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# HYDROLOGY OF LAKE KAMPESKA

by

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for

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## ABSTRACT

Lake Kampeska is located northwest of Watertown in Codington County, South Dakota. Results of test hole drilling in the area indicate that an aquifer, located northeast of Lake Kampeska, hydraulically connects the Big Sioux River, Gravel Creek and the lake. Also, there is a direct connection between the Big Sioux River and the lake through the inlet-outlet channel.

Direct precipitation adds 20.52 inches of water annually to the surface of Lake Kampeska. Surface-water and ground-water recharge the lake when the lake has a lower water level than the river and the aquifer northeast of the lake.

Discharge from Lake Kampeska occurs in the form of evaporation, which removes 33 inches of water annually, and artificial discharge. The city of Watertown pumps approximately 3.2 inches of water from the lake annually for municipal purposes. In addition, ground water and surface water leave the lake through the inlet-outlet channel and the aquifer when the lake has a higher water level than the aquifer and the river.

During flooding a large quantity of water high in nutrients enters Lake Kampeska through the inlet-outlet channel. Sand and gravel deposits northeast of the lake and the low relief of this area prevent construction of an effective structure to stop floodwater from reaching the lake. Even if such a structure could function, the flood damage in Watertown would increase substantially.

It is recommended that the floodwater be stored north of the study area to reduce the flood damage around the lake and in the city of Watertown. Water will gradually discharge from such a storage area, and there will be more water in the river and the aquifer northeast of the lake during summer and fall. This increase in water will induce recharge or at least decrease discharge from Lake Kampeska, as a result, lake-level fluctuation will be reduced. A storage area will also reduce the amount of silt carried into the lake.

It is recommended that soil conservation practices be employed north of the lake and around the lake to reduce the amount of nutrients entering Lake Kampeska. Construction of a sewage system is also imperative to eliminate the influx of nutrients from residences around the lake.

## INTRODUCTION

### Purpose and Scope

Study of the factors influencing the water level at Lake Kampeska was initiated in 1966. The objectives of the project were to identify the sources of water recharging and discharging the lake, determine their quality and quantity, study the uses of the water, and relate the above factors as to the possible cause of lake-level fluctuation. One final objective was to recommend any method by which a more stable lake level could be achieved.

### Location and Extent of the Area

Lake Kampeska is located in Codington County in northeastern South Dakota. Included in the study area are approximately 80 square miles in the Coteau des Prairies division of the Central Lowlands physiographic province (fig. 1).

### Previous Investigations

The first report discussing water supplies and geology of Lake Kampeska was prepared by the South Dakota Geological Survey (Rothrock, 1933). This report described the geology and origin of the lake. Flint (1955) made a reconnaissance study of the glacial geology of eastern South Dakota. Steece (1958a) mapped the geology of the Watertown quadrangle, and in another report concerning ground-water resources (1958b) included the Lake Kampeska area. Tipton (1958) mapped the geology of the Henry quadrangle which borders the study area. Rukstad and Hedges (1964) described the ground-water supply for the city of Watertown. A report entitled, "Report on Water Supply Facilities and Proposed Improvements for the City of Watertown," was prepared by J. T. Banner and Associates, Inc. (1965).

### Methods and Procedures

During this investigation the surficial geology of the area was reviewed and the geologic map modified. Data obtained from all test holes drilled in the area since 1933 were analyzed, and additional test holes were drilled in areas having scattered or insufficient information. Seventeen observation wells were installed in the area to study the ground-water fluctuation. Data on recharge and discharge of water to the lake were analyzed, and 51 water samples were collected for chemical analyses.

### Acknowledgements

The project was financed by the South Dakota Department of Game, Fish and Parks (Dingell-Johnson Project F-19-R). The study was conducted under the direction of Duncan J. McGregor, State Geologist, with equipment provided by the South Dakota Geological Survey. Several water samples were analyzed by the Survey; the remainder of the samples were analyzed by the South Dakota Chemical Laboratory.

Assistance of the employees of the South Dakota Department of Game, Fish, and Parks in Pierre and Watertown, especially Robert Hanten and Harold Lundie, is appreciated. Also, the help of the East Dakota Conservancy Sub-District is acknowledged. Cooperation of the residents in the study area is appreciated, and special thanks are due to John Babcock, Watertown City Engineer, for his assistance.

### Climate

The climate of the area is characterized by large fluctuations in temperature. Average daily temperature is 43.0 degrees Fahrenheit, and the average annual precipitation is 20.52 inches at the U. S. Weather Bureau Station at Watertown Airport, one-half mile east of Lake Kampeska.

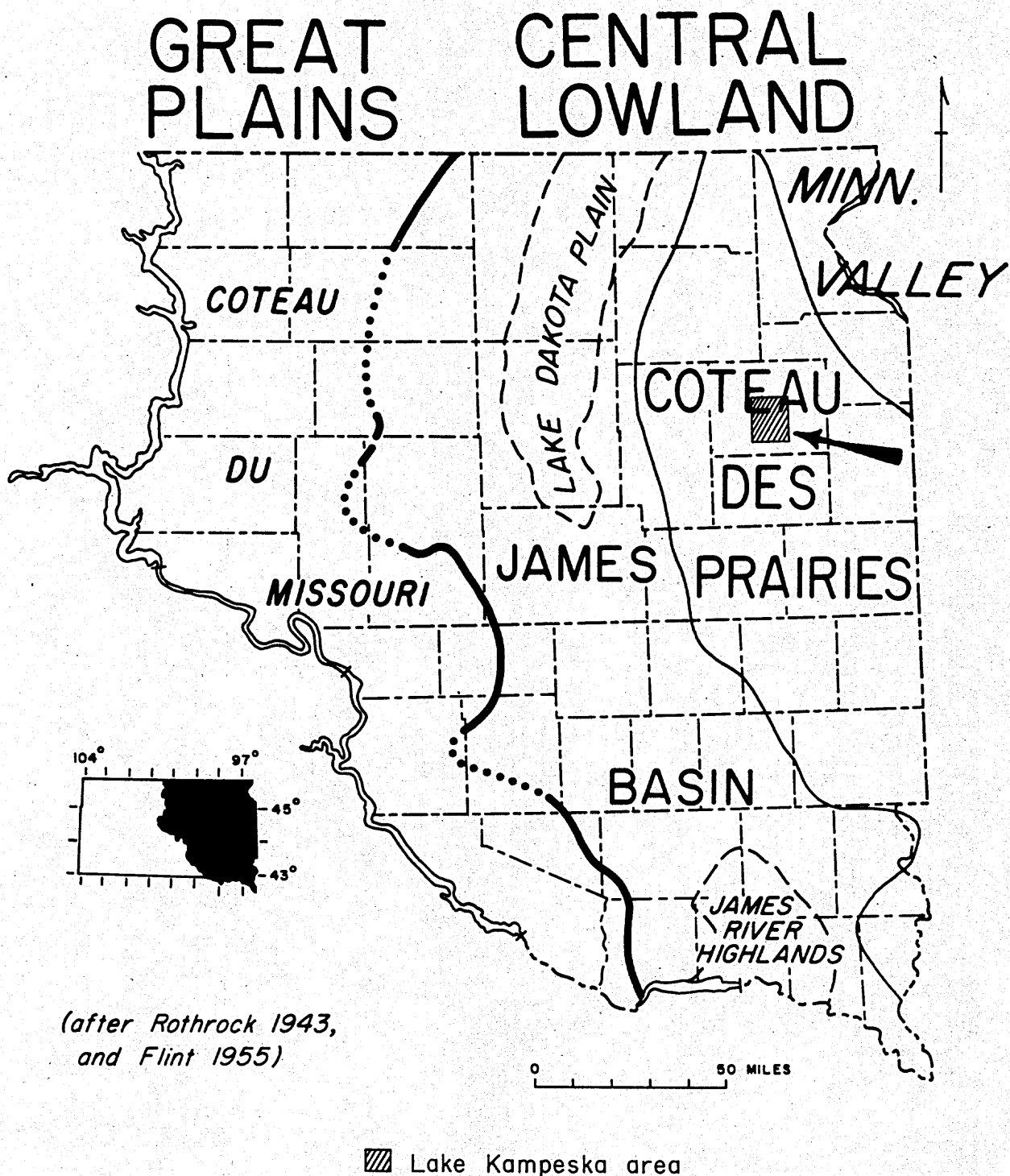


Figure 1. Major physiographic divisions of eastern South Dakota and location of the Lake Kampeska study area.

## Topography and Drainage

The topography of the Lake Kampeska area ranges from nearly flat, well drained, and gently undulating to rugged, poorly drained knob and kettle topography. Maximum relief in the study area is 150 feet with land elevations ranging from 1860 feet northwest of the study area to 1710 feet southeast of the study area (pl. 1).

The main stream in the area is the Big Sioux River which controls both surface and shallow ground-water movement. Gravel Creek (Mud Creek) and Willow Creek are tributaries to the Big Sioux River.

## Origin and History of Lake Kampeska

Lake Kampeska is a natural lake of glacial origin. Its existence is due to the action of glacial ice which covered this section of the State in the geologic past. The lake is ellipsoidal in shape with an extension at the southwest end. It is about 2½ miles wide and 5 miles long covering approximately 4,800 acres (fig. 2).

Lake Kampeska has been used for commercial and recreational purposes since early settlement. "The marvelous purity of its water at once attracts the attention of the visitor. There are no marshes or muddy banks" (City of Watertown Directory, 1886-1887, p. 12). "In a commercial way Lake Kampeska is a valuable asset to Watertown. It furnishes the city with the purest of water, some of which is bottled and sold throughout the northwest. Over 30,000 tons of ice are cut from its surface each year" (Pictorial Review of Watertown, S. D., 1916).

In 1887 a pump house was built on the lake shore and a pipeline constructed to Watertown. Since then the city has obtained most of its water from the lake.

Since the late nineteenth century several structures have been constructed northeast of the lake. In 1888 a mill dam was erected on the Big Sioux River downstream from the lake's inlet-outlet channel (located northeast of the lake, see A in fig. 3). In 1928 several structures were built in location B (fig. 3). These structures consisted of a concrete weir equipped with a swinging grill, a dike, and a dam. The purpose of these structures was to increase the water flow into the lake, decrease the discharge from the lake, and prevent the fish from leaving the lake. An ice jam considerably damaged the structures the following spring. Efforts to repair the construction failed and the system was abandoned. Figure 4 shows remains of the concrete weir.

In 1932 a rock dam was constructed on the Big Sioux River downstream from the lake on or near to the old mill dam (see A, fig. 3). In 1933 a diversion ditch (see E, fig. 3) was dug to connect Gravel Creek to the Big Sioux River. A dam was also constructed on the old Gravel Creek channel to block the water from flowing in old Gravel Creek channel. The purpose of this project was to increase the recharge into the lake.

A sheet piling dam was constructed across the Big Sioux River in 1941 (see C, fig. 3, and fig. 5). The purpose of this dam was to raise the water level in the lake; however, late one night the top of the dam was mysteriously cut to lower the lake level.

The flood of 1969 raised the lake level and flooded several cottages around Lake Kampeska. Consequently, the dam on the old Gravel Creek channel was blasted out to divert water from the lake and lower the lake level. Later a dam was placed in the diversion ditch (see G, fig. 3) to stop the discharge of lake water through this channel, and thereby stop the lake-level decline.

## GENERAL GEOLOGY

### Surficial Deposits

Surficial deposits in the Lake Kampeska study area can be divided into two main groups—(1) glacial deposits and (2) stream deposits.

### Glacial Deposits

During the Pleistocene Epoch of geologic time, ice moved into the Lake Kampeska area

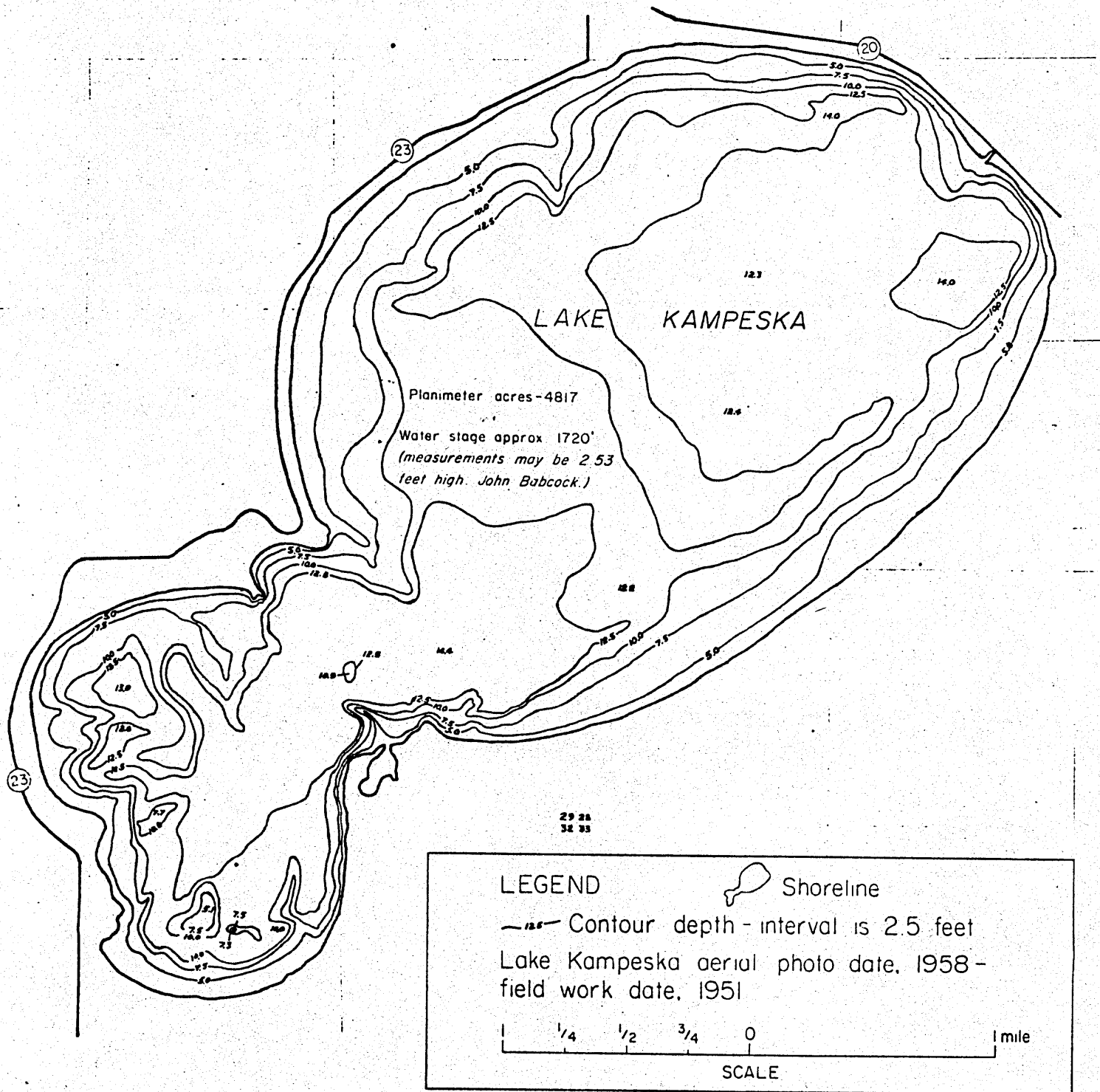


Figure 2. Depth contour map of Lake Kampeska.  
(from S.D. Dept of Game, Fish, and Parks)





