	10,732	1368.01	N/A	1366.01				
New damages between elevation 1366.62 and 1367.61	14	8,763	1366.96	N/A	N/A	$ 18,944	$ 27,313	$ 51,463	$ 65.480
	13	10,181	1367.36	N/A	N/A				
New damages between elevation 1367.62 and 1368.61	8	18,326	1368.56	N/A	N/A	$ 18,326	$ 49,628	$ 69,789	$115,108

[1] Moon Lake's water surface elevation was 1364.61' in April of 1987, which was the time the structure elevation data were collected.
[2] 1987 estimated market value supplied by County Assessor.
[3] Estimated crawlspace/block foundation 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 flood.

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

The reader should be cautioned these figures do not include any allowance for contents damage because of the uncertainty 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] Structures #4 and #5 were flooded, therefore no elevations were recorded.

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

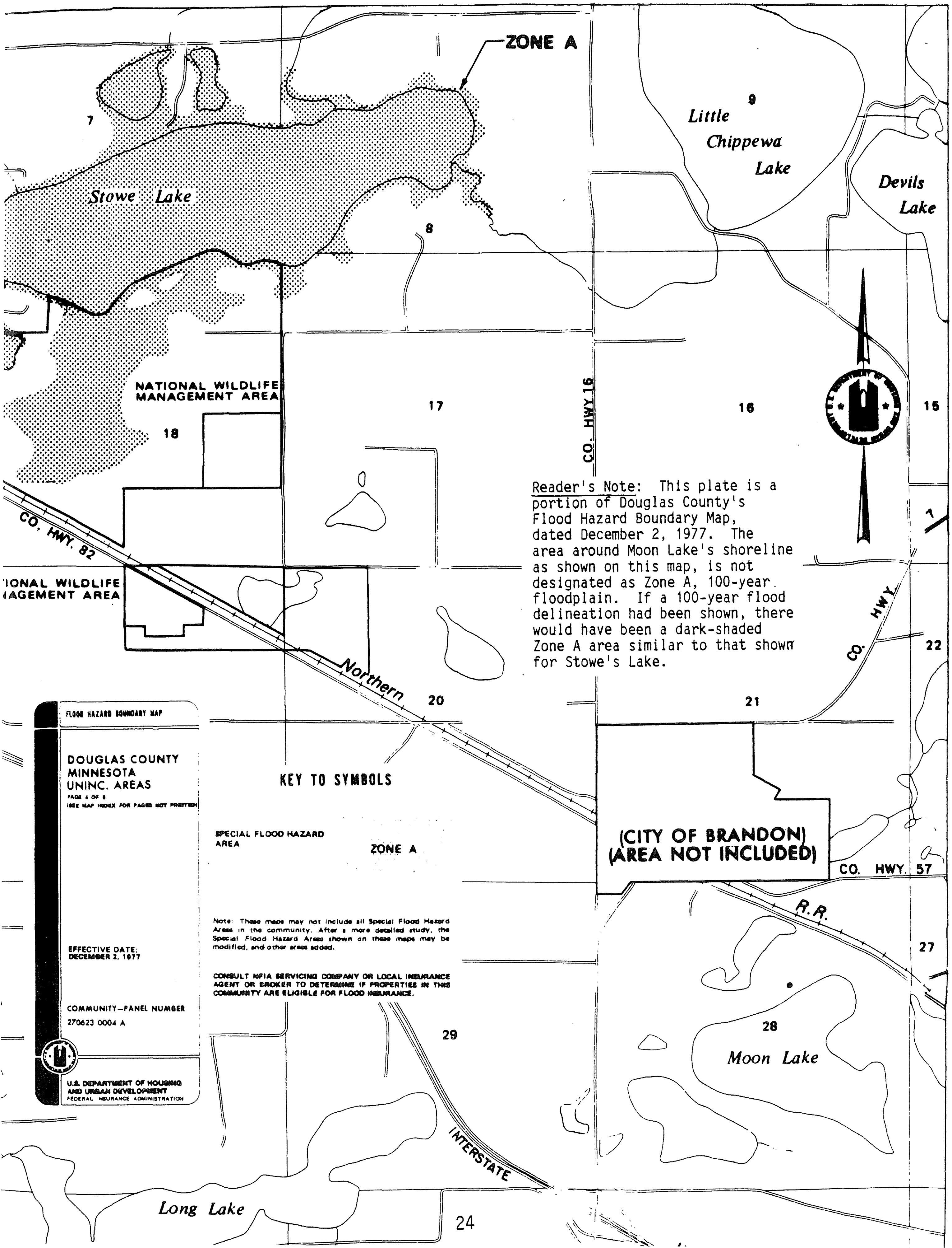
Landowners adjacent to Moon Lake can purchase flood insurance through Douglas County's eligibility in the National Flood Insurance Program (NFIP). Actually, all property owners and renters in the unincorporated areas of Douglas County can purchase flood insurance regardless of whether or not the property 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 (Plate 8) dated December 2, 1977 indicates a flood hazard delineation has not been provided for Moon Lake. The significance of a lack of a flood hazard delineation will be discussed in greater detail below and on Pages 29-30 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 all unincorporated areas of the County, and everyone would pay the same flood insurance premium regardless of risk.

PLATE 8


ZONE A
Little Chippewa Lake
Stowe Lake
Devils Lake
7
8
9
NATIONAL WILDLIFE MANAGEMENT AREA
17
18
16
15
CO. HWY 16
Reader's Note: This plate is a portion of Douglas County's Flood Hazard Boundary Map, dated December 2, 1977. The area around Moon Lake's shoreline as shown on this map, is not designated as Zone A, 100-year floodplain. If a 100-year flood delineation had been shown, there would have been a dark-shaded Zone A area similar to that shown for Stowe's Lake.
CO. HWY. 82
IONAL WILDLIFE
IAGEMENT AREA
Northern
20
21
22
CO. HWY
FLOOD HAZARD BOUNDARY MAP
DOUGLAS COUNTY
MINNESOTA
UNINC. AREAS
PAGE 4 OF 8
(SEE MAP INDEX FOR PAGES NOT PRINTED)
EFFECTIVE DATE:
DECEMBER 2, 1977
COMMUNITY–PANEL NUMBER
270623 0004 A
U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
FEDERAL INSURANCE ADMINISTRATION
KEY TO SYMBOLS
SPECIAL FLOOD HAZARD AREA
ZONE A
Note: These maps may not include all Special Flood Hazard Areas in the community. After a more detailed study, the Special Flood Hazard Areas shown on these maps may be modified, and other areas added.
CONSULT NFIA SERVICING COMPANY OR LOCAL INSURANCE AGENT OR BROKER TO DETERMINE IF PROPERTIES IN THIS COMMUNITY ARE ELIGIBLE FOR FLOOD INSURANCE.
(CITY OF BRANDON)
(AREA NOT INCLUDED)
CO. HWY. 57
R.R.
27
28
29
Moon Lake
INTERSTATE
Long Lake

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 increased 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 acoordingly.

The County, State and FEMA have all tentatively agreed that the current Flood Hazard Boundary Map for Doulgas County 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 Moon 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 Moon 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?

Landlocked lakes with no outlets or limited flow artificial outlets do not react to high water like streams/rivers and waterbodies with more efficient 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 Moon can increase and decrease in elevation very slowly over a long period of time. While the NFIP will judge each land-locked lake with a high water problem individually, a general condition of flooding had been determined to exist on Moon 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 17 and 18 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 Moon Lake. If the lake should continue to rise, a dampening effect would occur as the lake reaches its runout elevation at elevation 1363.6'. 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 Moon 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 1363.6' Moon Lake would bounce 1.3' upward during a 100-year, 24 hour rainfall event and 1.5' upward to elevation 1365.1' for a 100-year, 10-day rainfall event. The situation would be worse if significant rainfall events had preceded the 100-year 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 consider purchasing flood insurance.

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

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

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

A discussion on basement coverage will be provided here. 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 Moon 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 Moon 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 Moon 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 Moon Lake.

The obvious question is what prudent course of action should Douglas County take when regulating new development adjacent to Moon 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/modifications/substantial repairs of existing construction should be elevated with the lowest floor (including basement) to 3' above the highest known water level. On Moon Lake, this is elevation 1366.89' + 3' or elevation 1369.89', NGVD-1929; however, since the lake does have a small (12" diameter) artificial drainage outlet, the Department feels that a more realistic elevation of 3' above the Ordinary High Water level would be acceptable (3' + 1365.1' = 1368.1'). Further justification for the recommended flood protection elevation of 1368.1' is due to the fact that the highest water elevation for which there is some physical evidence is 1368.2' and which occurred in the historical past.

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

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

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 <u>mandatory</u> 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 <u>approximate</u> Zone A on the FIRM better facilitate the future regulation of new development adjacent to Moon 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 Moon 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 at or near 1363.6' would cause the lake level to rise only to elevation 1365.1'. Evidence shows the lake was at or near 1368.2' in the past and the Department feels that 1368.1' (3' above the OHW) is by far the most prudent lon-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 County's current shoreland ordinance requires a lowest floor level of 1369.89' but a flood protection level for Moon Lake of 1368.1' (3' above the OHW) is reasonable in the eyes of DNR.

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 potential 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 9 and 10 provide a number of potential emergency protection measures. The decision to employ any given measure will depend on the site-specific flooding situation. These emergency protection measures are presented here so as to inform the reader of the general design factors which must be considered. The reader is cautioned that an engineer or architect and the local building code official should be consulted prior to the design of emergency flood protection measures.

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

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

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

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

The reader is requested to pay special attention to the discussion of levees and filling around structures on Plates 9 and 10 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.

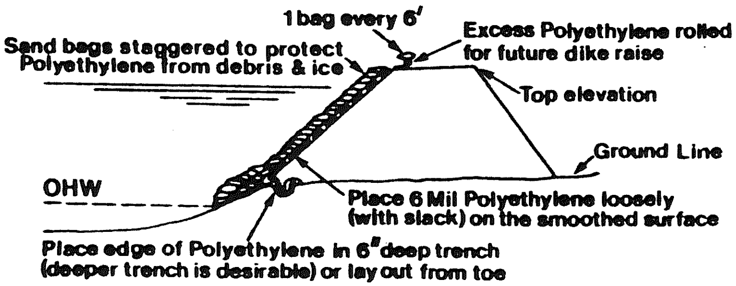
Secondly, fill could be placed around an existing building to keep surface water away. It is likely that the fill material adjacent to the building will become saturated because of the potentially long duration of the high water and the porosity of the soil. Water pressure will likely build on the outside 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 9
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

EARTHEN LEVEE



SECTION

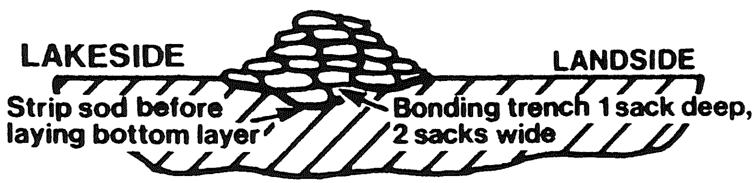
GENERAL DESIGN CONSIDERATIONS

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

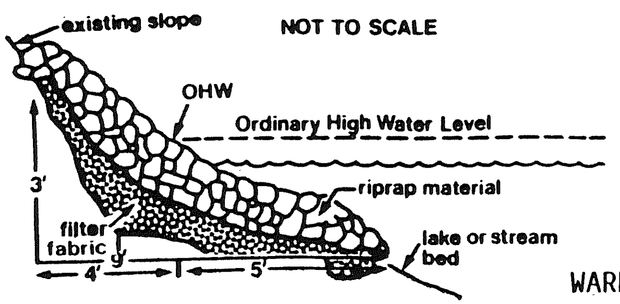


SECTION

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.

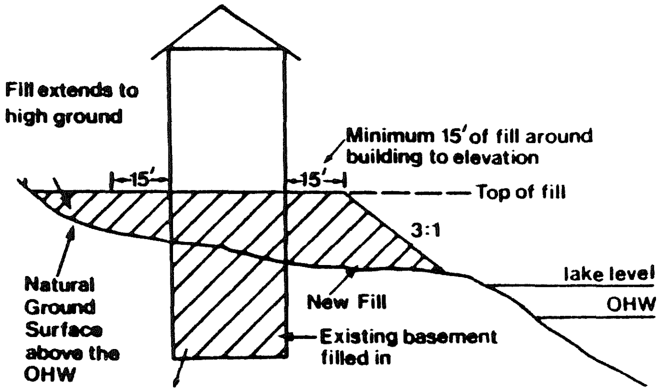
WARNING: Fill placed below the Ordinary High Water Level may require a permit.