Figure 3. Vertical aerial photo northeast of Lake Kampeska showing the locations of structures. (Photo courtesy of Soil Conservation Service - Photo date 7-14-65)

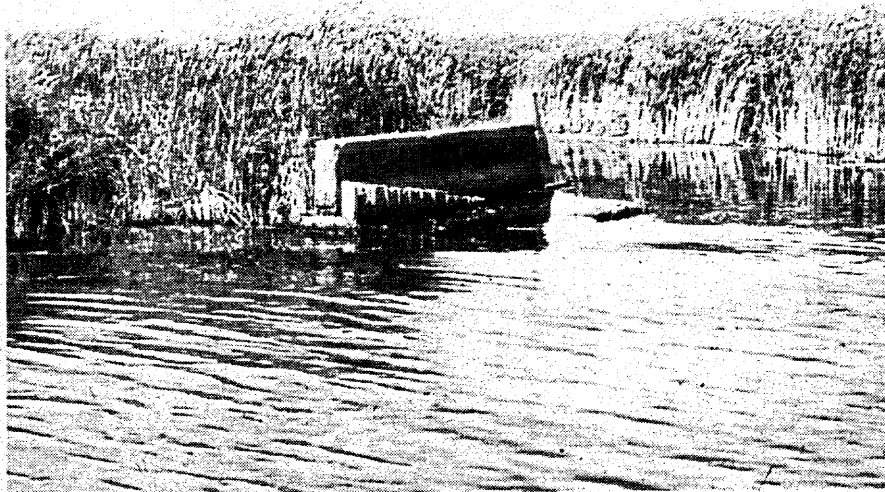


Figure 4. Photograph showing the remains of a concrete weir constructed in 1928.



Figure 5. Photograph showing the remains of a dam constructed in 1941.



and deposited glacial drift. Drift can be divided into till and outwash deposits. Till consists of a heterogeneous mixture of boulders, pebbles, and sand in a matrix of clay directly deposited by the ice. Outwash material, on the other hand, is a sorted deposit consisting of mostly sand and gravel with minor amounts of clay deposited by meltwater streams issuing from the ice. Figures 6 and 7 show the distribution of these deposits.

#### Stream Deposits

The Big Sioux River and some of its tributaries have deposited alluvium in their channels (fig. 6). Alluvium in the study area consists of sand, gravel, and clay.

#### Subsurface Bedrock

No bedrock is exposed in the Lake Kampeska study area. Data obtained from well logs in this area reveal that Cretaceous sedimentary rocks underlie the glacial drift. These deposits in descending order are the Pierre Shale, Niobrara Marl, Carlile Shale, Greenhorn Limestone, Graneros Shale, and the Dakota Formation.

Pierre Shale underlies approximately 500 feet of glacial drift, and consists of approximately 240 feet of light- to dark-gray shale.

Niobrara Marl consists of light- to medium-gray chalk with shaly layers and numerous microscopic white specks. These deposits have an average thickness of 90 feet.

Carlile Shale is chiefly light-gray to black shale with thin silt and sand layers, and is approximately 200 feet thick.

Greenhorn Limestone is composed of about 30 feet of hard, gray limestone.

Graneros Shale is siliceous and has an average thickness of approximately 150 feet.

A sequence of alternating sand, sandstone, and shale beds approximately 80 feet thick makes up the Dakota Formation. Beneath the Dakota Formation are rocks of Precambrian age, usually quartzite and granite.

### HYDROLOGY OF LAKE KAMPESKA

Hydrology of a lake may be defined as the study of factors controlling the quality and processes governing the depletion and replenishment of the water in a lake. It takes into consideration precipitation, evaporation, flow into and out of the lake from both surface and subsurface, and the effects of artificial control. Hydrology of a lake is a science by which the behavior of lakes may be analyzed.

The water level of a lake is a function of the volume of water contained in the lake basin. The rate of change of water volume is controlled by the rate at which water enters the basin from all sources, minus the rate at which water is lost.

The following formula shows the relationship between recharge, discharge, and resulting lake level fluctuation:

$$\Delta h (A + \Delta A) = \Delta V = \text{Recharge} - \text{Discharge}$$

where

$\Delta h$  is the change of water level in the lake,

$A$  is the surface area of the lake,

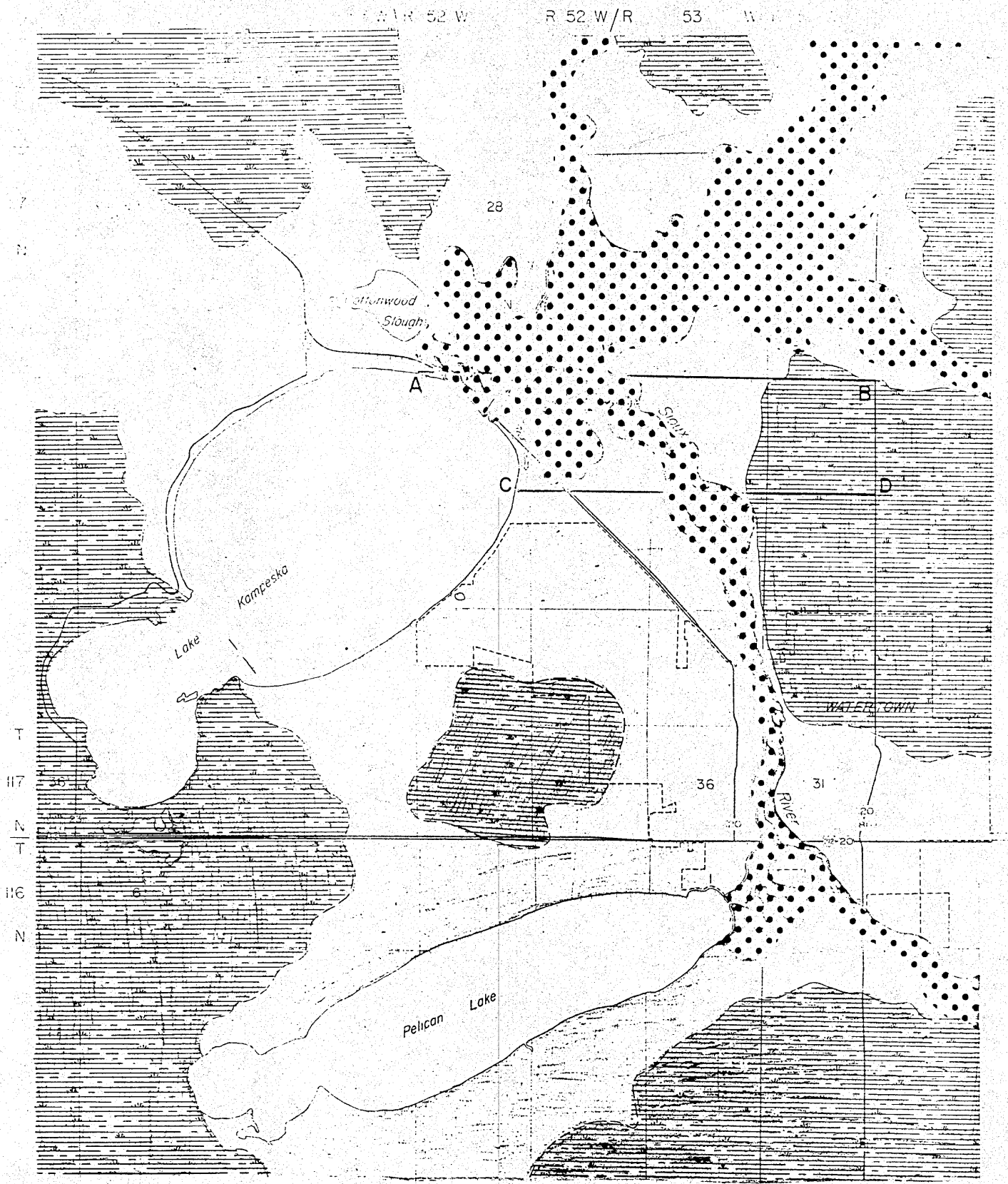
$\Delta A$  is the change of the surface area of the lake due to fluctuation of the lake level, and

$\Delta V$  is the change in volume of water in the lake.

The following is the analyses of these factors with presently available data.

#### Recharge

Recharge to the lake includes water from all sources, and may be divided into three major categories: (1) direct precipitation, (2) ground-water recharge, and (3) surface-water recharge.



**EXPLANATION**

Recent  
 Alluvium

Change  
 Outwash

Pleistocene  
 Clay (T.M.)

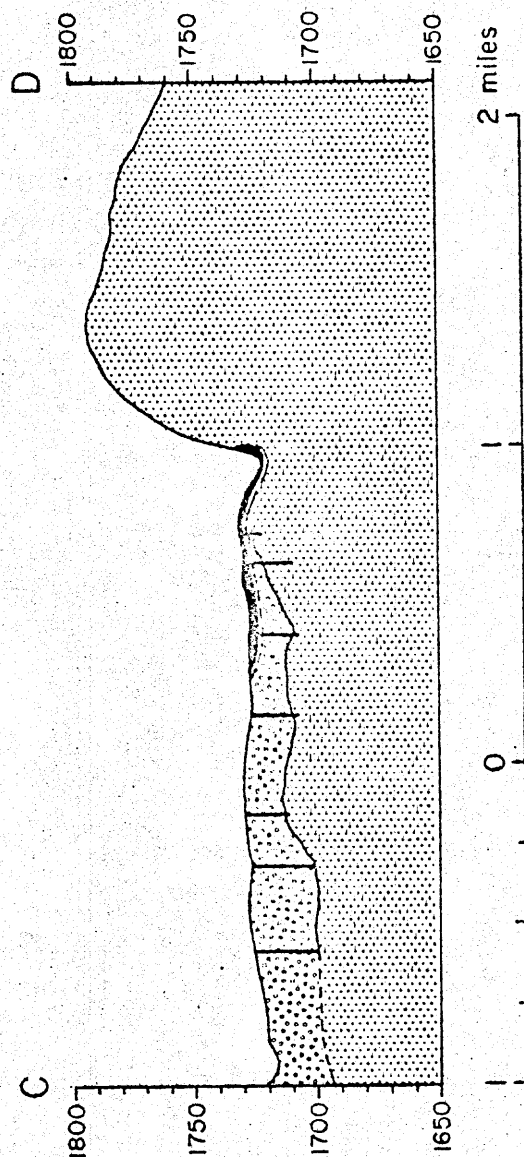
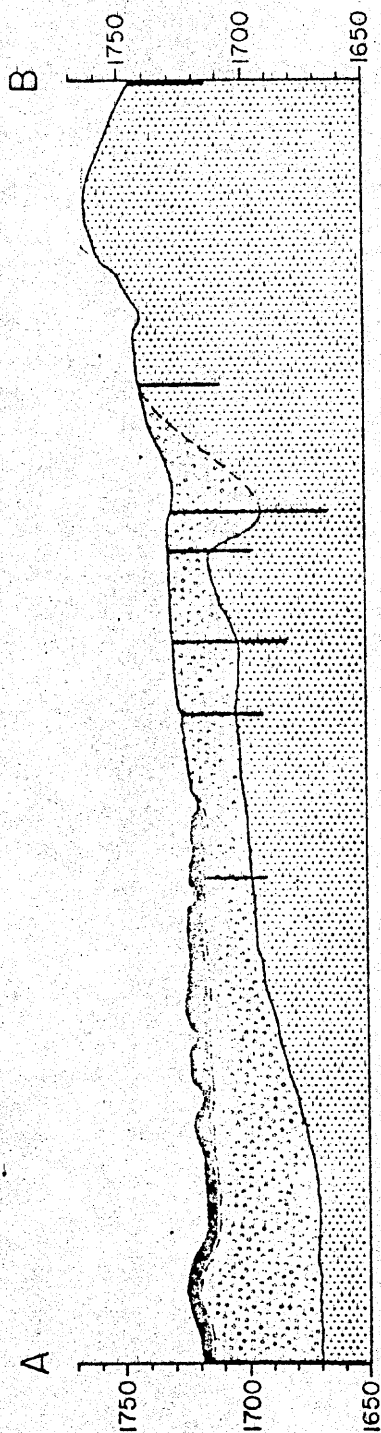
**A B** Cross sections (see fig. 7)

— Contact line—dashed where approximately located

by A. Barari, 1970

drafted by D. W. Johnson

Figure 6. Generalized geologic map of the Lake Kampeska study area. (modified from F V Steece, 1958 a-and M. J. Tipton, 1958).