PLATE 10

FLOOD PROTECTION MEASURES

TYPE OF PROTECTION

ELEVATED STRUCTURE (PERMANENT)

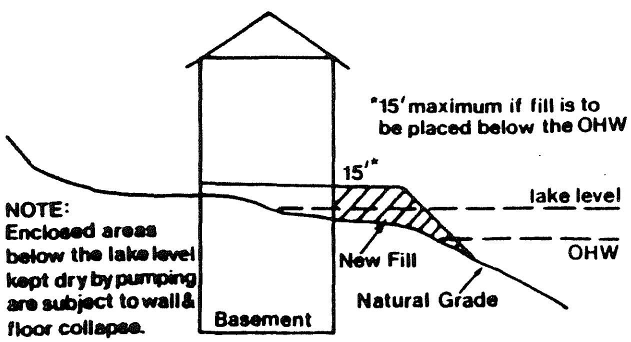


NOTE: Enclosed areas below the lake level intentionally kept dry by pumping are subject to wall and floor collapse.

GENERAL DESIGN CONSIDERATIONS

- 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 Moon 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. Moon Lake has been identified as a public water (Basin 226) 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 1365.1', the Ordinary High Water Elevation (OHW) for Moon 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.

A DNR permit would be required: 1) to lower the lake below 1365.1'; or 2) to control the lake at an elevation above 1365.1', 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 1.5 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 Moon 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 Moon 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 local sponsor and non-federal cost-sharing. Generally, the local sponsor must provide the lands, easements and rights-of-way necessary to construct the project or approximately 35% of the total project, whichever is greater. A political entity must sponsor the project and eventually enter into contractual agreements to insure all guarantees and cost-sharing commitments are met (the reader should refer to the next section on institutional arrangements).

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

SMALL CITIES DEVELOPMENT PROGRAM

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

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

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

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

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

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

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

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

-Benefit low and moderate income people;

-Eliminate slum or blight; or

-Eliminate threats to public health and safety.

Inquiries should be addressed to:

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

State Assistance Programs

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 in November of 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 at the time of loss 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.

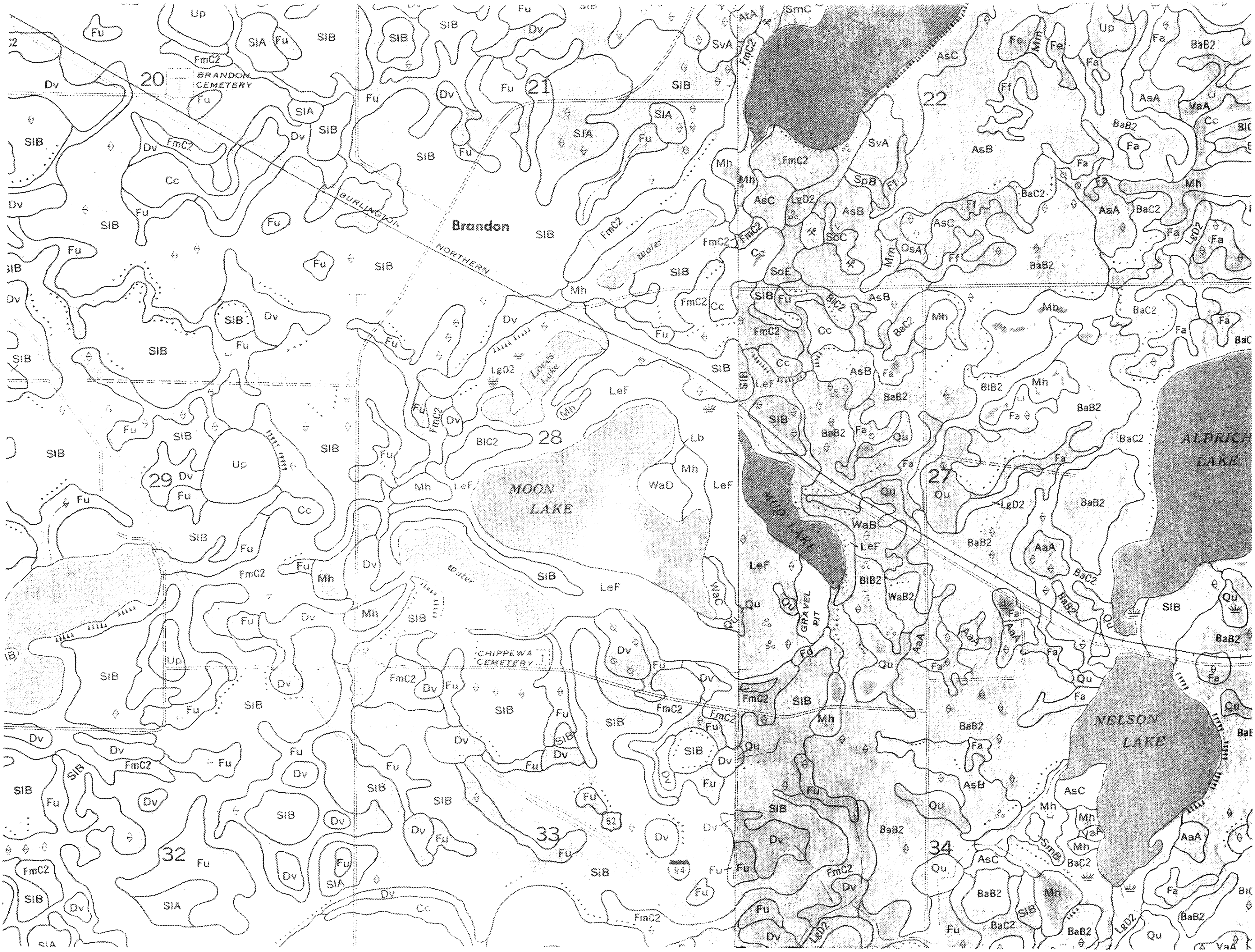
Watershed districts are suited to resolving multiple water resource issues over a large area. As noted earlier, there is no upper or lower limit on the geographic area which may be included in a watershed district. Establishment of a watershed district requires development of an overall plan, adoption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

Questions concerning watershed districts should be directed to:

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

APPENDIX A

SOIL TYPES AND CHARACTERISTICS


20
BRANDON CEMETERY
21
22
Brandon
BURLINGTON NORTHERN
Loves Lake
28
MOON LAKE
MUD LAKE
GRAVEL PIT
27
ALDRICH LAKE
29
CHIPPEWA CEMETERY
NELSON LAKE
32
33
34
52
94

SOIL SURVEY FOR MOON LAKE - DOUGLAS COUNTY

MAP SYMBOL	SOIL CLASSIFICATION	% SLOPE
AaA	Aastad clay loam	1-3
AsB	Arvilla sandy loam	0-2
AsC	Arvilla sandy loam	6-12
AtA	Arvilla sandy loam, thick solum	0-3
BaB2	Barnes loam, eroded	2-6
BaC2	Barnes loam, eroded	6-12
BIB2	Barnes-Langhei loam, eroded	2-6
BIC2	Barnes-Langhei loam, eroded	6-12
Cc	Cathro muck	
Dv	Dovray mucky silty clay	
Fa	Flom silty clay loam	
Fe	Forada loam, depressional	
Ff	Forada sandy loam, sandy subsoil	
FmC2	Forman clay loam, eroded	6-12
Fu	Fulda silty clay	
LeF	Langhei loam	18-40
LgD2	Langhei-Barnes loams, eroded	12-18
Mh	Marsh	
Mm	Marysland loam	
OsA	Osakis loam	0-3
Qu	Quam mucky silty clay loam	
SIA	Sinai clay	0-2
SIB	Sinai clay	2-6
SmB	Sioux loamy coarse sand	0-6
SmC	Sioux loamy coarse sand	6-12
SoC	Sioux gravelly loamy coarse sand	2-12
SoE	Sioux gravelly loamy coarse sand	12-35
SpA	Sverdrup sandy loam	0-2
SpB	Sverdrup sandy loam	2-6
SvA	Sverdrup loam, thick solum	0-3
Up	Urness mucky silt loam, peaty subsoil variant	0-3
WaB	Waukon loam	2-6
WaB2	Waukon loam, eroded	2-6
WaC	Waukon loam	6-12
WaD	Waukon loam	12-18

SOIL SURVEY FOR MOON LAKE - DOUGLAS COUNTY

Aastad clay loam, 1 to 3 percent slopes (AaA).

This soil has straight or slightly concave slopes and occurs in irregular patterns on till plains and in morainic areas.

Included in mapping were small areas of Barnes, Flom, and Darnen soils. Also included were some small areas of steeper soils and some areas where the surface layer is calcareous in a few places the black surface layer is thicker than normal, and in some areas the surface layer is loam.

This soil has few limitations. It is suited to all the crops commonly grown in the county.

The main management need is maintenance of fertility and tilth.

Arvilla sandy loam, 2 to 6 percent slopes (AsB).

This soil is gently sloping and undulating. It is in outwash areas and on uplands. The areas are variable in size and shape. Slopes are 50 to 250 feet long. There are many narrow drainageways and small depressions scattered throughout the areas. This soil has the profile described as representative for the series.

Included in mapping were a few small areas of excessively drained Sioux soils, moderately well drained Osakis soils, and poorly drained Forada soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, spots of eroded soils, and areas where the surface layer is loam. Some areas are moderately eroded.

Nearly all this soil is used for cultivated crops. A few areas are used for pasture. This soil is suited to all crops commonly grown in the county, but it is better suited to early maturing crops because of the drought hazard. This soil is suited to irrigation, and field crops and vegetables can be irrigated. Water runs off at a medium rate. The hazard of further erosion is moderate.

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

Arvilla sandy loam, 6 to 12 percent slopes (AsC).

This sloping to rolling soil is in outwash areas and on uplands. The areas lie parallel to waterways or around sloughs. Slopes are irregularly shaped and are 50 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow to gravelly coarse sand.

Included in mapping were small areas of excessively drained Sioux soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, eroded spots, and areas where the surface layer is loam.

Nearly all of this soil is used for cultivated crops. A few areas are used for pasture. This soils is suited to all crops commonly grown in the county. Droughtiness is a serious limitation. Water runs off this soil at a medium to rapid rate. The hazard of further erosion is moderately severe.

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

Arvilla sandy loam, thick solum, 0 to 3 percent slopes (AtA).

This soil occurs in outwash areas of the county. It is nearly level to slightly depressed. The areas are variable in size and shape, but some areas are quite large. The profile differs from the one described as representative for the series in having a 22 to 36-inch combined surface layer and subsoil over the underlying gravelly coarse sand.

Included in mapping were small areas of well drained Arvilla soils, moderately well drained Osakis soils, and poorly drained Forada soils. In some places the depth to gravel is less than 22 inches. In a few places mottles are present in the lower part of the subsoil and some places have small areas of steeper soils. Some areas have a surface layer of loam.

Nearly all of this soil is used for cultivated crops. A few areas are used for pasture. This soil is suited to all crops commonly grown in the county. This soil has a slight drought hazard. Soil blowing is a hazard on bare fields in 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, conserve moisture, and maintain fertility.

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.

Barnes loam, 6 to 12 percent slopes, eroded (BaC2).

This is a rolling soil that occurs along the sides and around the heads of drainageways and around depressions. The slopes are complex and are 50 to 250 feet long. Along some of the drainageways and around some of the sloughs, slopes are more uniform. The profile differs from the one described as representative for the series in being thinner in most places. This soil has a plow layer that consists of the original surface layer mixed with some material from the subsoil because it is eroded.

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, areas of uneroded soils, and spots where there are stones on the surface. 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, a few other areas that have a surface layer of sandy loam were included.

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. Water runs off this soil 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.

Barnes-Langhei loams, 2 to 6 percent slopes, eroded (BIB2).

These soils are undulating. The areas vary in size and shape, have convex and concave relief, and are 50 to 200 feet long. Barnes soil makes up 60 to 80 percent of the areas where the slopes are more uniform. Langhei soil makes up 20 to 40 percent of the areas where the slopes are convex and more exposed. The surface layer of the Langhei soils is light gray when dry. The Barnes and Langhei soils occur in such an intricate pattern that it is not practical to map them separately. This unit is moderately eroded, and the soils have a surface layer that consists of the original surface layer mixed with moderate amounts of material from the subsoil.

Included in mapping were small areas of moderately well drained Aastad and Darnen soils and of poorly drained Flom and Vallers soils. Also included were small areas of steeper soils, gravelly soils, and severely or slightly eroded soils. In addition, some areas where stones are scattered on the surface were included.

Nearly all the acreage is used for cultivated crops. A few areas are used for pasture. These soils are suited to all crops commonly grown in the county. Langhei soil is less suited to crops than Barnes soils because of the nutrient imbalance caused by the high content of lime. Surface runoff is medium, and the hazard of erosion is moderate.

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

Barnes-Langhei loams, 6 to 12 percent slopes, eroded (BIC2).

These soils are rolling. The areas vary in size and shape and have complex topography. Slopes are 75 to 250 feet long. Barnes soil makes up 50 to 70 percent of the area, and Langhei soil, 30 to 50 percent. Barnes soil occurs on the more uniform parts of the side slopes, and Langhei soil is on the exposed knobs, ridges, and knolls. This unit has been moderately eroded, and the surface layer is a mixture of the original surface layer and moderate amounts of material from the subsoil. This gives the surface layer of the Barnes soil a dark-brownish color and the Langhei soil 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 more strongly sloping soils, small areas of less sloping soils, areas of gravelly soils, areas of severely or slightly eroded soils, and areas where stones were scattered on the surface.

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

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.

Dovray mucky silty clay (Dv).

This soil is nearly level. It is in depressions and potholes. It is flooded in spring and often throughout the entire year.

Included in mapping were some small areas of Fulda and Cathro soils. Also included were some areas of Dovray soil that does not have a mucky surface layer and some areas where the soil is black to a depth of more than 60 inches.

If undrained, this soil is covered with marsh vegetation consisting of reeds, sedges, and rushes. These undrained areas provide excellent food and cover for wildlife. Many of these areas can be improved by digging or blasting level ditches or trenches to provide additional open water.

If drained, this soil is suited to all crops common in the county. It is better suited to corn and soybeans than to small grains, because small grains have a tendency to lodge.

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

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.

Forada loam, depressional (Fe).

This soil occupies depressions and drainageways in outwash areas. The areas generally are circular or oblong in shape. This soil is flooded in spring and often throughout the entire year. The profile differs from the one described as representative for the series in commonly having a black loam surface layer 16 to 24 inches thick. In addition, this oil is very poorly drained.

Included in mapping were small areas of Forada sandy loam and of Marysland loam, depressional. Also included were areas where the surface layer is clay loam, silt loam, or silty clay loam.

If undrained, this soil is generally covered with marsh vegetation consisting of reeds, sedges, rushes, and, in some areas, willows. These undrained areas are well suited to wildlife habitat. They provide nesting, mating, and escape cover for wildlife.

If drained, this soil is used for crops, hay, and pasture. If adequately drained, this soil is suited to all crops commonly grown in the county.

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

Forada sandy loam, sandy subsoil (Ff).

This soil is nearly level. It occurs in upland drainageways and on outwash plains. The drainageways are 50 to 200 feet wide, and the areas on outwash plains vary in size and shape. The profile differs from the one described as representative for the series in being underlain by sand at a depth of 22 to 40 inches.

Included in mapping were small areas of Dassel, Forada, and Arveson soils and areas where the surface layer is loam.

This soil is used for crops and pasture. It has a fluctuating water table and needs additional drainage. If adequately drained, all crops common in the county can be grown. Soil blowing is a hazard on bare fields during winter and spring.

The main management needs are drainage, control of erosion, and maintenance of fertility.

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.

Fulda silty clay (0 to 2 percent slopes) (Fu).

This soil is slightly depressed to nearly level. It is in swales and drainageways. The areas are variable in size and shape and are commonly surrounded by more strongly sloping soils.

Included in mapping were small areas of Sinai and Dovray soils. In some areas the surface layer is calcareous. In some areas there is clay loam till within a depth of 42 inches.

This soil is not well suited to cultivation unless it is drained. If adequately drained, it is suited to all crops commonly grown in the county. Some areas are used for pasture or wildlife habitat. Open ditches provide adequate drainage in most years.

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

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.

Lanhei-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.

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.

Marysland loam (0 to 2 percent slopes) (Mm).

This soil is nearly level or slightly depressed. The areas generally are broad, irregular in shape, and variable in size. A few areas are waterways. This soil has the profile described as representative for the series.

Included in mapping were small areas of Arveson, Forada, and Osakis soils. Also included were a few areas where the soil is deeper over sand and gravel than in the representative profile.

This soil is used for cultivated crops and pasture. It is not well suited to cultivation unless drained. If adequately drained, this soil is suited to all crops common in the county. Soil blowing is a limitation on fields that are left bare in winter and spring.

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

Osakis loam, 0 to 3 percent slopes (OsA).

This soil occurs on the outwash plains of the county. Areas are variable in size and shape. This soil generally occurs next to areas of Arvilla soils.

Included in mapping were small areas of Arvilla and Forada soils. Also included were small areas of more strongly sloping soils, areas where depth to gravel is more than 22 inches, and areas that are underlain by sand.

Nearly all of this soil is used for cultivated crops. A few small areas are used for pasture. This soil is suited to all crops commonly grown in the county, but it is better suited to early maturing crops because of the drought hazard. Soil blowing is a hazard on fields left unprotected in 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, conserve moisture, and maintain fertility.

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, 0 to 2 percent slopes (SIA).

This soil is nearly level. It occurs in scattered areas throughout the county adjacent to drainageways and flat hilltops. The profile differs from the one described as representative for the series in being thicker.

Included in mapping were small areas of Dovray and Fulda soils. Also included were small areas of more strongly sloping soils.

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. Soil blowing is a hazard on unprotected fields during winter and spring. The main management needs are practices that control erosion and improve 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.

Sioux loamy coarse sand, 0 to 6 percent slopes (SmB).

This soil is nearly level to undulating. It occurs in outwash areas and on uplands. The areas are variable in size and shape. Slopes are 50 to 200 feet long. This soil has the profile described as representative for the series.

Included in mapping were small areas of Arvilla soils and Sioux gravelly loamy coarse sand. Also included were small areas of more strongly sloping soils.

This soil is used for cultivated crops, pasture, and woodland. It is poorly suited to crops commonly grown in the county because the hazard of drought is severe. There is a hazard of soil blowing on unprotected fields. The main management needs are practices that control erosion, improve fertility, and conserve moisture.

Sioux loamy coarse sand, 6 to 12 percent slopes (SmC).

This soil is rolling. It occurs in outwash areas and on uplands. The areas are variable in size and shape. Slopes are 50 to 200 feet long. The profile differs from the one described as representative for the series in being more shallow to gravel.

Included in mapping were small areas of Arvilla soils and Sioux gravelly loamy coarse sands. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are stony on the surface.

This soil is used for cultivated crops, pasture, and woodland. It is poorly suited to crops commonly grown in the county because the hazard of drought is severe. Soil blowing and water erosion are hazards on unprotected fields. The main management needs are practices that control erosion, improve fertility, and conserve moisture.

Sioux gravelly loamy coarse sand, 2 to 12 percent slopes (SoC).

This soil is gently sloping to rolling. It occurs in outwash area and on uplands. The areas are variable in size and shape. Slopes are 50 to 200 feet long. The profile differs from the one described as representative for the series in having a surface layer of gravelly loamy coarse sand.

Included in mapping were small areas of Arvilla soils and Sioux loamy coarse sand. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and areas that are stony on the surface. This soil is used for pasture and woodland. Some areas are cropped along with other soils, because these areas are too small to manage separately. This soil is suited to permanent vegetation. The hazard of drought is severe. Soil blowing and water erosion are hazards on unprotected fields. The main management needs are practices that control erosion, improve fertility, and conserve moisture.

Sioux gravelly loamy coarse sand, 12 to 35 percent slopes (SoE).

This soil is hilly to very steep. It occurs in outwash and morainic upland areas. The areas are irregular in size and shape. They are cut up by many drainageways. Slopes are 80 to 250 feet long. The profile differs from the one described as representative for the series in having a surface layer of gravelly loamy coarse sand.

Included in mapping were small areas of Sioux loamy coarse sand and areas where there are many surface stones.

Most areas are in permanent vegetation. Plants do not grow well, because of very low available water capacity. The hazards of soil blowing and water erosion are severe. The main management needs are practices that control erosion and conserve moisture.

Sverdrup sandy loam, 0 to 2 percent slopes (SpA).

Areas of this soil vary in size and shape. Some of the areas are extensive and occur on broad outwash plains. This soil has the profile described as representative for the series.

Included in mapping were small areas of Maddock, Clontarf, Arvilla, and Dassel soils. Also included were small areas of more strongly sloping soils, eroded areas, and sandy areas.

Nearly all 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 better suited to early maturing crops than to other crops because of the drought hazard. Soil blowing is a hazard on fields left unprotected 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, conserve moisture, and maintain fertility.

Sverdrup sandy loam, 2 to 6 Opercent slopes (SpB).

This soil is on the outwash plains along waterways and surrounding depressions. The areas vary in size and shape. Slopes are fairly uniform and 50 to 150 feet long. The profile differs from the one described as representative for the series in being more shallow to sand.

Included in mapping were small areas of Arvilla, Clontarf, and Maddock soils. Also included were small areas of less sloping soils, small areas of more strongly sloping soils, and eroded areas. Other inclusions were areas where the surface layer is loam and areas where the depth to sand is more than 22 inches.

Nearly all this soil is used for cultivated crops. A few areas are in pasture. All crops common in the county can be grown. This soil is better suited to early maturing crops than to other crops because of the droughty hazard. Soil blowing is a hazard on unprotected fields during winter and spring. Water erosion is also a hazard. This soil is suited to irrigation, and field crops and vegetables can be irrigated. The main management needs are practices that control erosion, conserve moisture, and maintain fertility.

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.

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, 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.

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: MOON

Lake Type: Panfish Lake
Dominant Forest/Soil Type: Not Available
Size of Lake: 126 Acres
Shorelength: NA
Maximum Depth: NA
Median Depth: NA

Secchi Disk Reading (water clarity): 4.0 feet
Lake Contour Map Number: D0086 (available at cost from Documents Division)
(Phone: 612-297-3000)

DEVELOPMENT CHARACTERISTICS FOR LAKE: MOON

Shoreland Zoning Classification: Natural Environment
Public Accesses in 1983: 0

FISH INFORMATION NOT AVAILABLE

PERMIT DATA FOR LAKE MOON

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

Permit Types	Number Issued	Number Denied
Public (Protected) Waters Permits	0	0
General Appropriation Permits Temporary Projects	2	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