# EXPLANATION

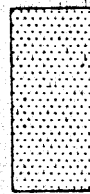
Test hole



RECENT



PLEISTOCENE



Clay (Till)

Contact line - dashed where approximately located

SCALE

2 miles

0

Figure 7. Geologic cross section along line A-B and C-D as shown on fig. 6.

by A. Barari, 1970

drafted by D. W. Johnson

### Direct Precipitation

The term precipitation, as used in hydrology, is a general term for all forms of water derived from atmospheric vapor deposited on the lake surface.

Precipitation received in this area is measured at the U. S. Weather Bureau Station at the Watertown Airport, one-half mile east of the lake. The records show that the average annual precipitation at this station is 20.52 inches.

Appendix A is a table of monthly and annual precipitation for the Lake Kampeska area from 1898 through 1970. Figure 8 is a graph showing monthly precipitation from 1889 to 1945, and figure 9 shows the monthly precipitation and lake-level hydrograph at Lake Kampeska from 1945 through 1970.

### Ground-Water Recharge

#### Occurrence of Ground Water

Ground water is defined as water contained in the voids or openings of rocks or sediments below the water table. The water table is the upper surface of the zone of saturation which is under atmospheric pressure. Practically all the pores of permeable rocks that lie below the water table are filled with water. Rocks (including the soil) that lie above the water table are in the zone of aeration. Some of the interstices in this zone are also filled with water, but the water is either held by molecular attraction or is moving downward toward the zone of saturation. Water in the ground moves downward through the unsaturated zone under the influence of gravity, whereas in the saturated zone it moves in a direction determined by the hydraulic gradient.

Nearly all ground water is derived from precipitation in the form of rain, melting snow, or ice. Water from these sources either evaporates, percolates directly downward to the water table and becomes ground water, or drains off as surface water. Surface water either evaporates, escapes to the lakes or ocean by streams, or percolates downward into the rocks.

Recharge is the addition of water to an aquifer (a formation having structures that permit appreciable amounts of water to move through it under ordinary field conditions), and is accomplished in four main ways: (1) by downward percolation of precipitation from the ground surface, (2) by downward percolation from surface bodies of water, (3) by lateral flow of ground water into the area, and (4) by artificial recharge, which takes place from excess irrigation, seepage from canals, and water purposely applied to augment ground-water supplies.

Discharge of ground water from an aquifer is accomplished in four main ways: (1) by evaporation from free-water surfaces and transpiration by plants, (2) by seepage upward or laterally into surface bodies of water, (3) by lateral movement of water out of the area, and (4) by pumping from wells, which constitutes the major artificial discharge of ground water.

### Definitions

The porosity of a rock or soil is a measure of the contained open spaces and is expressed as the percentage of these open spaces to the total volume of the rock.

$$\alpha = \frac{100W}{V}$$

where

$\alpha$  is the porosity,

W is the volume of water required to fill all of the pore space, and

V is the total volume of the rock or deposit.

The porosity of a sedimentary deposit depends mainly on (1) the shape and arrangement

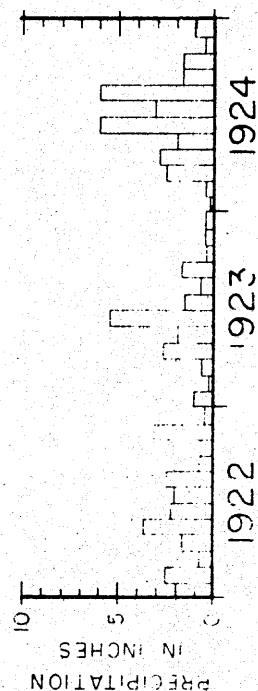
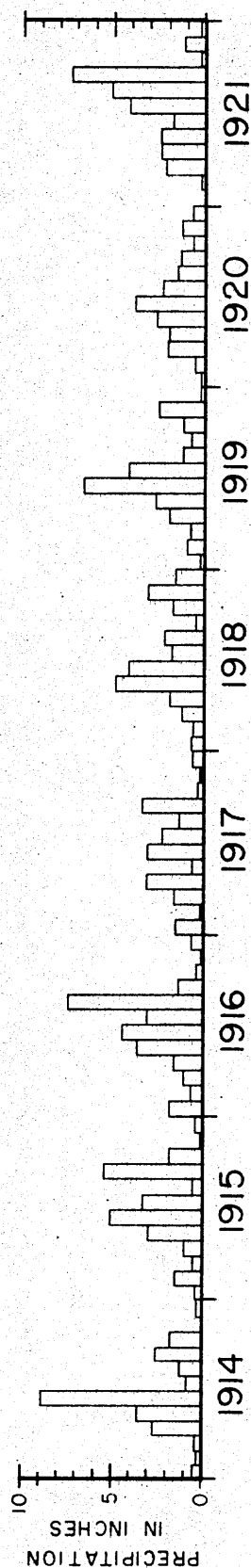
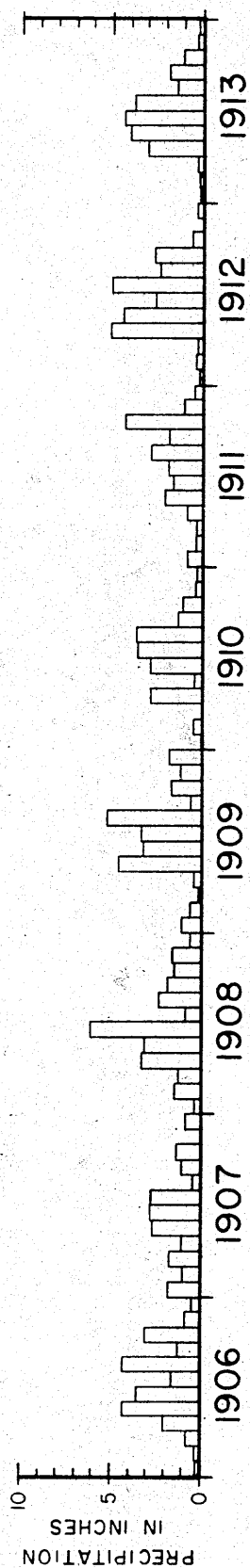
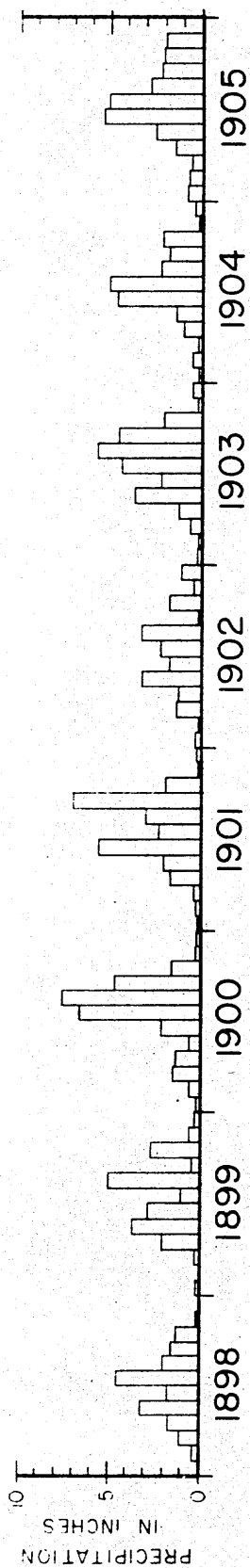


Figure 8. Graph showing monthly precipitation for the Lake Kameska area (*Watertown Airport*) from 1898 to 1945.

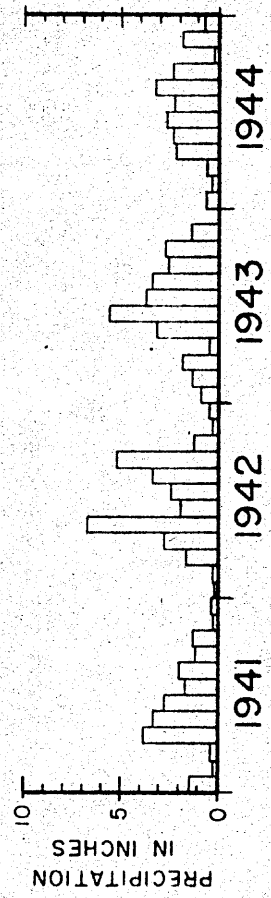
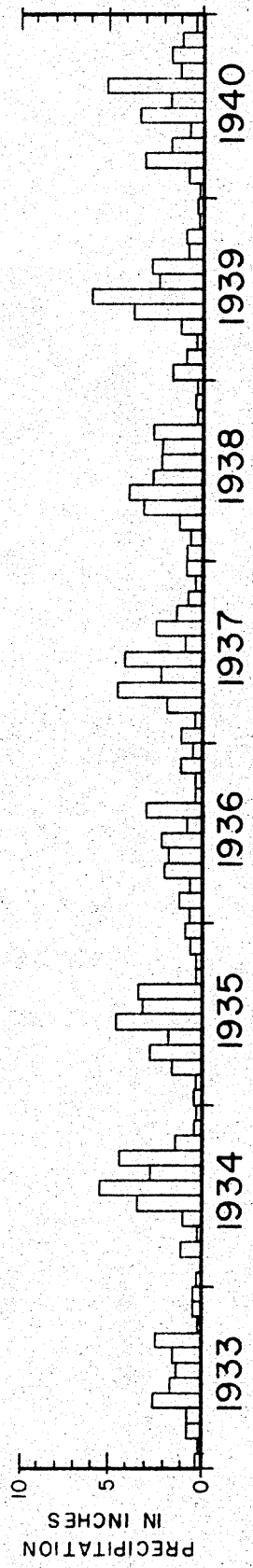
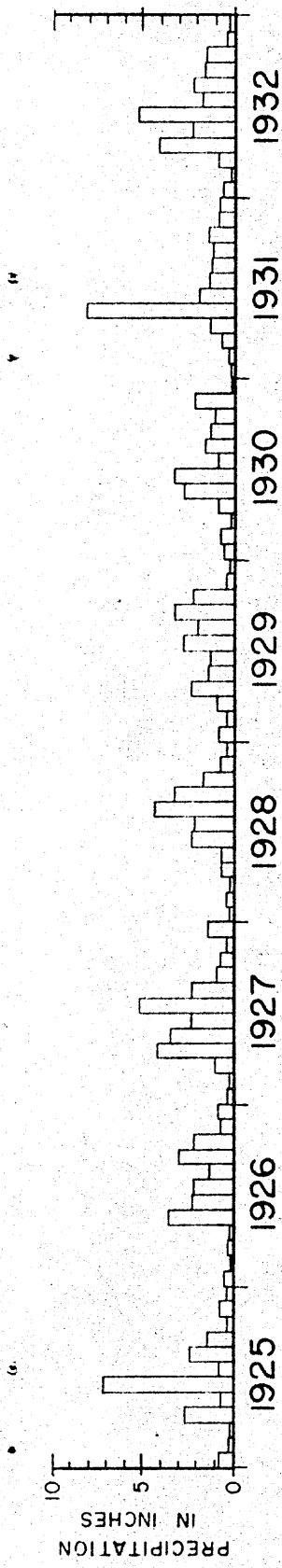


Figure 8. (Cont.)

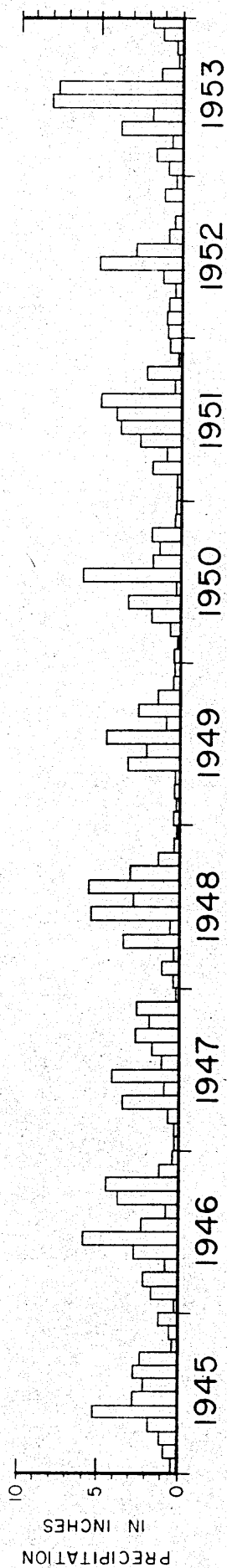


Figure 9 Graph showing monthly precipitation and lake-level hydrograph\* for Lake Kameska from 1945 through 1970.