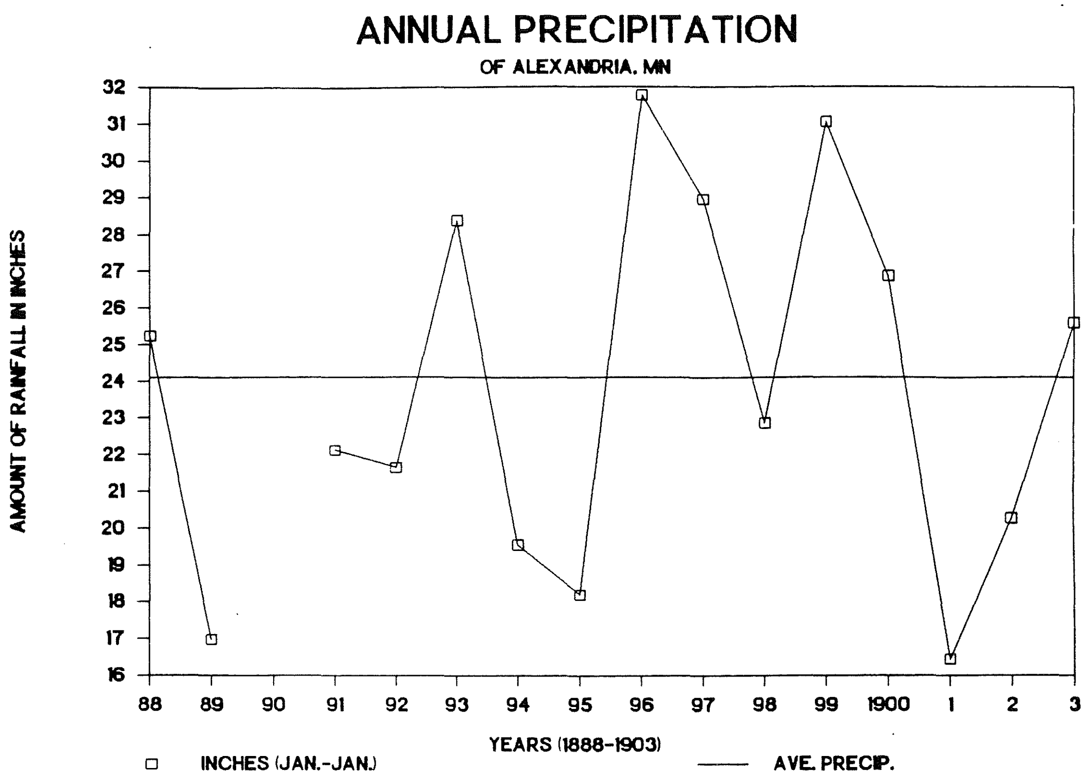
####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
112	1928	0.22	0.00	0.00	0.77	0.14	2.16	6.50	4.37	1.82	2.16	0.62	0.89	19.65
112	1929	0.19	0.50	1.38	2.32	1.81	0.85	2.78	3.10	3.95	2.02	0.38	0.11	19.39
112	1930	0.42	0.21	0.60	1.38	6.85	1.66	2.80	2.30	0.92	0.66	3.79	0.02	21.61
112	1931	0.00	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
32
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1900
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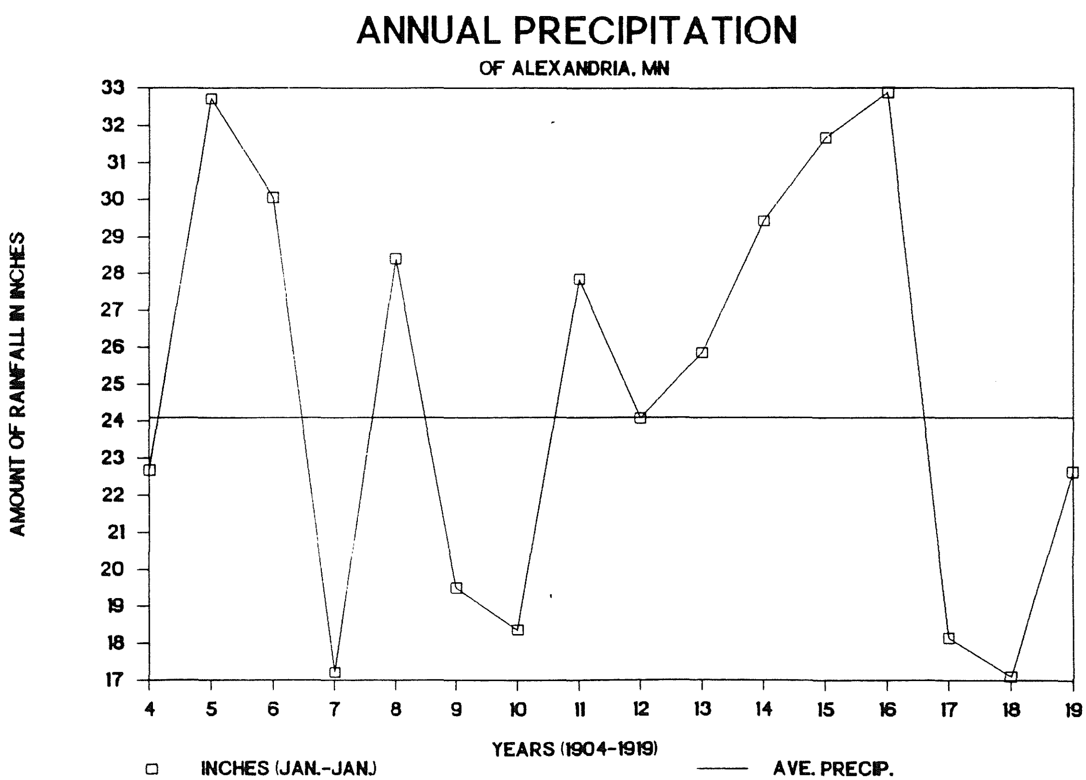
3
YEARS (1888-1903)
INCHES (JAN.-JAN.)
AVE. PRECIP.


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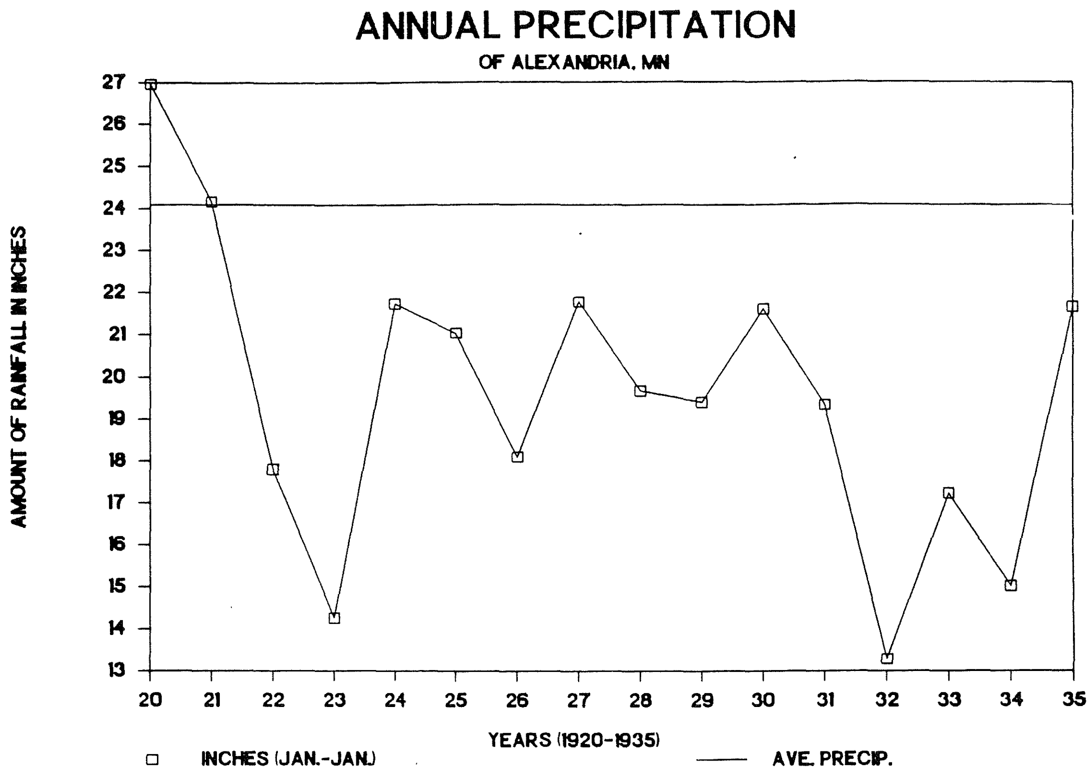
YEARS (1904-1919)
INCHES (JAN.-JAN.)
AVE. PRECIP.



ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
AMOUNT OF RAINFALL IN INCHES
27
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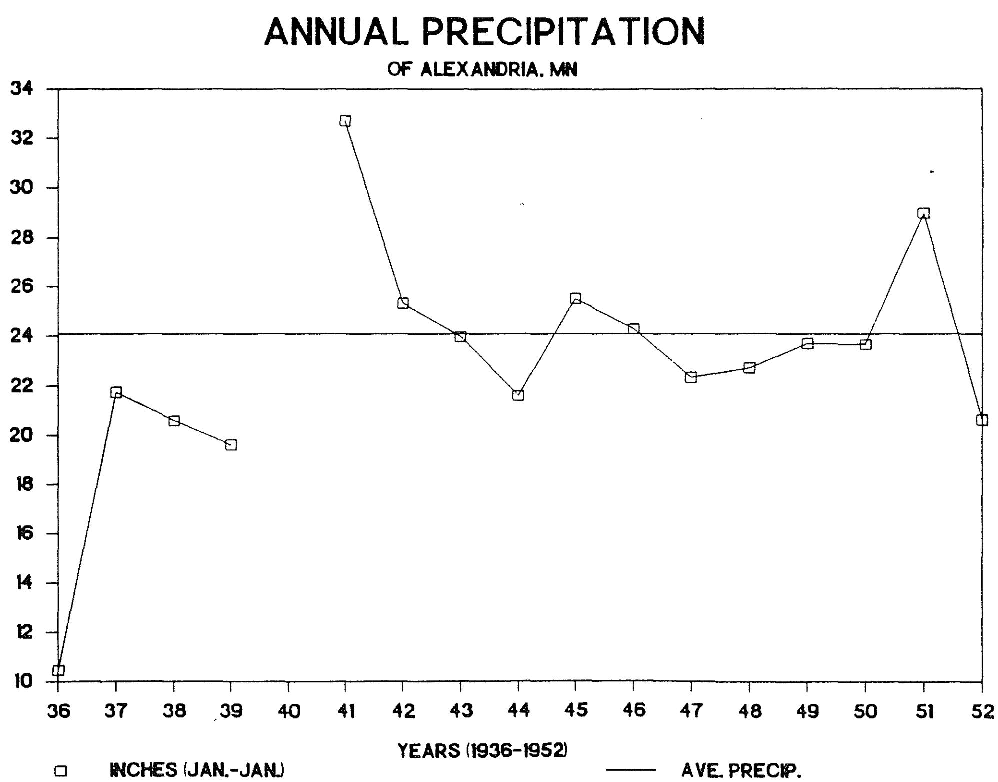
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
YEARS (1920-1935)
INCHES (JAN.-JAN.)
AVE. PRECIP.



ANNUAL PRECIPITATION
OF ALEXANDRIA, MN
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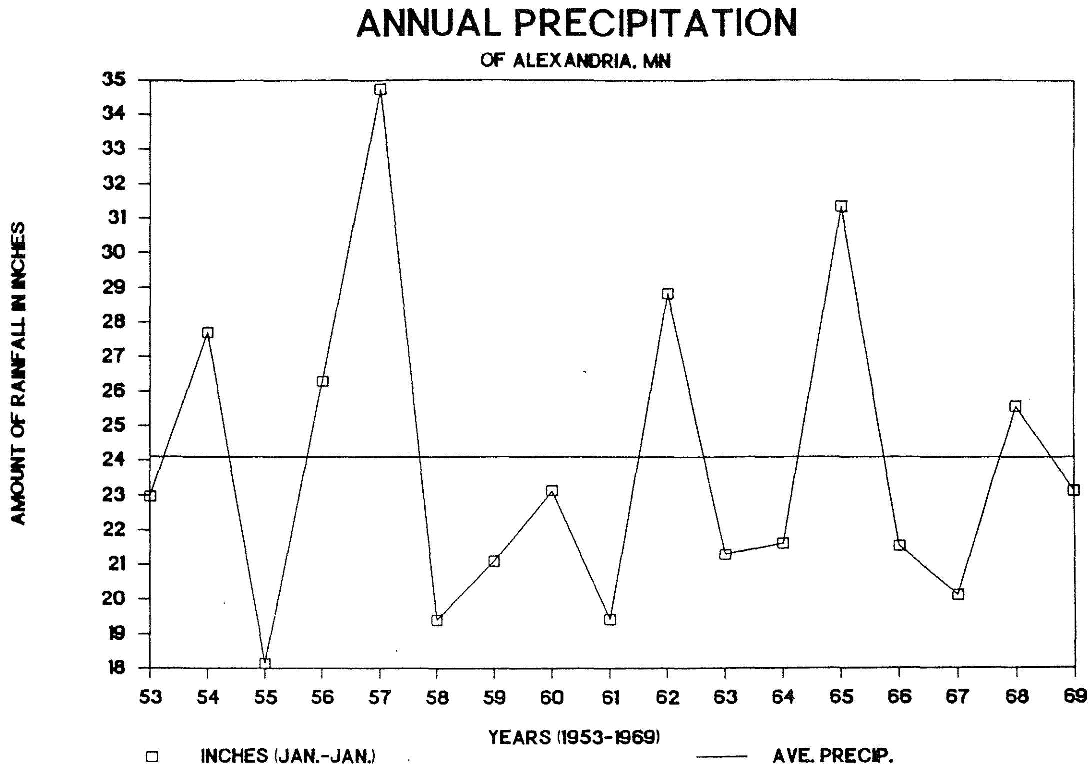
36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
YEARS (1936-1952)
INCHES (JAN.-JAN.)
AVE. PRECIP.


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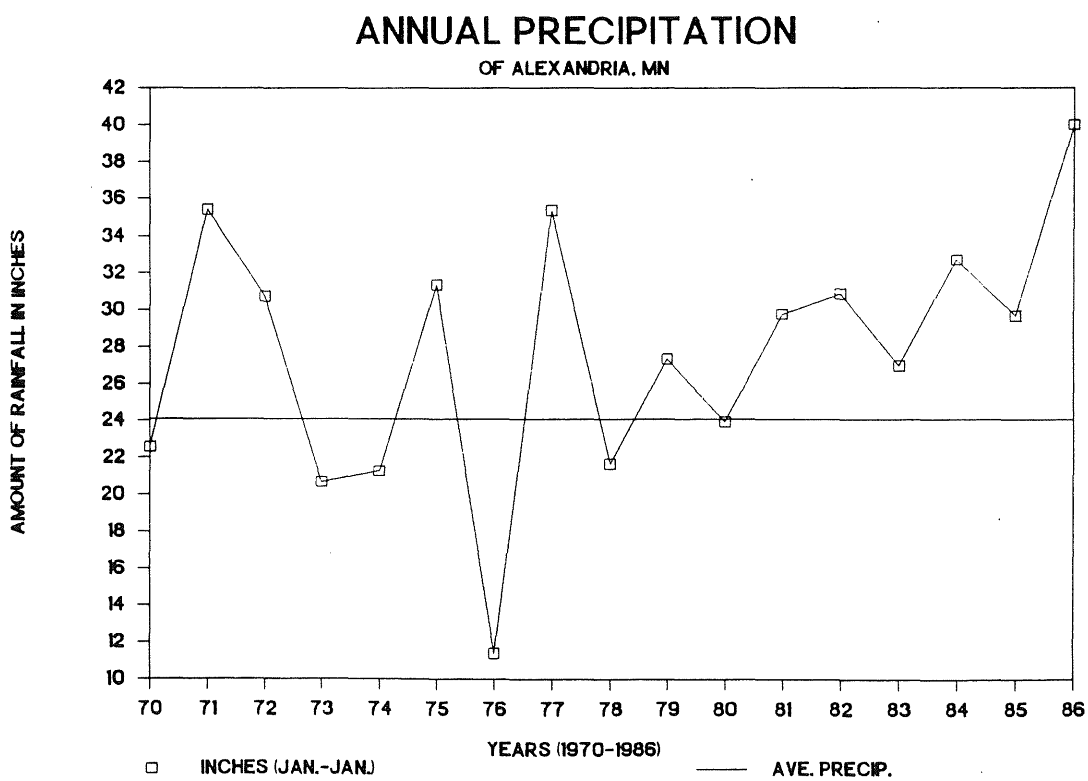
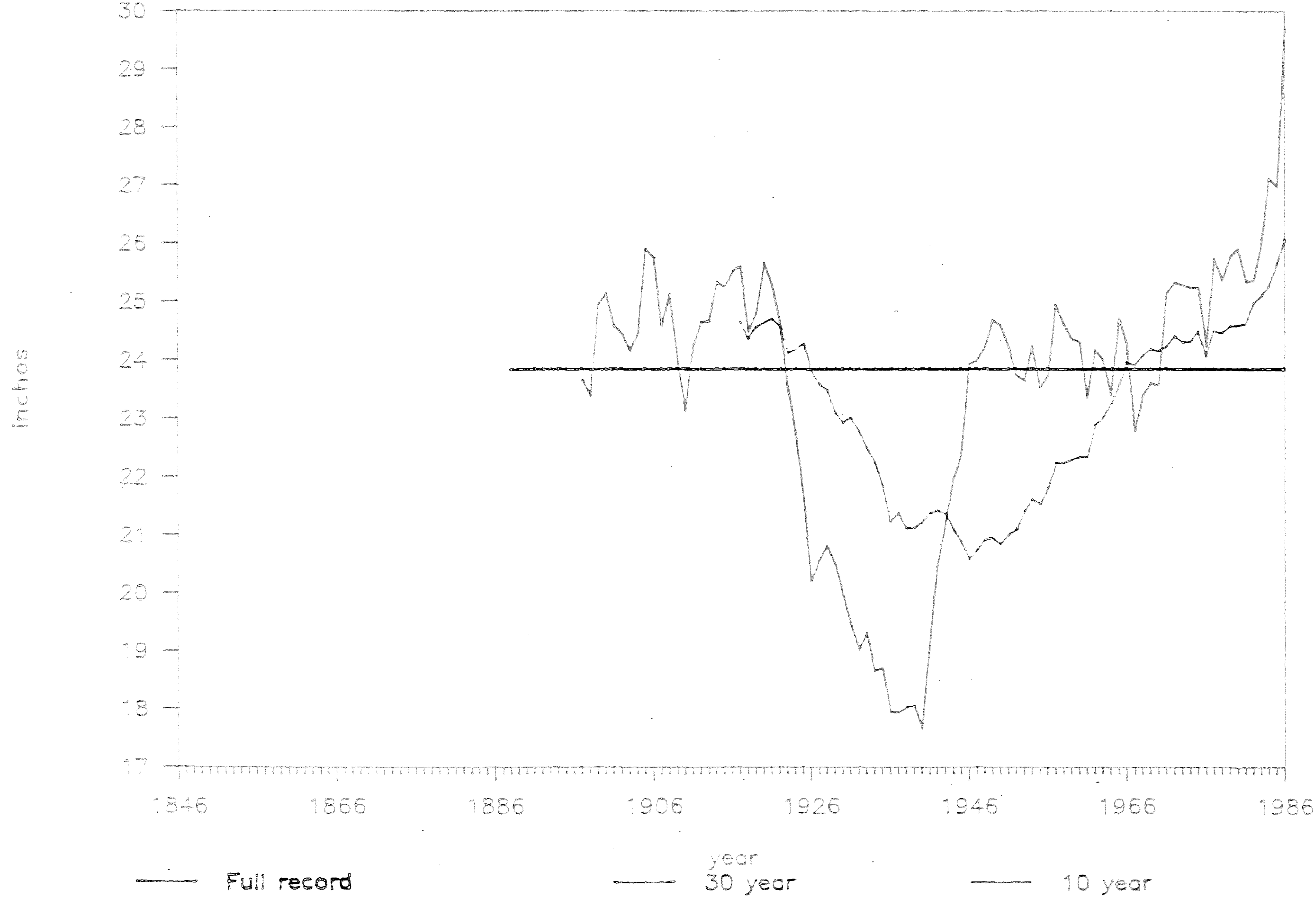
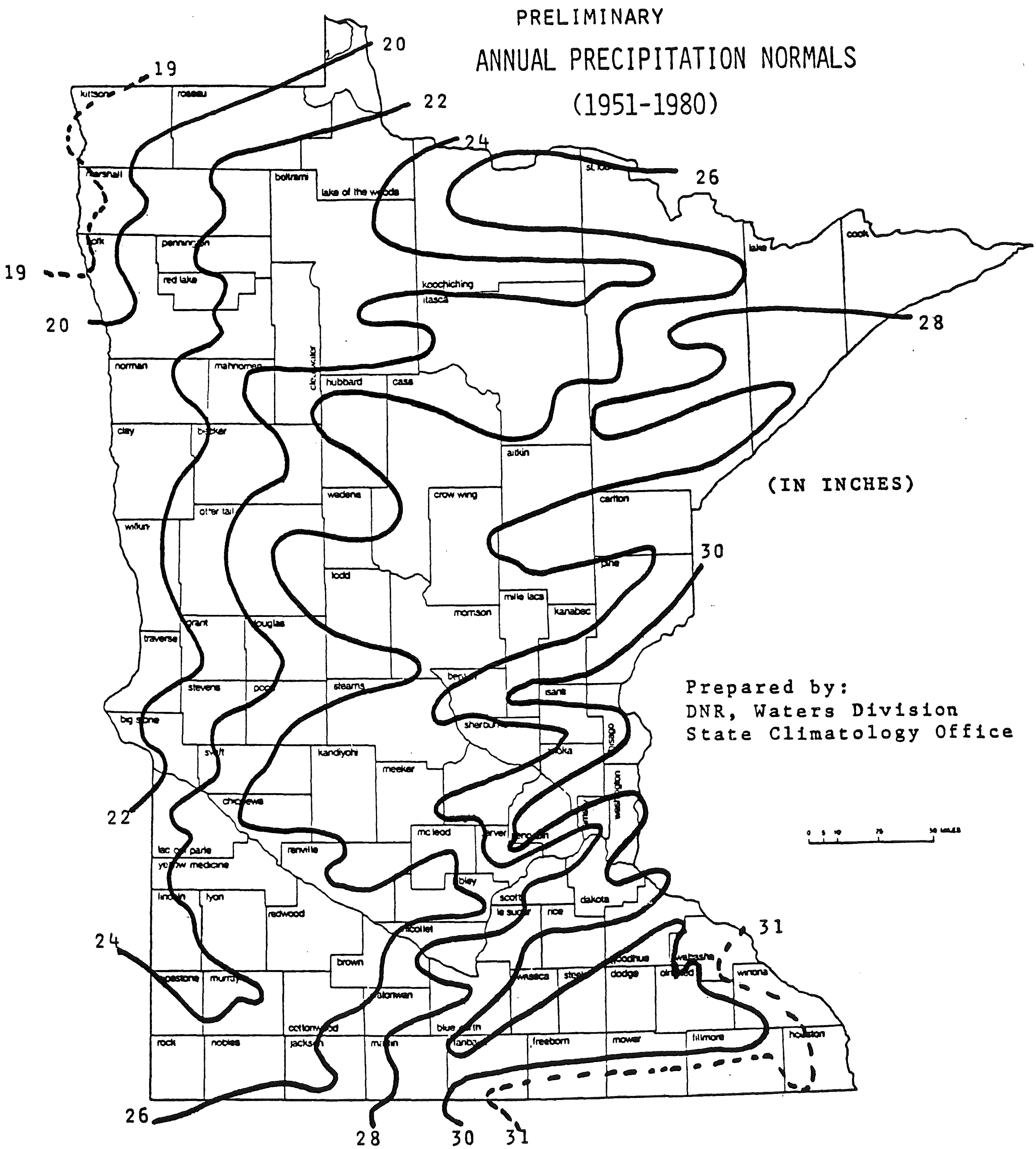
23
22
21
20
19
18
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69
YEARS (1953-1969)
INCHES (JAN.-JAN.)
AVE. PRECIP.


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.