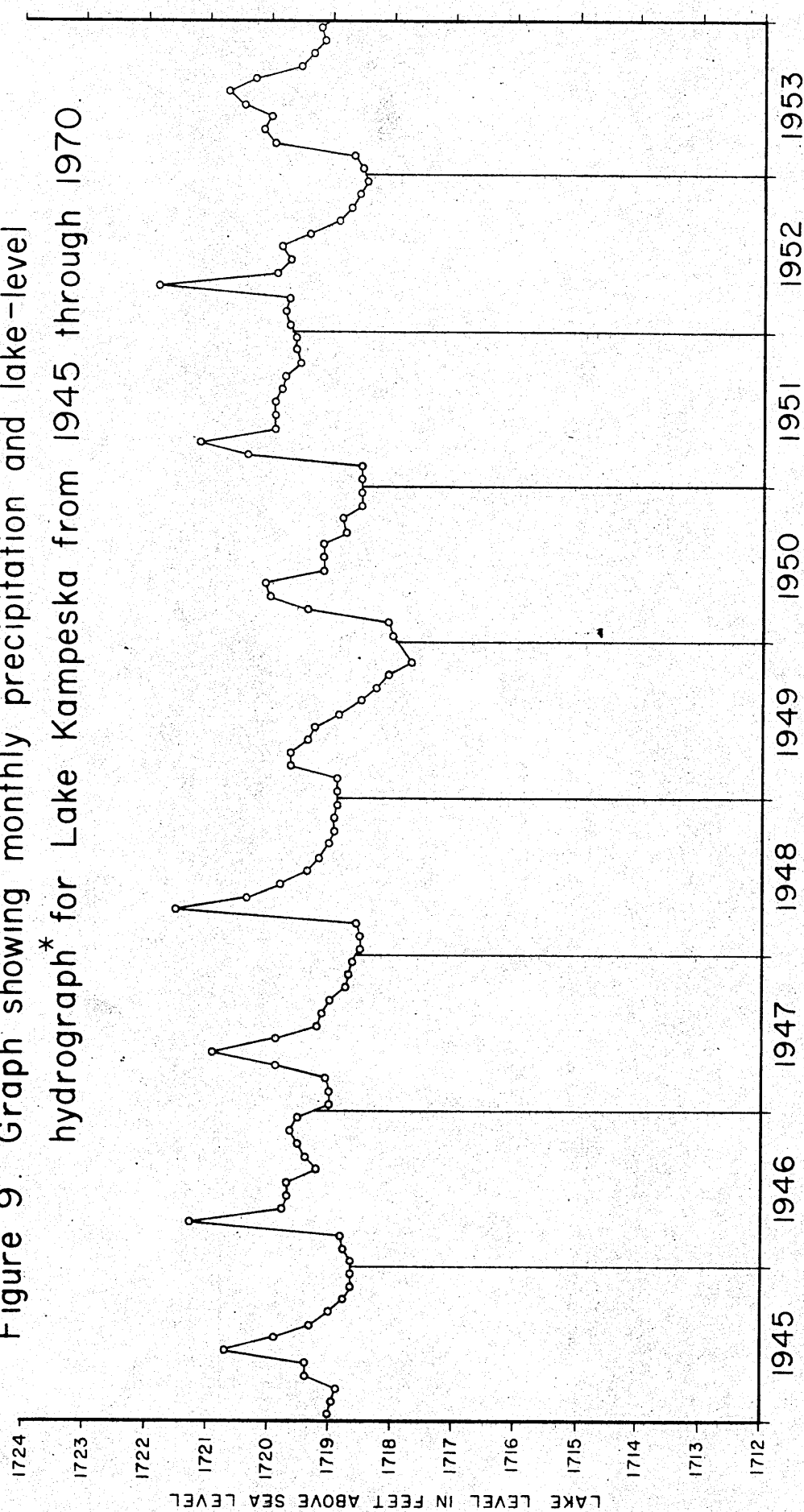
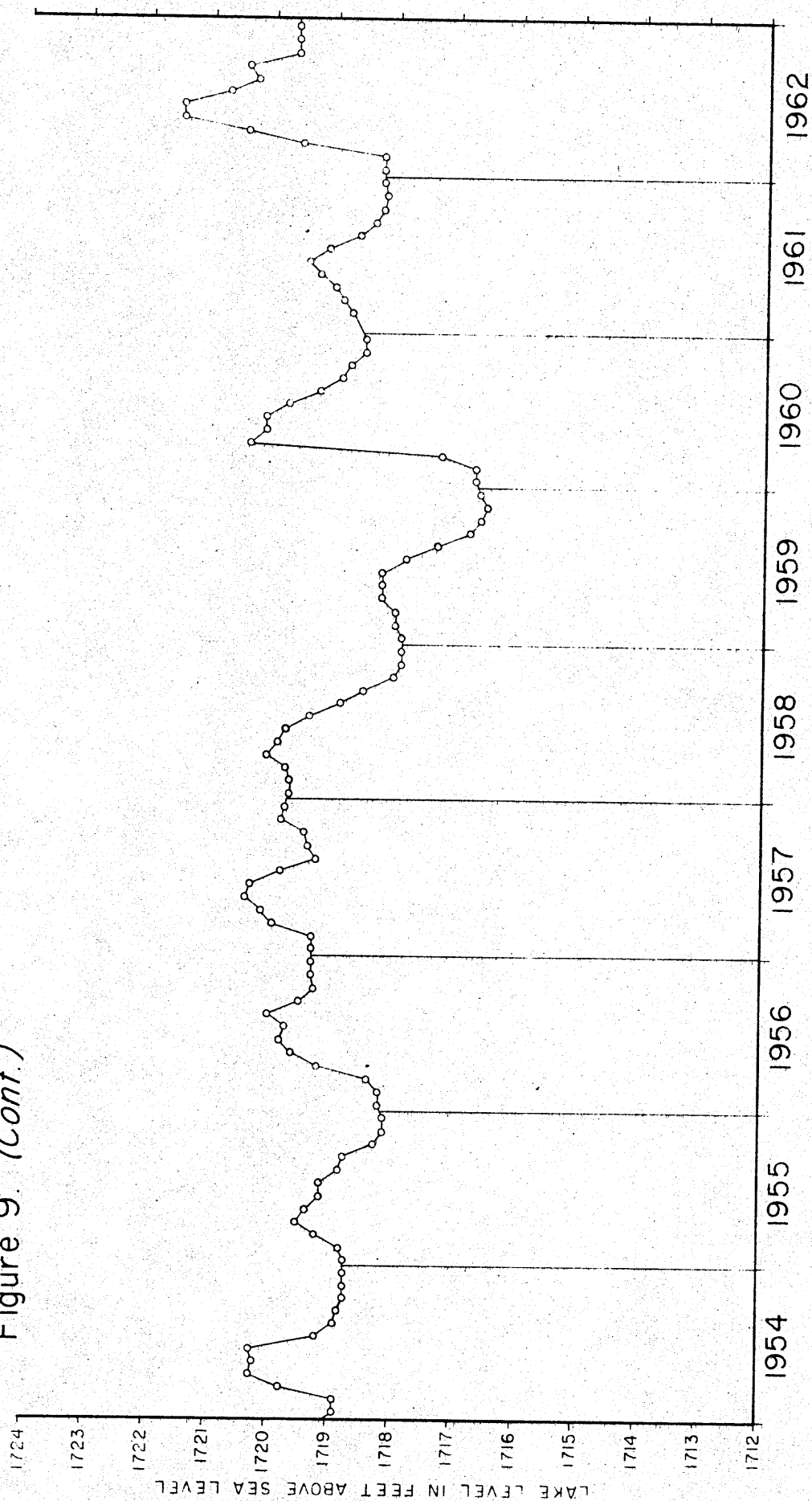






Figure 9. (Cont.)





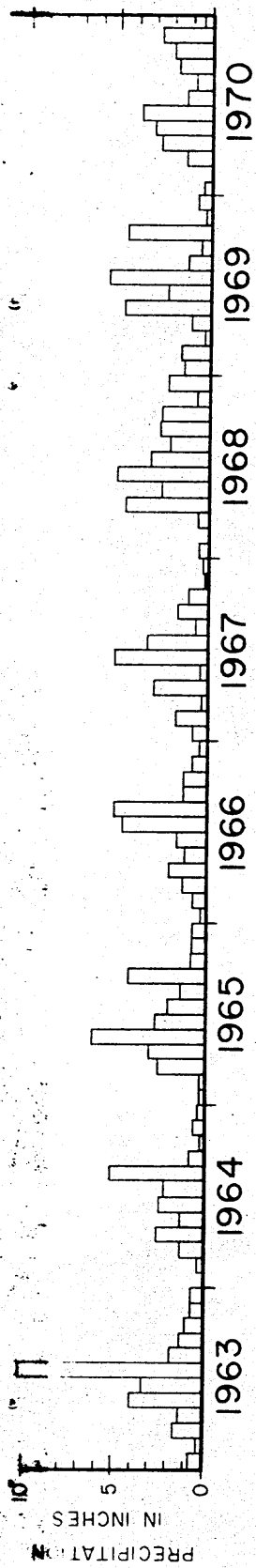
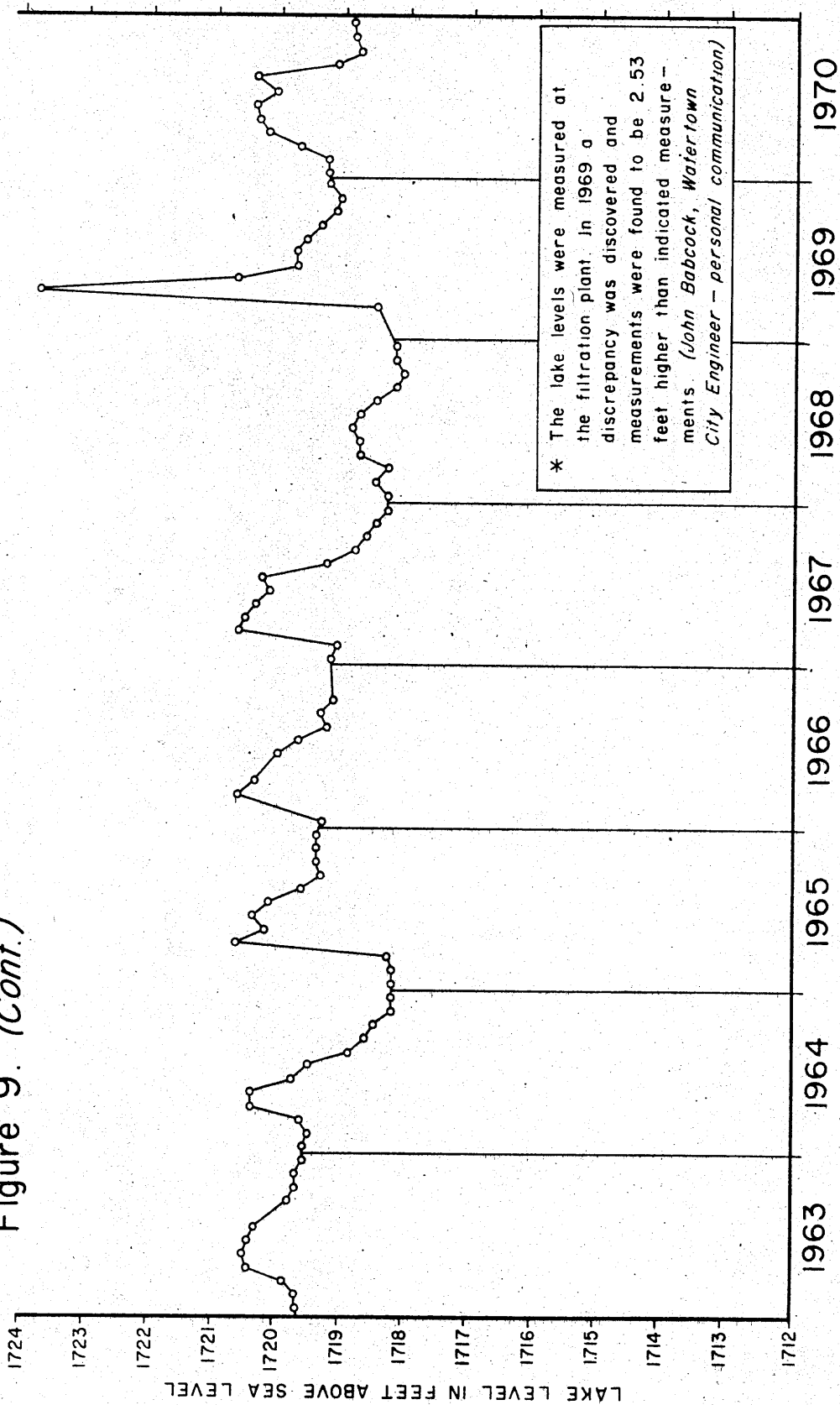


Figure 9. (Cont.)



of its constituent particles, (2) the degree of sorting of its particles, (3) the cementation and compaction to which the sediments have been subjected since deposition, (4) the removal of mineral matter through solution by percolating waters, and (5) the fracturing of the rock, resulting in joints and other openings. Thus, the size of the material has little or no effect on porosity providing all other factors are equal. Porosities of rocks range from near zero to more than fifty percent, depending upon the above factors.

Permeability or hydraulic conductivity of a rock is its capacity for transmitting a fluid. The coefficient of permeability (K) is defined as the rate of flow of water in gallons per day through a cross-sectional area of one square foot under a unit hydraulic gradient. Water will pass through a material with interconnected pores, but will not pass through a material with unconnected pores, even if the latter material has a high porosity. Therefore, permeability and porosity are not synonymous terms.

Coefficient of transmissibility (T) is expressed as the rate of flow of water in gallons per day through a vertical strip of the aquifer one foot wide extending the full saturated thickness of an aquifer under a hydraulic gradient of 100 percent. The relation between the coefficient of permeability and transmissibility is shown by the following equation:

$$T = Km$$

where

T is the coefficient of transmissibility,  
K is the coefficient of permeability, or hydraulic conductivity, and  
m is the thickness of the saturated deposits.

The coefficient of storage (S) of an aquifer is the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

Specific yield is the ratio of the volume of water that a rock or soil will yield by gravity to the total volume of rock.

$$S_y = \frac{100 W_y}{V}$$

where

S<sub>y</sub> is the specific yield,  
W<sub>y</sub> is the volume of water yielded, and  
V is the total volume of the rock or soil.

Coefficient of storage of a water-table aquifer is essentially equal to the specific yield; however, for an artesian aquifer the coefficient of storage is generally much smaller than the specific yield.

All of the water contained in the ground can not be removed by pumping from a well or under the influence of gravity; thus, retained water is held against gravity by surface tension and other means. The specific retention of a rock or soil is expressed as the percentage of the volume of water an aquifer holds against the force of gravity to the total volume of the deposits.

$$S_r = \frac{100 W_r}{V}$$

where

S<sub>r</sub> is the specific retention,  
W<sub>r</sub> is the volume of water retained, and  
V is the total volume of the deposits.

### Extent of the Shallow Aquifer

Logs of test holes drilled in the area since 1933 were used to define the extent of the shallow aquifer in the study area. During the study additional test holes were drilled in the areas of limited information. Figure 10 shows the location of test holes in the study area. Because of discrepancies in the data some of the old test holes were not plotted on this map. To facilitate finding the location of test holes a new number starting from the top of the map is assigned to each test hole or observation well. Appendix B, in addition to giving the logs of all test holes and observation wells, shows the new and old numbers.

Results from test holes in the area indicate that an extensive sand and gravel deposit northeast of the lake hydraulically connects the Big Sioux River and Gravel Creek to Lake Kampeska. Figure 11 shows the thickness of saturated sand and gravel in the study area.

### Aquifer Tests

Three aquifer tests were conducted in the area by the South Dakota Geological Survey and United States Geological Survey during a study by J. T. Banner in 1964-65. The test conducted northeast of Lake Kampeska in sec. 14, T. 117 N., R. 53 W. (see fig. 10) is discussed below. The test was started on April 20, 1965, and continued for 72 hours at an average rate of 260 gallons per minute. Results of the test were calculated by personnel from the U. S. Geological Survey (written communication, May 28, 1965), and indicate the average transmissibility under field conditions to be  $T = 5.0 \times 10^4$  gal/day/ft, with an average thickness of saturated sand of approximately 23 feet. The permeability was  $K = 2.2 \times 10^3$  gal/day/ft<sup>2</sup>.

### Quantity of Ground-Water Recharge

Figure 12 is a water-table map of the study area for July 30, 1970 (see app. C for water-level measurements). This figure shows that ground water was moving toward the northeast of Lake Kampeska along two main gravel deposits, the Big Sioux River and Gravel Creek. Rates of these flows can be calculated by applying the following equation:

$$Q = KA \frac{dh}{dl} \quad [1]$$

where

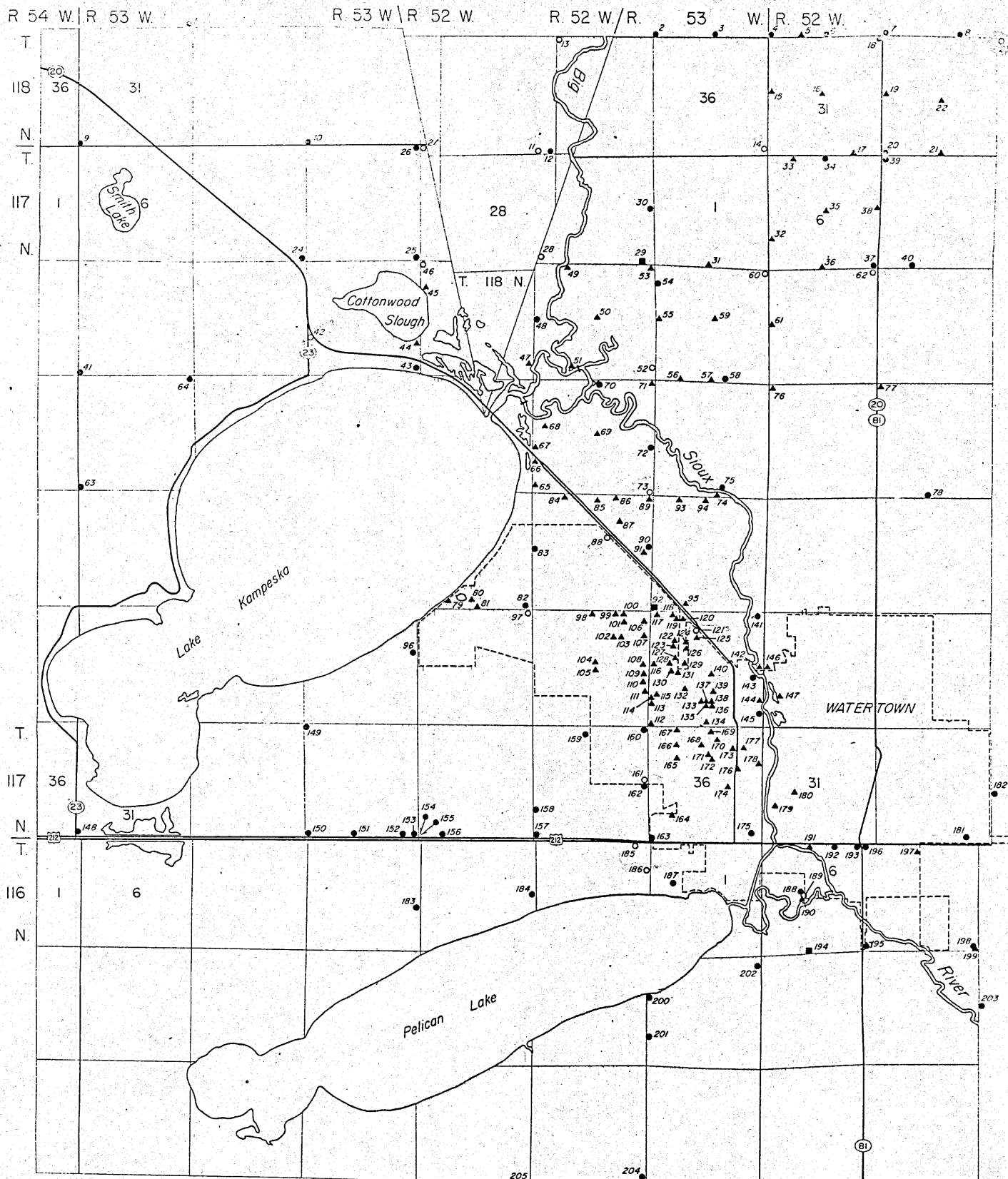
Q is the discharge per unit time (in gallons per day)  
 K is the coefficient of permeability or hydraulic conductivity  
 of the aquifer in gallons per day per square foot.  
 A is the cross-sectional area of the aquifer,  
 $\frac{dh}{dl}$  is the hydraulic gradient (dh is the change of hydraulic  
 head-dl is the change of horizontal distance).

Ground water flow from a cross section of the aquifer along the Big Sioux River, 2 miles north of the inlet-outlet was calculated by applying equation [1] and using the sand and gravel thickness along with the water-table map. The results indicate that  $3.3 \times 10^5$  gal/day of water was flowing along the Big Sioux River 2 miles north of the inlet-outlet.

Ground-water flow in the aquifer along Gravel Creek was calculated 2 miles northeast of the inlet-outlet and was  $4.0 \times 10^5$  gal/day.

The above flow rates do not include the water flow in the Big Sioux River and Gravel Creek.

Because of an extensive connection between the surface and ground water northeast of the lake and the lack of a stream gage upstream from the lake, the quantity of ground-water and surface-water recharge could not be differentiated with present data.



#### EXPLANATION

73○ Observation well - S. D. Geological Survey

104▲ Test hole - City of Watertown

181● Test hole - S. D. Geological Survey

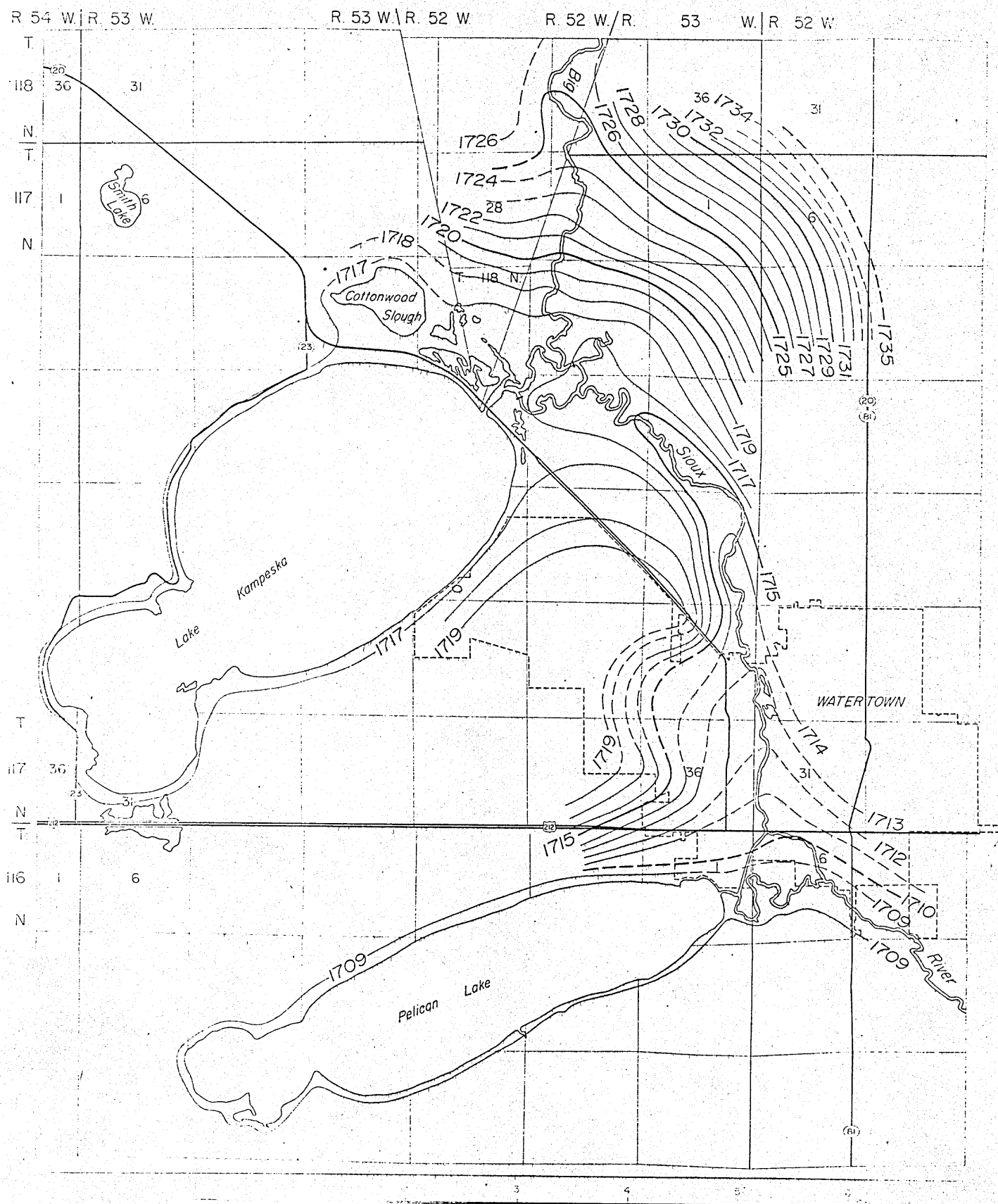
29■ Observation well - Water Resource Commission

× Pump test location

by A. Barari, 1970 drafted by D. W. Johnson

Figure 10 Map showing the location of test holes, observation wells, and pump test site in the Lake Kapeska study area.





# EXPLANATION

— 1711 — Contour lines connect points of equal elevation (dashed where approximately located)  
 Contour interval = 1 foot

by A. Barari, 1970      drafted by D. W. Johnson

Figure 12 Water-table map of the Lake Kameska study area for June 30, 1970

### Surface-Water Recharge

Precipitation in the form of melting snow or rain reaching the ground surface becomes either surface runoff or infiltration, depending on whether or not the rain intensity exceeds the infiltration capacity. Relatively high relief around the lake, except for northeast of the lake (pl. 1), causes some surface runoff into the lake. However, flow to the lake by this source is small when compared with the flow through the inlet-outlet channel, especially during flooding. Surface water flows into the lake through the inlet-outlet channel whenever the water level in the Big Sioux River is higher than the lake level.

During the study, no flow or very little flow was observed on several occasions in the Big Sioux River 2 miles north of the lake and in Gravel Creek. The largest measured flow in June, July and August of 1968 was 2 cfs (cubic feet per second) in the Big Sioux River and was measured in the NW¼ of sec. 2, T. 117 N., R. 53 W. On the other hand, a substantial quantity of water flows in this stream and over the land during flooding.

### Flood of 1969

The 1969 spring flood in the Big Sioux River valley can be attributed to an exceptionally thick blanket of snow which accumulated in the winter and early spring of 1969. In April when the snow melted, maximum stage and record discharges occurred in some stations on the Big Sioux River. A large quantity of water flowed over the land and along the channels of the Big Sioux River and Gravel Creek in the study area. Figures 13 and 14 are aerial photos taken northeast of Lake Kampeska and show the Highway 20 Bridge on the inlet-outlet channel. The bridge was not designed to carry such large volumes of water, and as a result, the east side of the bridge was destroyed by erosion (see figs. 15 and 16). The attachment to appendix E shows that the lake level on April 7, 1969 was 1718.5 feet and on April 10 the lake level was 1723.7 feet indicating that floodwater raised the lake level 5.2 feet. In other words, 26,000 acre-feet of water entered the lake during the flood. As a result, approximately one-third of the water contained in the lake after the flood was floodwater.

At 10:15 a.m., April 9, the rate of water entering the lake was measured at the Highway 20 Bridge on the inlet-outlet channel by the U. S. Geological Survey and was found to be 3900 cfs. Appendix E shows that the lake level rose .2 feet between 12:30 a.m. and 2:30 a.m. on April 9. Calculation indicates that the recharge during this time was 5800 cfs.

The flow was also measured in the channel under the bridge 1 mile downstream from the lake inlet-outlet channel. Measurements by the U. S. Geological on April 9 show that the rate of flow was 1550 cfs (Anderson and Schwab, 1970, p. 517-518). Flow rates indicate that the rate of water flowing into the lake was approximately three times as large as the flow through Watertown. Several cottages around the lake were flooded as were sections of Watertown (figs. 17 and 18).

To discharge water more rapidly from the lake after the flood, the dam on the old Gravel Creek was removed allowing water to flow out through this channel. When the lake reached a desired level, further decline of water level in the lake was stopped by placing a dam on Gravel Creek, and finally, by constructing a dam on the diversion ditch. Presently, water in Gravel Creek is flowing in its old channel.

### Discharge

Discharge from the lake includes all waters leaving the lake, and can be divided into (1) evapotranspiration, (2) surface-water discharge, (3) ground-water discharge, and (4) artificial discharge.