Alexandria Annual Precipitation

Multi-year averages




PRELIMINARY
ANNUAL PRECIPITATION NORMALS
(1951-1980)
(IN INCHES)
Prepared by:
DNR, Waters Division
State Climatology Office
19
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22
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28
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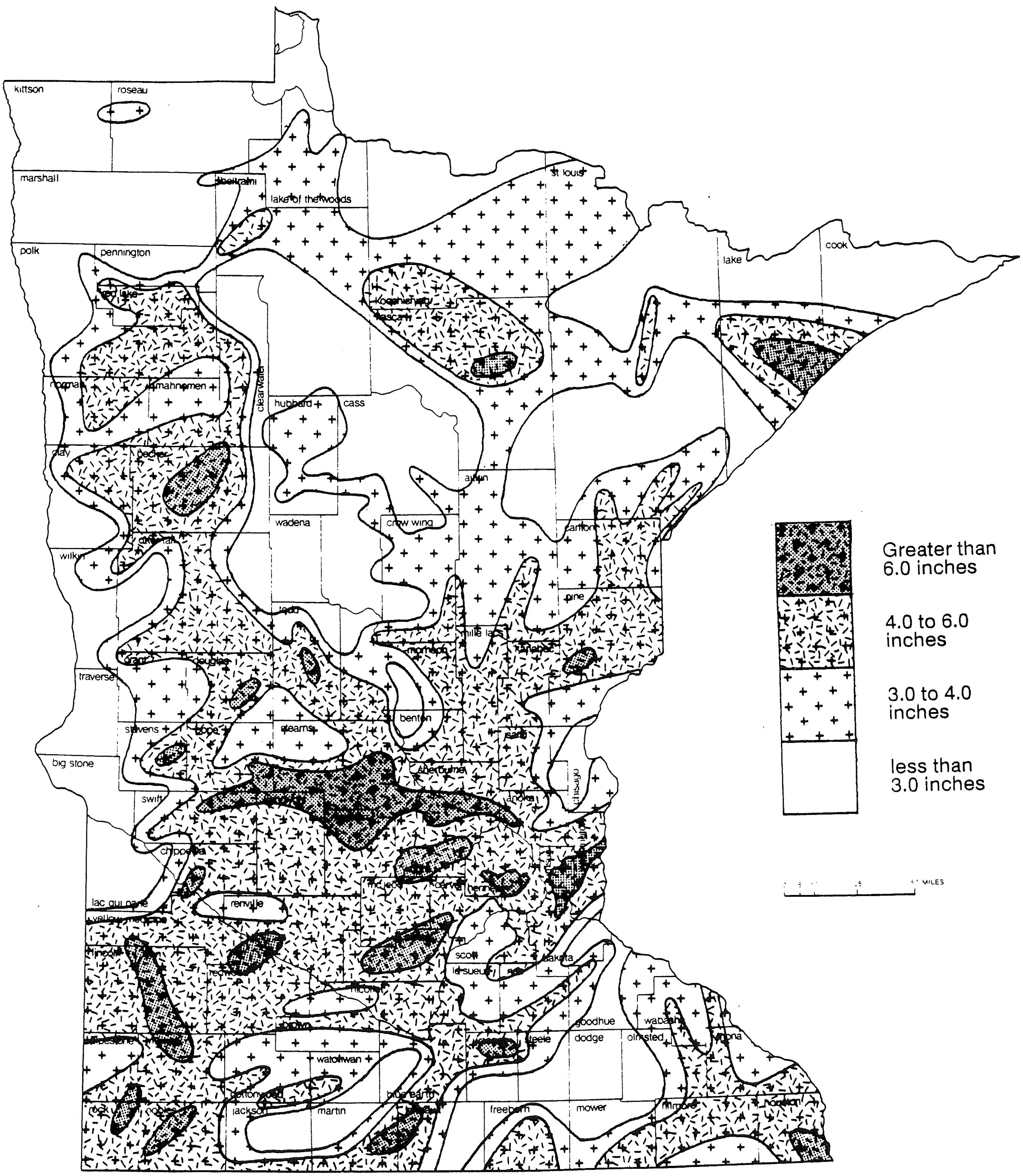
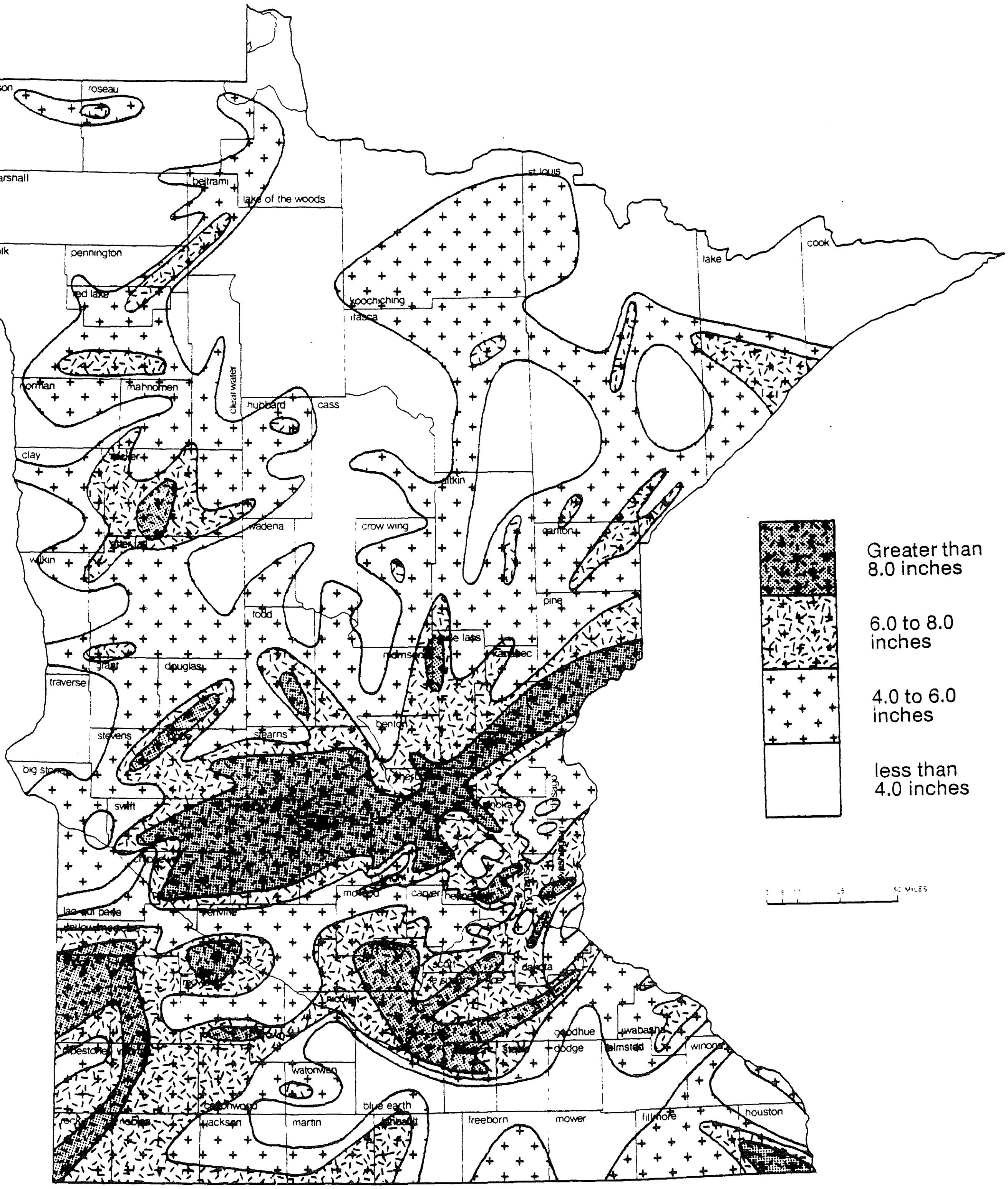
31
kittson
roseau
marshall
beltrami
lake of the woods
polk
red lake
koochiching
itasca
norman
mahnomen
clearwater
hubbard
cass
clay
aitkin
wadena
crow wing
carlton
wilkin
lake
cook
todd
mille lacs
morrison
kanabec
pine
traverse
grant
douglas
stevens
stearns
isanti
big stone
swift
kandiyohi
meeker
anoka
chisago
chippewa
mc leod
washington
lac qui parle
yellow medicine
renville
dakota
lincoln
lyon
redwood
scott
rice
nicollet
brown
goodhue
wabasha
winona
murray
dodge
olmsted
waseca
rock
nobles
jackson
cottonwood
blue earth
freeborn
mower
fillmore
houston

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



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

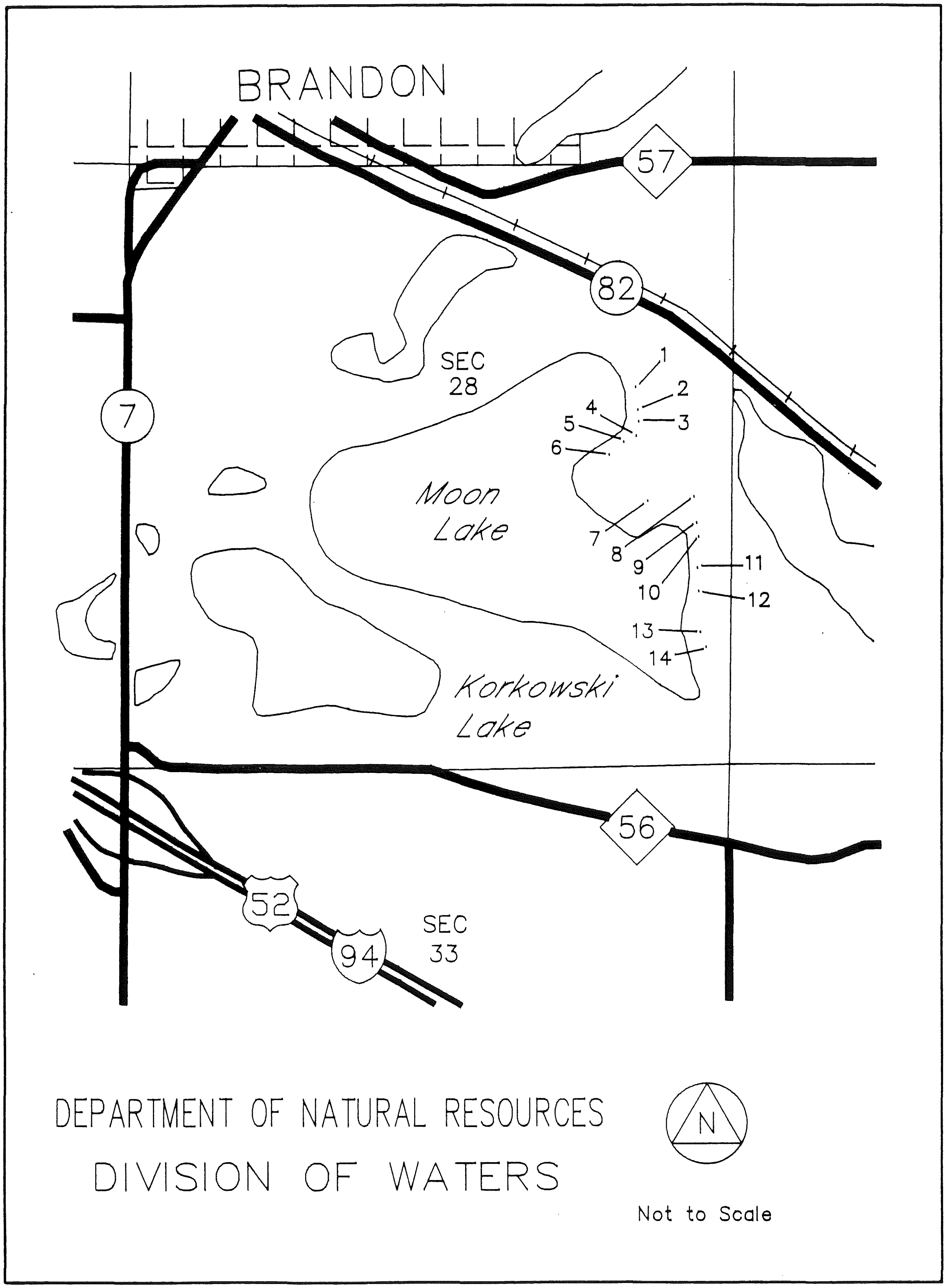
AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1982 - 1986 (5 YEARS)



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

APPENDIX D

FACT SHEET FOR EACH POTENTIALLY DAMAGED STRUCTURE


BRANDON
57
82
7
SEC
28
1
2
3
4
5
6
Moon
Lake
7
8
9
10
11
12
13
14
Korkowski
Lake
56
52
94
SEC
33
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS
N
Not to Scale

MOON LAKE - DOUGLAS COUNTY

Structure Number: 1
Name: Robinson, Curtis G. and Nancy A
Address: 202 W. 77th Street, Chanhassen, MN 55317

Assessment Number: 09-0517-000

Walkout/1sFl Elev.: 1366.96

Basement: No
Walkout: No

Market Value

Buildings: $11,159

MOON LAKE - DOUGLAS COUNTY

Structure Number: 2
Name: Hanson, Meridel A.
Address: 6421 Oliver Avenue S., Richfield, MN 55423

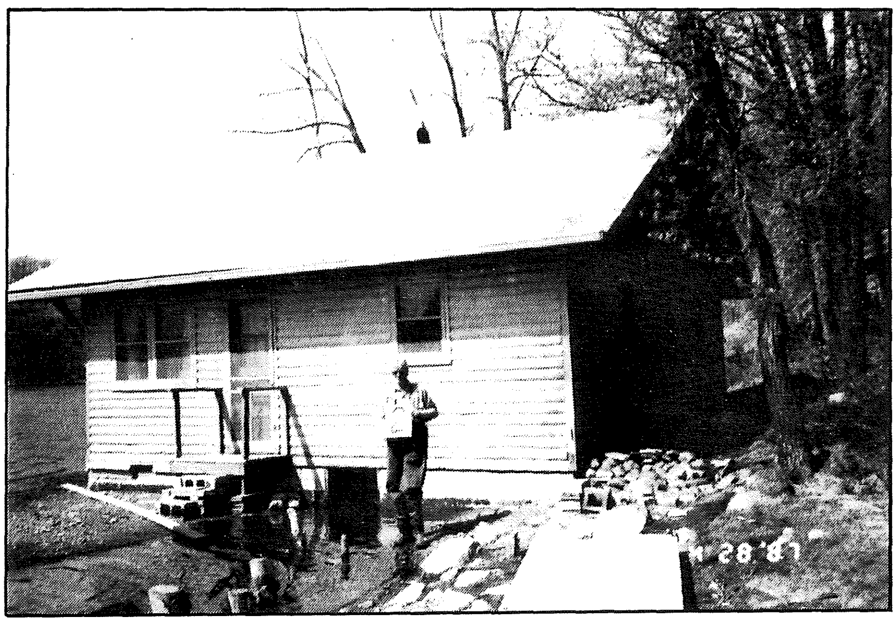
Assessment Number: 09-0519-000

Walkout/1sFl Elev.: 1366.61

Basement: No
Walkout: No

Market Value

Buildings: $12,265



MOON LAKE - DOUGLAS COUNTY

Structure Number: 3
Name: Paige, Isabel E.
Address: 3105 Mondamin Street, Minneapolis, MN 55417