### Evapotranspiration

All water, surface and subsurface, released into the atmosphere by processes of evaporation and transpiration is called evapotranspiration.

Transpiration is the process whereby the moisture that has circulated through a plant



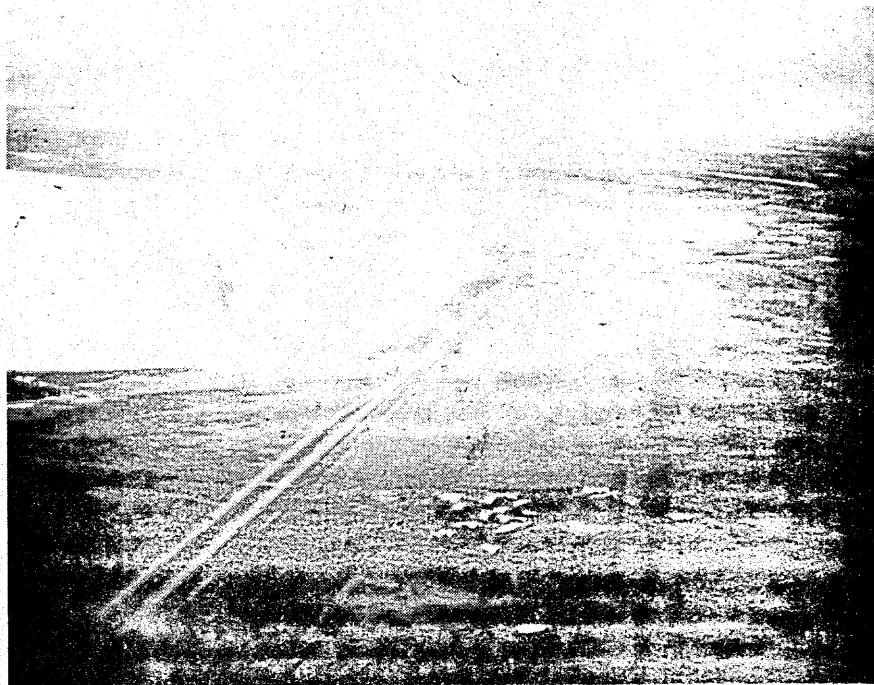


Figure 13. Aerial photo taken northeast of Lake Kampeska during the flood of 1969.

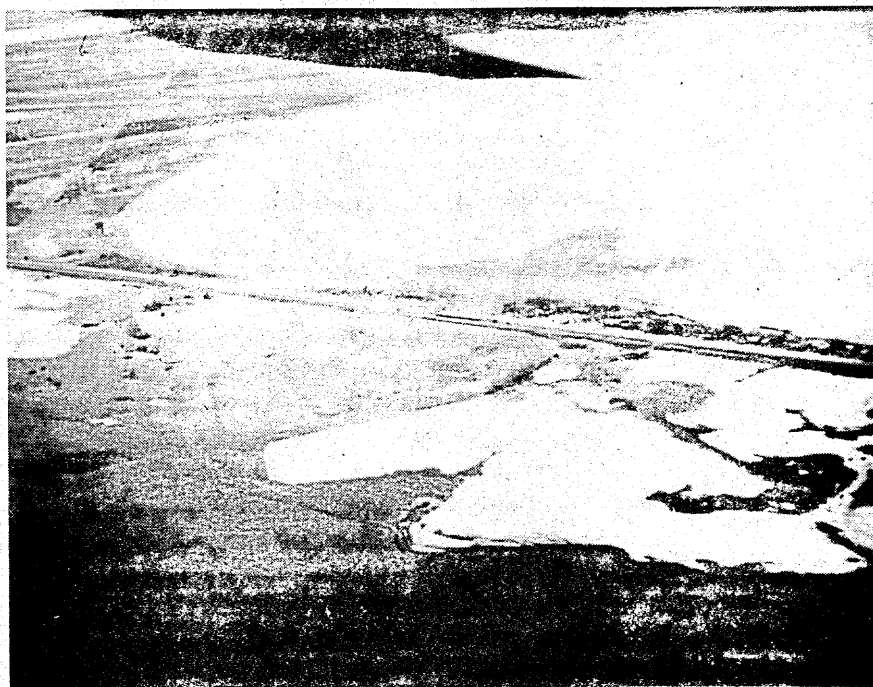


Figure 14. Aerial photo of Lake Kampeska showing the floodwater during the flood of 1969.



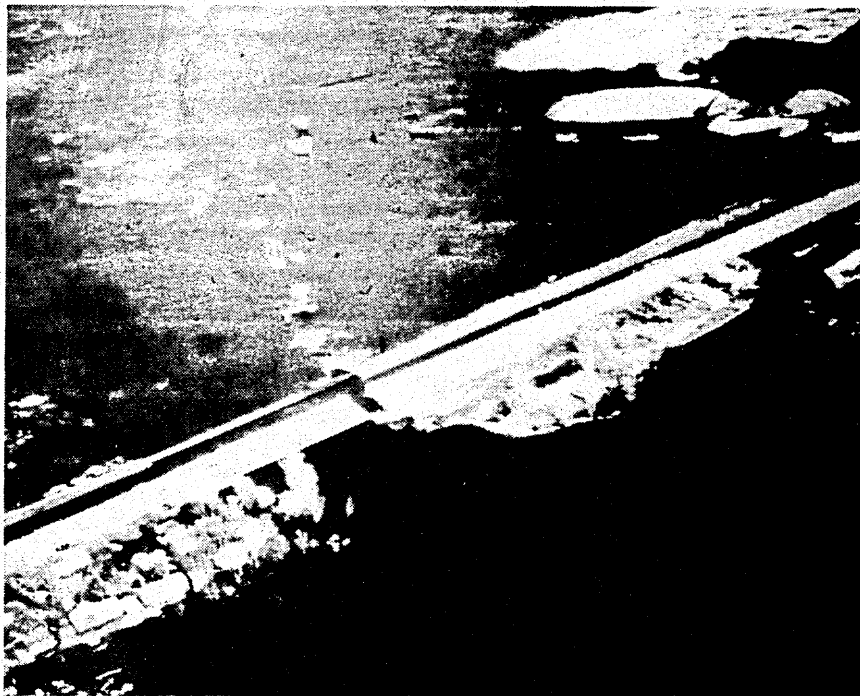


Figure 15. Aerial photo showing Highway 20 and erosion on the east side of the bridge (April 10, 1969).



Figure 16. Photograph showing erosion on the east side of Highway 20 Bridge on the inlet-outlet channel (April 10, 1969).



Figure 17. Photograph showing flooded cottages around Lake Kampeska (April 10, 1969).



Figure 18. Aerial photo showing the floodwaters in Watertown, (April 10, 1969).

structure is returned to the atmosphere, principally in the form of water vapor. Rate of transpiration depends on climate and type of vegetation.

Evaporation is the process by which a liquid (water) is changed into vapor. The evaporation process occurs from the surface of land, lakes, ponds, and streams. Depth has a pronounced influence upon the rate of evaporation from any body of water. Likewise, water from a soil surface will evaporate initially at quite a high rate, but as soon as a thin layer of soil dries out the rate of evaporation is considerably reduced. Evaporation from the surface of a lake in this area is 33 inches per year (Kohler and others, 1959). At this rate Lake Kampeska loses 13,500 acre-feet of water per year.

#### Surface-Water Discharge

The only surface-water discharge from the lake is by the inlet-outlet channel through which water flows to the Big Sioux River when the lake elevation is higher than the water level in the river northeast of the lake.

#### Ground-Water Discharge

The main ground-water discharge takes place through the sand and gravel deposits northeast of the lake. Figure 12 is a water-table map of the Lake Kampeska study area for July 30, 1970. This map indicates that ground water was being discharged through the sand and gravel northeast of the lake. Because of the exchange between ground water and surface water in this location, the quantity of each flow could not be estimated accurately with the available data.

#### Artificial Discharge

Water is discharged directly from the lake by the city of Watertown. Seventy-two percent of the city's total water from 1944 through 1970 (app. F) was obtained from Lake Kampeska. During 1970 the city of Watertown removed 3.2 inches of water from the lake.

In addition, water is presently being pumped from the sand and gravel by domestic wells around the lake. However, the quantity of water pumped by domestic wells around the lake is small when compared with the water pumped from the lake by the city. Most of the water pumped for private use around the lake is directly or indirectly returned to the lake or to the aquifer around the lake.

#### Chemical Quality of Water

Ground water and surface water always contain dissolved chemical substances in various amounts. Contained chemicals are derived (1) from the atmosphere as water vapor condenses and falls, (2) from soil and underlying deposits as the water moves over the land and downward to the water table, and (3) from rocks below the water table where the water is moving. In general, the more chemical substances that a water contains, the poorer its quality, the suitability of water being determined by the purpose for which it is used. A certain quality of water may be suitable for one purpose and unsuitable for another.

Table 1 shows the quality of water samples collected from the Lake Kampeska area during the study, along with drinking water standard limits recommended by the U. S. Department of Public Health (sample W-Z). All W-B samples were collected from the inlet-outlet channel; all W-F samples and W-L samples were collected from the Big Sioux River north of the lake; all W-H samples and sample W-G were collected from Gravel Creek; and all W-K samples were collected from the lake at the filtration plant. For locations of these and other samples collected during the study see figure 19.

Except for high iron and manganese content in some of the samples and low fluoride in all samples (except sample W-B<sub>3</sub>), the rest of the chemicals are within the limits set by the South Dakota Department of Health for drinking water standards.

Because this section of the report is concerned with the water quality of the lake, concentration of the chemicals in the following quotations from the Federal Water Pollution

Table 1. Chemical analyses of water samples  
from the Lake Kameska Area

(Concentrations are given in parts per million)

Sample	Date	Calcium	Sodium	Magnesium	Chloride	Sulfate	Iron	Manganese	Nitrogen	Soluble Phosphorus	Fluoride	Alkalinity Methyl- Orange	Hardness as $\text{CaCO}_3$	Total Solids
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
W-A	7-1-67	92		22	0	183	0.06						320	486
W-B <sub>1</sub>	7-1-67	40		36	Tr.	55	0.08						190	326
W-B <sub>2</sub>	10-28-67	44	10	27	0.6	61	0.4	0.3	0.84		0.6	183	222	286
W-B <sub>3</sub>	9-15-68	28	13	42	0	92	0.2	0.4	0.1		1.2	196	242	384
W-B <sub>4</sub>	10-13-68	49	13	38	6	104	0	0	1.2		0.4	187	280	464
W-B <sub>5</sub>	11-10-68	43	12	42	2	104	0.1	0	<0.1		0.4	200	278	364
W-B <sub>6</sub>	4-8-69	13	Tr.	10	0	18	1.4	0.4	1.5			61	72	98
W-C	7-1-67	87		16	0	Tr.	0.07						280	397
W-D	7-1-67	61		18	0	0	Tr.						225	409
W-E	7-1-67	106		33	20	60	0.08						400	573
W-F <sub>1</sub>	10-28-67	63	13	34	2	91	0	0.2	0.33		0.8	220	296	370
W-F <sub>2</sub>	3-26-68	47	11	24	3	72	0.8	0.2	0.3		0.4	156	215	250
W-F <sub>3</sub>	4-27-68	72	18	35	0.2	110	0	0	0.3		0	240	326	436
W-F <sub>4</sub>	9-15-68	36	13	40	3	66	0.2	0	0.2		0.6	194	253	366
W-F <sub>5</sub>	10-13-68	57	16	39	5	116	0	0	0.6		0.2	210	302	488
W-F <sub>6</sub>	11-10-68	44	17	48	3	92	1.1	0	<0.1		0.4	240	306	404
W-F <sub>7</sub>	5-3-69	46	11	44	0	56	0.04	0	<0.1		0.4	249	296	350
W-F <sub>8</sub>	10-3-69	46	14	43	4	98	1.0	0	<0.1		0.2	203	290	348
W-F <sub>9</sub>	10-19-69	45	16	44	6	104	0.3	0	0.6		0.2	196	293	348
W-F <sub>10</sub>	11-23-69	63	17	50	6	98	0.3	0	0.5		0.4	277	364	499
W-F <sub>11</sub>	3-7-70	21	2	13		22	1.1				0.2	93	105	138
W-F <sub>12</sub>	4-4-70	37	5	26	2	30	0.7		0.4		0.2	164	199	254
W-F <sub>13</sub>	4-24-70	41	10	34		62	0.3		2	0.2	0.4	176	241	308
W-F <sub>14</sub>	5-10-70	61	10	49	2	68				0.2	0.2	290	355	422
W-F <sub>15</sub>	5-28-70	58	13	51	0	64	1.4	0	<0.1	<0.1	0.4	277	356	394
W-G	3-26-68	74	11		3	118	0.4	0.4	0.7		0.4	190	307	396
W-H <sub>1</sub>	4-27-68	94	12	39	3	156	0.78	0	0.2		0.4	240	396	556
W-H <sub>2</sub>	10-13-68	85	10	18	6	148	0	0	1.4		0.2	233		530
W-H <sub>3</sub>	4-8-69	7	Tr.	7	0	10	0.2	0	1.8	0.5	0.4	33	44	66
W-H <sub>4</sub>	4-10-69	5	3	5		24	0.5	0	1.6	0.4	0.2	51	77	118
W-H <sub>5</sub>	5-3-69	64	11	56	0	120	0	0	Tr.		0.4	262	392	464

Continued on next page.

Table 1—continued.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
W-H6	3-7-70	8	3	16		30	0.8				0.2	68	86	120
W-H7	4-4-70	62	7	7	2	102	0.2				0	186	182	370
W-H8	4-24-70	70	11	45	2	120	0.3				0.2	234	362	466
W-H9	5-10-70	83	9	39	2	116	0.2				0.2	289	368	492
W-H10	5-28-70	70	9	41	1	106	0	0	<0.1	<0.1	0.2	240	344	420
W-I1	4-27-68	50	76	65	47	256	0.12	0	<0.1	<0.1	0.6	238	392	708
W-I2	4-10-69			11		12	0.5		0.5			34	45	66
W-K1	4-27-68	44	9	26	0.8	66	0.22	0	0.25		0.4	184	218	308
W-K2	5-3-69	26	14	25	0.2	46	0	0	0.7		0.2	131	168	216
W-K3	10-3-69	28	9	29	4	66	0.1	0	<0.1		0.2	144	191	240
W-K4	10-19-69	41	13	34	8	72	0.3	3.9	2		0.2	168	240	290
W-K5	11-23-69	21	10	34	6	56	0.6	0	2.7		0.2	142	194	298
W-K6	3-7-70	38	10	37	4	82					0.2	174	246	318
W-K7	4-4-70	35	10	35	5	58	0.3			0.5		174	230	304
W-K8	4-24-70	27	9	55	2	46	0.3			0.5	0.2	140	295	240
W-K9	5-10-70	30	7	27	5	54	0.2			0.5	0.2	154	187	258
W-K10	5-28-70	29	8	28	2	60	0	0	<0.1	<0.1	0	148	189	220
W-L	4-9-69	8	Tr.	6	0	12	0.9	0			0.2	41	45	68
W-M	5-3-69	48	12	43	7.6	60	0	0	2.1		0.2	244	297	360
W-N	5-10-70	44	80	42	98	180	1.6		1.3	1.1	0.8	235	285	626
W-Z					250	500 <sup>1</sup>	0.3	0.005 <sup>1</sup>	10.0		0.9-2			1000

W-Z. Drinking water standards, U. S. Public Health Service (1962).

Samples W-A, W-B1, W-C, W-D, and W-E were analyzed by the South Dakota Geological Survey. All other samples were analyzed by the South Dakota Chemical Laboratory.

<sup>1</sup> Modified for South Dakota by the Department of Health (Written communication, Water Sanitation Section, March 20, 1968).

<sup>2</sup> 1.2 is optimum for South Dakota.

Location of water samples in table 1.

(For map location see fig. 19.)

- W-A. NE $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec 12, T. 117 N., R. 53 W., irrigation pond.
- W-B. All samples collected from SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 15, T. 117 N., R. 53 W., Lake Kampeska.
- W-C. NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W., City Well 3.
- W-D. NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 31, T. 117 N., R. 52 W., Big Sioux River.
- W-E. NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 12, T. 116 N., R. 53 W., 30 foot deep well.
- W-F. All samples collected from SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 35, T. 118 N., R. 53 W., Big Sioux River.
- W-G. SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 31, T. 118 N., R. 52 W., Gravel Creek.
- W-H. NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 12, T. 117 N., R. 53 W., Gravel Creek.
- W-I. All samples collected from SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 13, T. 117 N., R. 53 W., Big Sioux River.
- W-K. All samples collected from NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 28, T. 117 N., R. 53 W., Lake Kampeska next to filtration plant.
- W-L. SE $\frac{1}{4}$  sec. 2, T. 117 N., R. 53 W., Big Sioux River floodwater.
- W-M. SW $\frac{1}{4}$  sec. 11, T. 117 N., R. 53 W., diversion channel.
- W-N. SE $\frac{1}{4}$  sec. 5, T. 116 N., R. 52 W., flow from sewage pond into Big Sioux River.



Control Administration (MacKenthun and Ingram, 1967) are used to compare the quality of water samples listed in table 1. Extensive discussion of the biological aspect of the lake water is beyond the scope of this report.

Eutrophication is a term used to mean enrichment of waters by nutrients.

"Present knowledge indicates that the fertilizing elements contributing most to lake eutrophication are nitrogen and phosphorus. Iron and certain 'trace' elements are also important... As nutrient concentrations increase, the number of algal cells increase... Reservoirs or lakes are the settling basins of drainage areas. The potential productivity of a body of water is determined to a great extent by the natural fertility of the land over which the runoff drains and by the contributions of civilization. Biological activity within the lake influences such chemical characteristics as dissolved oxygen, pH, carbon dioxide, hardness, alkalinity, iron, manganese, phosphorus, and nitrogen; it is varied through temperature fluctuation and stimulated by nutrient variations (e.g., phosphorus and nitrogen). A lake's basin gives dimension to biological activity and may, because of unique physical characteristics, concentrate the nutrients it receives as well as the developing biomass. Sawyer (1947) studied the southern Wisconsin lakes and concluded that a 0.30 mg/l concentration of inorganic nitrogen (N) and a 0.01 mg/l concentration of soluble phosphorus (P) at the start of the active growing season could produce nuisance algal blooms... A continued high rate of nutrient supply is not necessary for continued algal production. After an initial stimulus, the recycling of nutrients within the lake basin may be sufficient to promote algal blooms for a number of years without substantial inflow from contributing sources." (MacKenthun and Ingram, 1967, p. 103-133).

The nutrient level of the lake water and waters recharging the lake vary seasonally. For example, floodwater introduces a high concentration of nutrients. Samples collected from the northeast of the lake during the flood of 1969 show that floodwater had as high as 2.1 ppm nitrogen and 0.5 ppm soluble phosphorus. The concentration of these chemicals are higher than the figures referred to in the above quotations. Even if the lake water did not have any phosphorus and nitrogen before flooding, the concentration of these chemicals after flooding would be raised to a level higher than the concentration needed to produce algal blooms. (After the flood of 1969 approximately one-third of the water contained in the lake was floodwater, [see page 22]).

#### DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

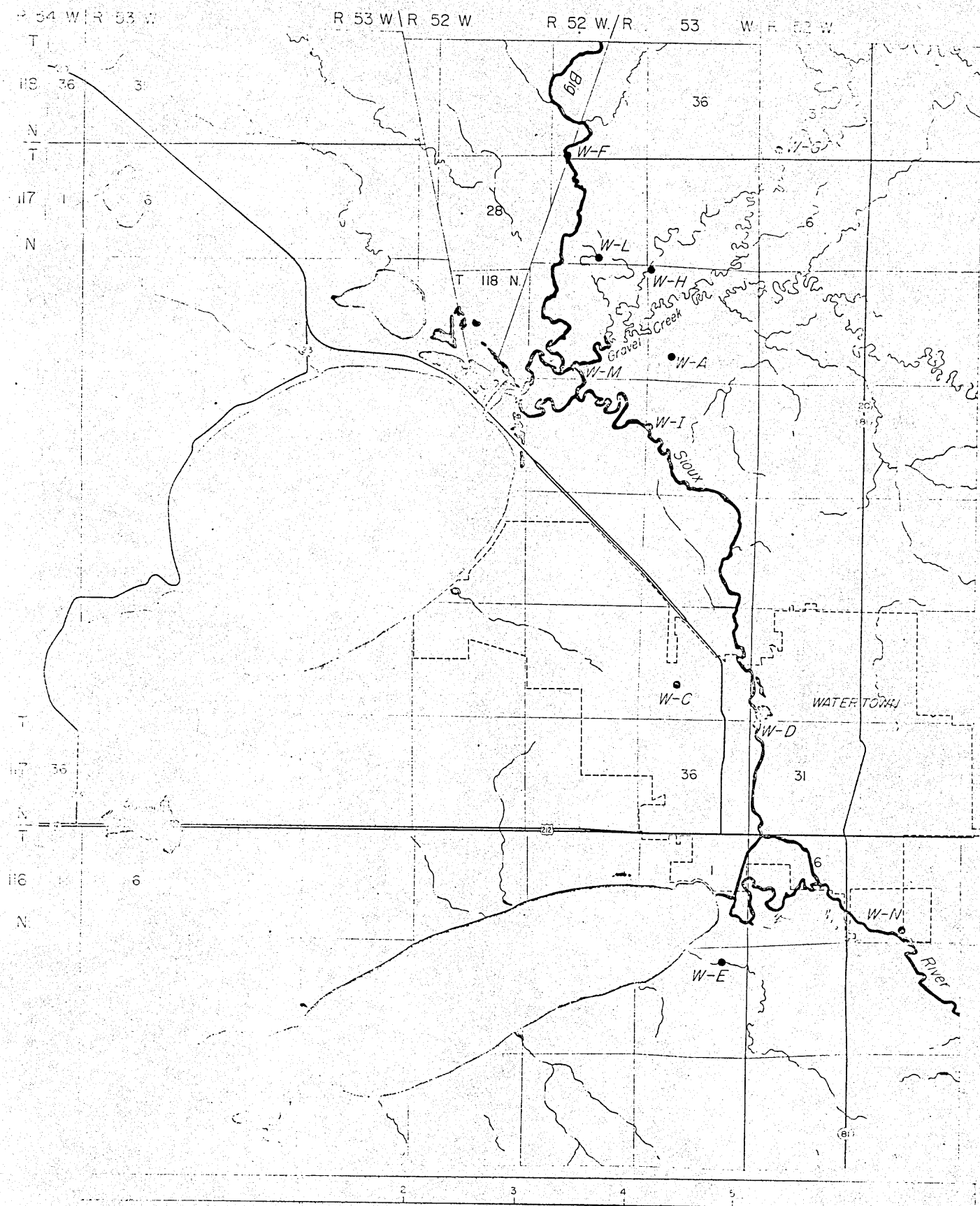
The Big Sioux River is directly connected to Lake Kampeska through the inlet-outlet channel northeast of the lake. In addition, an aquifer northeast of the lake hydraulically connects the Big Sioux River and Gravel Creek to the lake. These two mediums of exchange, i.e., the inlet-outlet channel and the aquifer, are the primary avenues of surface and ground-water recharge and discharge for Lake Kampeska.

Recharge to Lake Kampeska includes direct precipitation, which adds 20.52 inches of water annually, runoff, and recharge through the inlet-outlet channel and through the aquifer northeast of the lake. Surface runoff from the area around the lake is small when compared with the flow from the northeast.

Discharge from the lake includes evaporation, which removes 33 inches of water from the surface of the lake annually, artificial discharge by the city of Watertown, which removes approximately 3.2 inches annually by pumping for municipal use, and discharge through the aquifer and inlet-outlet channel.

The change in the balance between the total recharge and discharge is reflected as fluctuation in lake level. When the water level in the Big Sioux River and the aquifer is higher than the lake level, water recharges the lake. When the water level in the lake is higher than the river and the water table in the aquifer, water is discharged from the lake.

During flooding a large quantity of water reaches Lake Kampeska through the



#### EXPLANATION

- W - B • Location of water samples (letters correspond to water samples listed in table 1.)
- Intermittent stream

by A. Barari, 1970

drafted by D. W. Johnson

Figure 19 Map showing location of water samples collected from the Lake Kampeska study area.



inlet-outlet channel. The flood of 1969 caused the lake level to rise 5.2 feet indicating that 26,000 acre-feet of water was recharged into the lake. The rate of flow into the lake through the inlet-outlet channel was approximately 3 times greater than the rate of flow through Watertown.

A construction on the inlet-outlet channel to block the flow of floodwaters to the lake without controlling the quantity of water reaching the study area will not function during flooding. Either the sand and gravel deposits on the sides of such a construction will be eroded (see fig. 16) and the structure destroyed (see origin and history of Lake Kampeska, this report), or the water will flow over the construction. (See fig. 11 showing the location and thickness of sand and gravel deposits, and pl. 1 showing the very low relief of this area.) Even if the floodwater could be diverted from the lake during flooding, without construction of a deep wide channel through Watertown flood damages in Watertown would increase substantially.

Several plans have been proposed for flood control around Lake Kampeska and the city of Watertown. One proposal suggests construction of a channel between Lake Kampeska and Pelican Lake which would bypass the city and thus decrease flood damage there; unfortunately, such a project would also increase siltation and nutrient recharge to the lake. Dredging out the Big Sioux River downstream from Gravel Creek will reduce flooding in Watertown if dredging is deep enough, but this will induce increased ground-water discharge from the lake in dry seasons and, consequently, lower the lake level. Another alternative incorporates a design for a deep concrete channel along the Big Sioux River south of Gravel Creek through Watertown. This plan requires construction of a gate at the north end of the concrete channel to control the flow of water through the channel, and dredging of the river downstream. Thus, remedies for reducing flood damage and loss of lake water through the channel during dry seasons are embodied in this proposal, however, they will be very costly.

It is recommended that any management plan for Lake Kampeska should include provisions for the following major factors: There should be provisions for quality and quantity of water recharging the lake, both during low precipitation and high precipitation (flooding) periods, and there should be a provision made for the quantity of discharge passing through the inlet-outlet channel and through the gravel northeast of the lake. Taking the above factors into consideration, it is recommended that the floodwater be contained upstream from the study area. A reconnaissance study for the storage of floodwater north of Lake Kampeska was made by the Soil Conservation Service, and presently, engineering studies are being conducted under contract with the East Dakota Conservancy Sub-District. Such a storage area will reduce the flood damage around the lake and in Watertown, because stored water will gradually flow through the sand and gravel and in the river, thus increasing the flow during summer and fall when there is little or no flow in the river. Additional water in the aquifer and in the river northeast of the lake will also increase water flow into the lake or at least decrease the discharge of water from the lake. As a result, lake-level fluctuation will decrease, and siltation of the lake will be reduced.

Phosphorus and nitrogen content of the water is of primary importance to the biological aspect of the lake (see p. 30). Nutrient content of the lake and streams recharging the lake fluctuates seasonally, being especially high during flooding (see p. 30). Retaining water upstream will probably reduce some of the nutrient in the water reaching the lake, but it is recommended that soil conservation practices be employed to reduce the nutrient in the waters reaching the lake from the north and from areas around the lake. A sewage system should be constructed as soon as possible to eliminate the flow of nutrients introduced to the lake directly or indirectly (through the gravel) by residences around the lake.

Because the problems associated with the quantity and quality of lake water are inter-related, the total water management of the lake requires the cooperation of several government agencies. Furthermore, it is recommended that the public be fully informed about the problems, in order to gain their cooperation and support. Without public support not many projects can be implemented.