Assessment Number: 09-0520-000

Walkout/1sFl Elev.: 1365.94

Basement: No
Walkout: No

Market Value

Buildings: $500

MOON LAKE - DOUGLAS COUNTY

Structure Number: 4
Name: Heath, Larry E.
Address: Box 514, Brandon, MN 56315

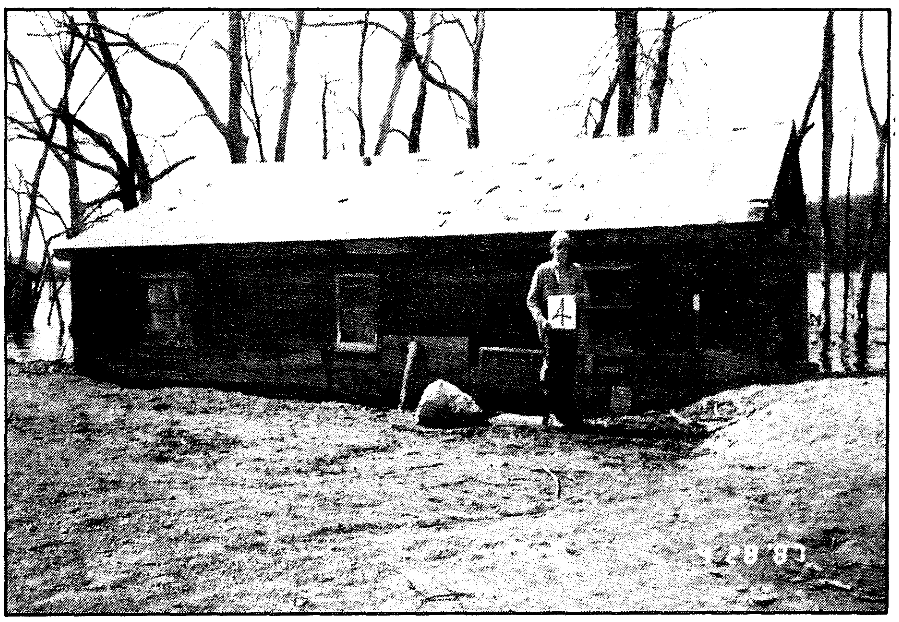
Assessment Number: 09-0521-000

Walkout/1sFl Elev.:

Basement: No
Walkout: No

Market Value

Buildings: $500



MOON LAKE - DOUGLAS COUNTY

Structure Number: 5
Name: Boutin, Kenneth R. & Jullian M.
Address: RR 1, Box C-12, Loretto, MN 55357

Assessment Number: 09-0522-000

Walkout/1sFl Elev.:

Basement: No
Walkout: No

Market Value

Buildings: $500

MOON LAKE - DOUGLAS COUNTY

Structure Number: 6
Name: Anderson, Elmer G. & Frances
Address: 3369 W. Broadway, Robbinsdale, MN 55422

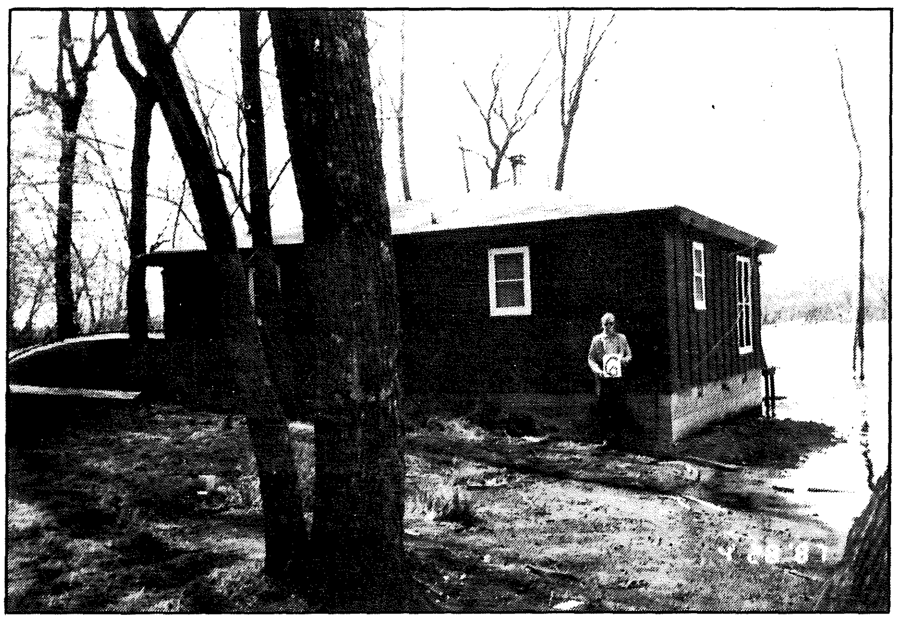
Assessment Number: 09-0523-000

Walkout/1sFl Elev.: 1367.71

Basement: No
Walkout: No

Market Value

Buildings: $12,909



MOON LAKE - DOUGLAS COUNTY

Structure Number: 7
Name: Corner, David J.
Address: 6625 Cedar Lake Road, St. Louis Park, MN 55426

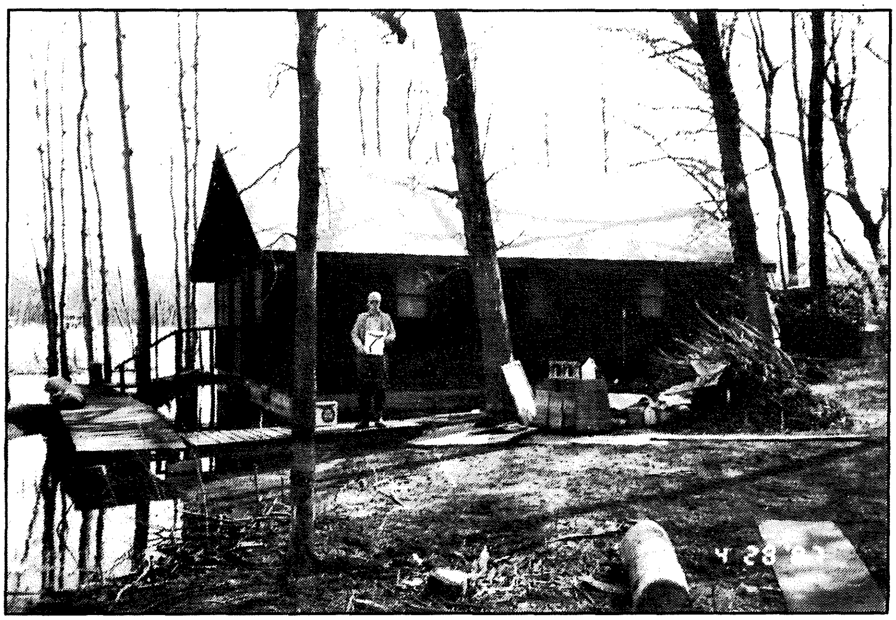
Assessment Number: 09-0530-000

Walkout/1sFl Elev.: 1366.91

Basement: No
Walkout: No

Market Value

Buildings: $15,183



MOON LAKE - DOUGLAS COUNTY

Structure Number: 8
Name: Hill, Robert J., et al.
Address: 505 Sunset Drive S., Minnetonka, MN 55343

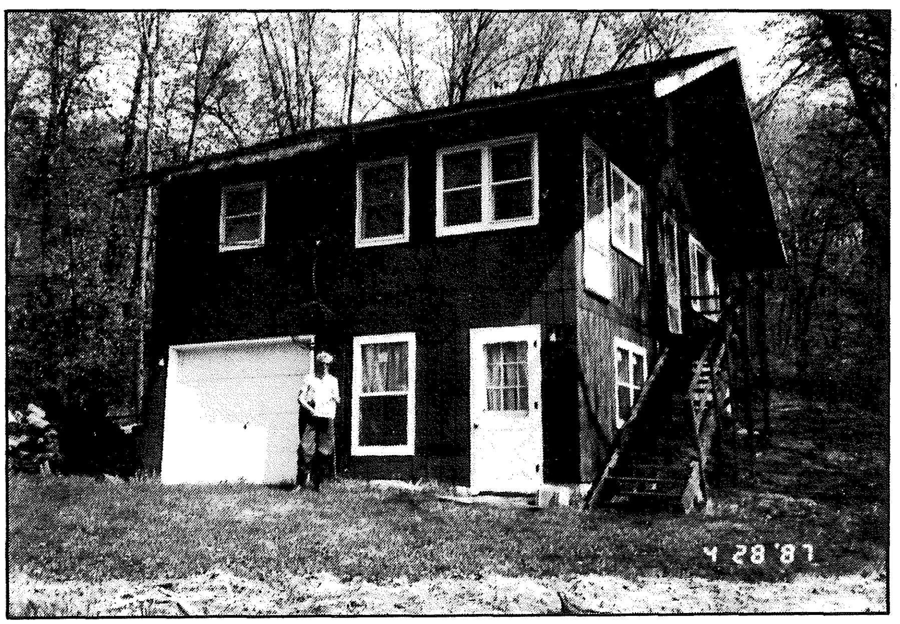
Assessment Number: 09-0540-000

Walkout/1sFl Elev.: 1368.56

Basement: Yes
Walkout: No

Market Value

Buildings: $18,326



MOON LAKE - DOUGLAS COUNTY

Structure Number: 9
Name: Dell Rojas, Thomas J. & Iva
Address: 6048 W. Broadway, Apt. 2, New Hope, MN 55428

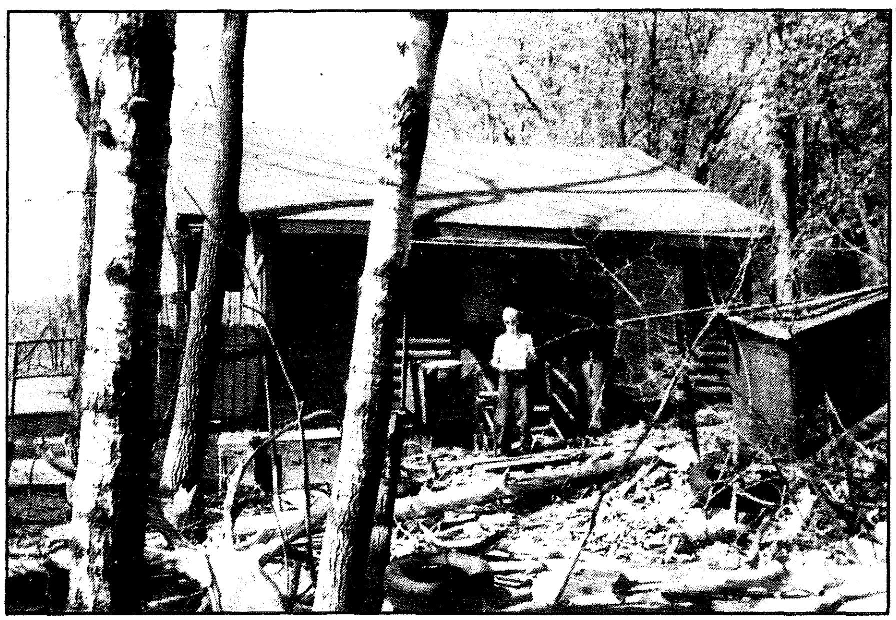
Assessment Number: 09-0541-000

Walkout/1sFl Elev.: 1368.01

Basement: No
Walkout: No

Market Value

Buildings: $10,732



MOON LAKE - DOUGLAS COUNTY

Structure Number: 10
Name: Perkins, Thomas C. & Shirley
Address: 7437 Dupont Avenue S., Minneapolis, MN 55423

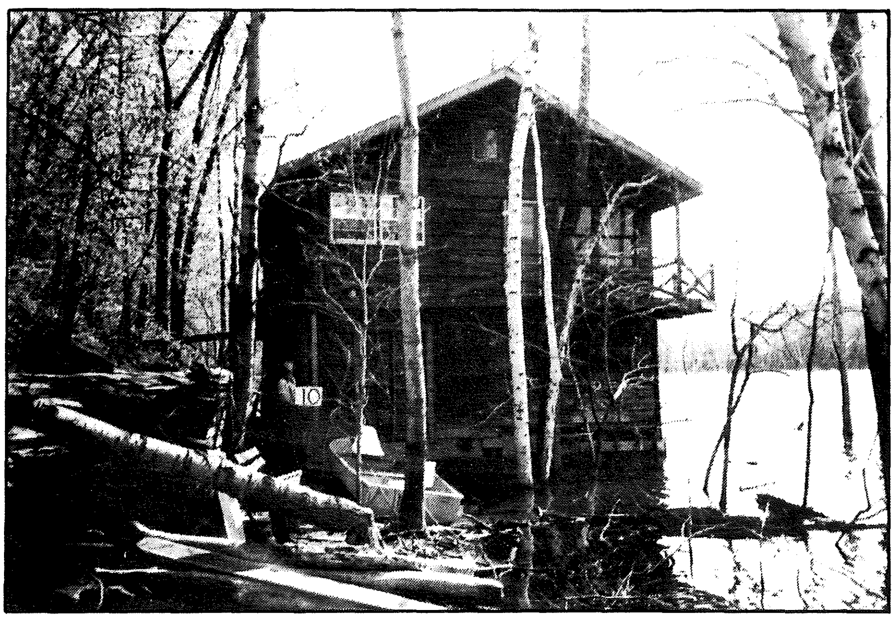
Assessment Number: 09-0542-000

Walkout/1sFl Elev.: 1366.61

Basement: No
Walkout: No

Market Value

Buildings: $12,603



MOON LAKE - DOUGLAS COUNTY

Structure Number: 11
Name: Thiesfeld, Dale H. & Gloria M.
Address: 10095 Vega Avenue, Young America, MN 55397

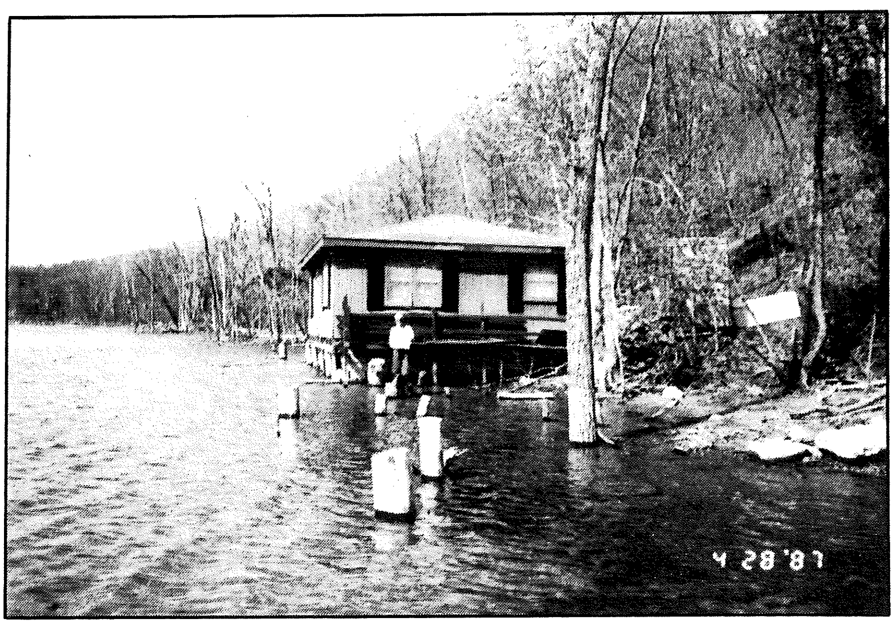
Assessment Number: 09-0544-000

Walkout/1sFl Elev.: 1368.31

Basement: No
Walkout: No

Market Value

Buildings: $9,218

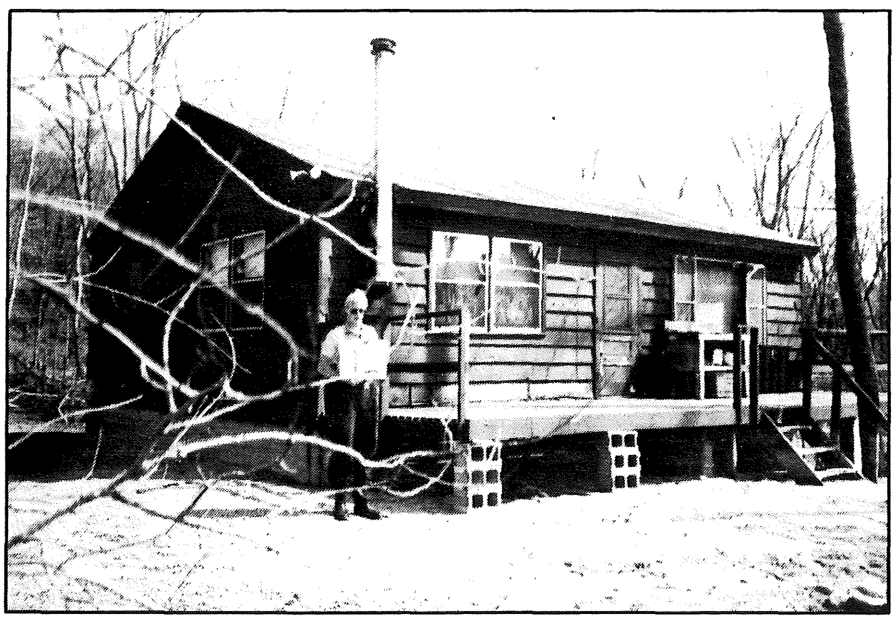


MOON LAKE - DOUGLAS COUNTY

Structure Number:	12
Name:	Schurrer, Roland N. & Jean M.
Address:	3132 6th Avenue N., Anoka, MN 55303
Assessment Number:	09-0546-000
Walkout/1sFl Elev.:	1367.91
Basement:	No
Walkout:	No

Market Value

Buildings:	$8,878



MOON LAKE - DOUGLAS COUNTY

Structure Number: 13
Name: Larson, Helen C.
Address: 506 6th Street E., Minneota, MN 56264

Assessment Number: 09-0550-000

Walkout/1sFl Elev.: 1367.36

Basement: No
Walkout: No

Market Value

Buildings: $10,181

MOON LAKE - DOUGLAS COUNTY

Structure Number: 14
Name: Thiemann, LeRoy J. & Delores
Address: 11221 Arrowwood Circle, Dayton, MN 55327

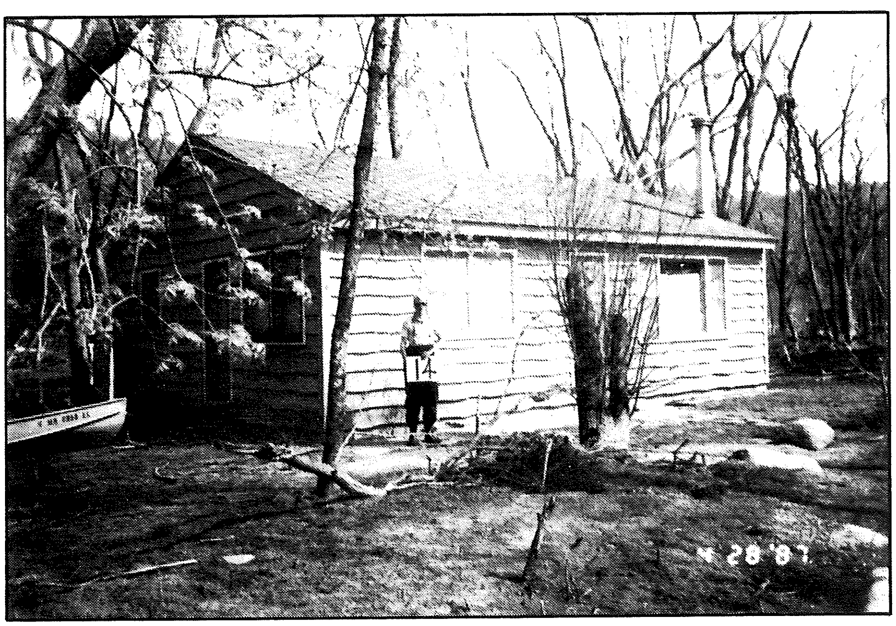
Assessment Number: 09-0551-000

Walkout/1sFl Elev.: 1366.96

Basement: No
Walkout: No

Market Value

Buildings: $8,763



APPENDIX E

GEOLOGIC MAP OF MINNESOTA

APPENDIX E

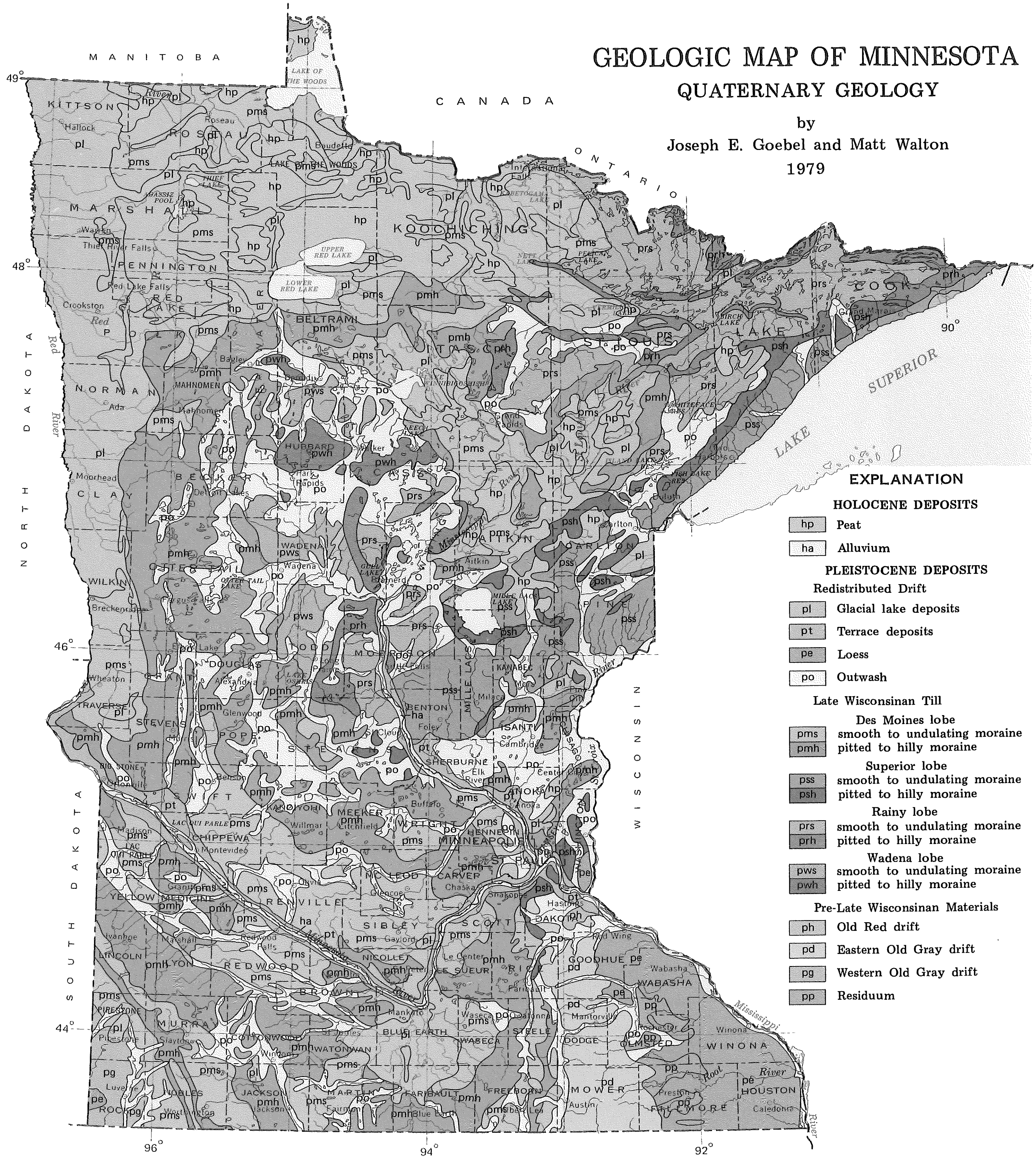
GEOLOGIC MAP OF MINNESOTA

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

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QUATERNARY GEOLOGY OF MINNESOTA

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

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

HOLOCENE DEPOSITS

hp

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

ha

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

PLEISTOCENE DEPOSITS

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

Redistributed Drift

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

pl

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

pt

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

pe

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

po

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

Late Wisconsinan Drift Deposited Directly From Glaciers

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

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

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

pms
pmh

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

pss
psh

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

prs
prh

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

pws
pwh

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

Pre-Late Wisconsinan Materials

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

ph

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

pd

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

pg

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

pp

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

REFERENCES

DeMartelaere, D.E., 1975. Soil Survey of Douglas County, Minnesota. U.S. Department of Agriculture, Soil Conservation Service.

Cotter, R.D., L.E. Bidwell, W.A. VanVoast, and R.P. Novitzki, 1968. Water Resources of the Chippewa River Watershed, West-Central Minnesota. U.S. Geological Survey. Hydrologic Investigations Atlas HA-286.

Douglas County, Minnesota, Assessor's Office, Assessment Records.

Hobbs, H.C., and J.E. Goebel, 1982. Geologic Map of Minnesota. Quaternary Geology. Minnesota Geological Survey, University of Minnesota. State Map Series S-1.

Minnesota Department of Natural Resources, Division of Waters, State Climatology Office. St. Cloud WSD Airport, Minnesota, Monthly Precipitation, 1887-1986.

Minnesota Department of Natural Resources, Division of Waters, State Climatology Office. Alexandria, Minnesota. 1888-1987

Minnesota Department of Natural Resources, Division of Fisheries and Wildlife, Fisheries Section. Fisheries Lake Survey Report, Moon Lake, Douglas County, Minnesota, 1987.

Planning and Information Center (PIC). Lake Survey Data from Moon Lake, Douglas County, Minnesota, 1987.

United States Department of the Interior, Geological Survey, Quadrangle, Minnesota. 7.5 Minute Series, Topographic Map, Scale 1:24000.