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## APPENDIX A

Table of monthly and annual precipitation for  
the Lake Kampeska area (Watertown Airport)  
from 1898 through 1970\*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1898	.00	.35	1.10	1.72	3.25	1.65	4.54	1.93	1.53	1.32	.15	.00	17.54
1899	.19	.00	.30	2.02	3.79	2.85	.95	5.03	.45	2.75	.53	.25	19.11
1900	.15	.52	1.45	1.30	.56	2.17	6.73	7.67	4.74	1.45	.12	.10	26.96
1901	.13	.25	.38	1.63	1.98	5.61	2.27	2.89	7.00	1.87	.08	.14	24.23
1902	.25	.07	1.29	1.28	3.25	1.70	2.35	3.34	.13	1.75	.44	1.05	16.90
1903	.15	.13	.53	1.20	3.73	2.26	4.48	5.76	4.52	1.91	.14	.43	25.24
1904	.20	.46	.10	.93	1.34	4.60	5.08	2.27	1.87	2.24	.01	.34	19.44
1905	.77	.72	.59	1.46	2.53	5.46	5.12	2.86	2.17	2.02	1.97	.00	25.67
1906	.26	.30	.78	2.12	4.30	3.44	1.63	4.25	1.25	3.07	.75	.47	22.62
1907	1.85	.93	1.74	.56	2.71	2.79	2.80	.39	.96	1.36	.00	.80	16.67
1908	.25	1.40	1.20	3.25	3.06	6.12	.88	2.37	1.82	1.48	1.50	.47	23.80
1909	1.09	.67	.10	.35	4.56	3.23	3.38	5.26	.50	1.65	1.14	1.72	23.65
1910	.00	.40	.00	2.75	.39	2.78	3.16	3.17	1.20	1.05	.30	.20	15.40
1911	.80	.31	.30	.85	2.14	1.51	1.87	2.82	1.85	4.24	.96	.34	17.99
1912	.10	.35	.22	5.16	4.30	2.55	5.01	2.29	2.61	.41	.00	.30	23.30
1913	.10	.10	.21	3.04	3.86	4.30	3.77	1.39	2.28	1.13	.27	.13	20.58
1914	.52	.38	.42	2.72	3.69	8.99	.95	1.30	2.64	1.84	.00	.30	23.75
1915	.40	1.64	.55	1.11	3.01	5.20	3.38	.57	5.49	1.80	.10	.41	23.66
1916	1.85	.69	1.09	1.53	3.62	4.40	3.06	7.40	1.25	.37	.02	.65	25.93
1917	1.43	.18	1.55	3.03	.46	2.94	2.21	1.21	3.28	.20	.08	.44	17.01
1918	.52	.40	1.12	1.70	4.73	3.95	1.62	2.00	.35	1.53	2.97	1.40	22.29
1919	.05	.84	.60	1.75	2.64	6.50	4.10	1.08	.53	1.18	2.47	.02	21.76
1920	.15	.32	1.92	1.81	2.58	3.72	2.20	1.42	1.28	.52	1.20	.54	17.66
1921	.00	.18	2.05	2.22	2.27	1.64	4.18	5.10	7.22	.15	.90	.16	26.07
1922	1.87	2.28	.56	1.56	3.49	2.03	1.82	2.39	.67	.52	2.93	.35	20.47
1923	.91	.15	.48	2.65	1.77	5.29	1.41	.63	1.67	.23	.31	.38	15.88
1924	.13	.32	2.46	2.72	1.72	5.86	2.96	5.83	1.52	1.50	.32	.07	26.31
1925	.77	.13	.08	2.73	.68	7.27	1.75	2.44	1.44	.29	.57	.37	18.52
1926	.49	.06	.27	.19	3.58	2.24	2.19	1.25	2.99	2.06	.57	.73	16.62
1927	.24	.16	.90	4.19	3.49	2.29	5.11	2.30	.97	.56	.39	1.48	22.08
1928	.18	.38	.05	.61	.60	2.33	2.09	4.41	3.22	1.58	.70	.26	16.41
1929	.85	.45	.93	2.31	1.35	1.27	2.77	1.91	3.17	2.10	.45	.20	17.76
1930	.54	.63	.17	.94	2.93	3.42	.88	1.54	1.28	1.09	2.13	.02	15.57
1931	.03	.31	.58	1.38	8.16	1.91	1.37	1.19	1.16	1.48	.88	.82	19.27
1932	.60	.02	.76	4.21	2.37	5.31	1.74	2.47	1.66	1.57	.47	.38	21.56
1933	.11	.00	.70	.70	2.65	1.67	1.33	1.99	2.49	.03	.31	.34	12.32
1934	.19	.04	1.02	.17	.99	3.51	5.65	2.81	4.53	1.43	.39	.20	20.93
1935	.40	.34	1.58	2.91	1.83	4.61	3.26	3.56	.17	.22	.54	.92	20.34
1936	.57	1.21	.53	2.02	1.81	2.29	.88	3.06	.30	.35	1.05	.49	14.56
1937	1.00	.36	1.91	4.62	2.30	4.40	.92	2.54	1.44	.73	.39	.83	21.44
1938	.81	.57	1.20	3.36	4.05	2.72	2.28	2.23	2.63	.12	.38	.29	20.64
1939	1.68	.85	.24	1.17	3.91	6.11	2.46	2.79	.73	.87	.02	.10	20.93
1940	.12	.70	3.16	1.77	.60	3.50	1.84	5.40	1.19	1.62	1.15	.47	21.52
1941	1.45	.09	.40	3.88	3.36	2.66	1.52	1.95	1.54	1.65	.14	.24	18.88
1942	.02	.08	1.56	2.83	6.80	1.91	2.46	3.39	5.20	1.08	.14	.37	25.84
1943	.92	1.35	1.98	.48	3.15	5.65	3.69	3.48	2.51	2.69	1.42	.00	27.32
1944	.58	.32	.52	2.16	2.25	2.57	2.24	3.21	2.28	.11	1.79	.68	18.71
1945	.41	.95	1.12	1.89	5.22	2.86	2.12	2.76	2.41	.32	.50	1.10	21.66

\*Climatological summary, Climatography of the U.S., No. 20-39; and South Dakota annual summary, 1967, 1968, 1969, and monthly climatological summary for 1970.

Year	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1946	.07	1.67	2.23	.67	2.74	6.00	2.37	.68	3.86	4.53	1.14	.36	26.32
1947	.31	.27	.68	3.50	.99	4.18	1.00	1.65	2.80	1.98	2.64	.03	20.03
1948	.26	1.04	.38	3.60	.51	5.52	2.88	5.63	3.11	1.26	.31	.07	24.57
1949	.54	.01	.41	.36	3.31	2.09	4.55	.79	2.55	1.42	.97	.82	17.82
1950	.41	.03	.65	1.85	3.21	.33	6.14	1.71	1.37	1.83	.42	.26	18.21
1951	.20	.21	1.85	.83	2.55	3.82	4.08	5.00	.40	2.24	.08	.80	22.06
1952	.77	.91	.73	.31	1.15	5.10	2.92	.82	.47	.00	1.10	.27	14.55
1953	.88	1.64	.50	3.86	1.77	8.15	7.77	1.19	.12	.32	1.07	1.85	29.12
1954	.37	.65	2.13	1.74	3.10	3.74	.88	1.67	2.42	1.09	.23	.02	18.04
1955	.26	1.39	.17	1.26	1.23	4.65	4.74	4.35	.94	.16	.46	3.36	22.97
1956	1.33	.20	1.04	1.80	2.88	6.56	4.02	6.25	.70	2.44	.97	.16	28.35
1957	.21	.99	.44	3.67	5.68	2.75	.46	3.47	1.98	2.42	.51	.42	23.00
1958	.10	.49	.44	1.46	1.34	1.73	1.35	.77	1.28	.10	2.53	.24	11.83
1959	.39	.74	.06	.64	3.77	.96	1.74	2.20	1.20	1.79	1.14	.56	15.19
1960	.68	.26	.87	2.64	2.49	3.81	1.29	4.40	1.59	.46	1.13	1.08	20.70
1961	.05	.50	.49	1.53	5.58	4.05	.79	2.03	2.31	1.50	.63	.73	20.19
1962	.42	1.67	1.49	2.36	8.75	4.71	4.62	.62	1.84	1.04	.42	.02	27.96
1963	.74	.28	1.65	1.34	4.18	3.48	10.36	1.89	1.39	1.11	.61	.61	27.64
1964	.05	.38	1.22	2.61	1.28	2.57	2.28	5.24	.77	.09	.53	.40	17.42
1965	.29	.29	2.67	3.14	6.41	2.89	2.02	1.39	4.36	.84	.78	.69	25.77
1966	.24	.77	1.33	2.02	1.10	1.63	4.67	5.13	1.37	1.37	.79	.28	20.70
1967	.85	1.75	.25	3.00	.41	5.19	3.41	.65	1.69	1.02	.12	.35	17.62
1968	.50	.01	.64	4.52	2.67	5.06	3.33	2.07	2.71	2.62	.58	2.40	27.11
1969	1.47	1.53	.23	1.02	4.77	2.47	6.67	1.26	.60	4.59	.25	.70	25.56
1970	.32	.08	1.46	2.69	3.12	3.96	1.37	.75	1.84	2.01	2.88	.32	20.80
Normal	.50	.59	.99	2.06	2.87	3.70	2.67	2.78	1.83	1.21	.81	.51	20.52

## APPENDIX B

Logs of test holes and observation wells in the  
Lake Kampeska study area

(For location see fig. 10.)

Abbreviations used in appendix B:

South Dakota Geological Survey, SDGS; City of Watertown, CW; Water Resources  
Commission, WRC.

Number following the date of drilling is the previous test hole number,

Test Hole 1, SDGS, 1957, No. 31

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 30, T. 118 N., R. 53 W.

Surface elevation: 1805 feet

Static water elevation: not measured

0- 1	Topsoil, black
1-30	Till, yellow-brown

\* \* \*

Test Hole 2, SDGS, 1957, No. 22

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 118 N., R. 53 W.

Surface elevation: 1743 feet

Static water elevation: 1718 feet

0- 5	Topsoil
5- 7	Clay
7-30	Sand, coarse; water
30-37	Silt, brown; sand
37-65	Silt, brown; clay

\* \* \*

Test Hole 3, SDGS, 1957, No. 32

Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 118 N., R. 53 W.

Surface elevation: 1761 feet

Static water elevation: not measured

0- 1	Topsoil, black
1-30	Till, yellow-brown

\* \* \*

Test Hole 4, SDGS, 1963, No. 9

Surface elevation: not taken

Depth to water: 12 feet

0-19	Clay, brown; some sand and gravel
19-29	Till, brown
29-64	Clay, blue

\* \* \*

## Test Hole 5, CW, 1964-65, No. 21

Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 30, T. 118 N., R. 52 W.

Surface elevation: 1755.90

Static water elevation: 1747.48

0- 2	Road bed
2- 5	Clay, sandy
5-17	Sand and gravel, medium to coarse; boulders; 4" mud loss
17-19	Clay, gray
19-42	Sand and gravel, medium to coarse; 6" mud loss
42-56	Clay, gray

\* \* \*

## Test Hole 6, SDGS, 1963, No. 10

Surface elevation: 1727 feet

Depth to water: 10 feet

0- 9	Gravel, red
9-29	Sand, medium to coarse; some clay
29-89	Sand, medium to coarse; less clay
89-99	Clay, blue

\* \* \*

## Test Hole 7, SDGS, 1963, No. 11

Surface elevation: 1734 feet

Depth to water: 4 feet

0-11	Clay, brown; gravel; unsorted
11-29	Gravel, coarse; some clay
29-44	Gravel; less clay
44-49	Gravel; more clay
49-54	Clay, blue

\* \* \*

## Test Hole 8, SDGS, 1963, No. 12

Surface elevation: 1739 feet

Depth to water: 15 feet

0-14	Clay; sand; gravel; poorly sorted
14-54	Sand, coarse; gravel, fine
54-64	Sand and gravel; more silty

\* \* \*

## Test Hole 9, SDGS, 1957, No. 48

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 31, T. 118 N., R. 53 W.

Surface elevation: 1748 feet

Static water elevation: not measured

0- 3	Topsoil
3- 4	Sand, clean, medium
4-13	Gravel, medium-fine
13-15	Gravel, medium-coarse; rocks

\* \* \*



## Test Hole 10, SDGS, 1963, No. 14

Surface elevation: 1765 feet

Depth to water: 18 feet

0-19	Sand, brown, medium; clay
19-24	Sand, fine; clay
24-29	Till, blue

\* \* \*

## Observation Well 11, SDGS, 1967-70

Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 21, T. 118 N., R. 52 W.

Top of observation well: 1739.18 feet

Depth to water: 10 feet

0- 1	Topsoil
1- 3	Sand, fine
3- 5	Clay, gray
5-10	Sand and gravel
10-15	Gravel; some sand
15-30	Sand
30-40	Sand, coarse

\* \* \*

## Test Hole 12, SDGS, 1963, No. 16

Surface elevation: 1748 feet

Depth to water: 9 feet

0- 9	Clay, brown; some sand and gravel
9-24	Sand; some clay
24-59	Clay, blue; some sand

\* \* \*

## Observation Well 13, SDGS, 1967-70, No. 10

Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 22, T. 118 N., R. 52 W.

Top of observation well: 1740 feet

Depth to water: 16 feet

0- 1	Topsoil
1-33	Sand, coarse; some pebbles
33-44	Clay, dark-gray; pebbly, (till)
44-49	Clay; some sand
49-74	Clay, blue

\* \* \*

## Observation Well 14, SDGS, 1967-70, No. 3

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 36, T. 118 N., R. 53 W.

Top of observation well: 1738.51 feet

Depth to water: 6 feet

0- 2	Topsoil
2- 6	Clay, dark-gray
6-16	Sand; some gravel

## Observation Well 14--continued.

16-29 Clay, dark-gray; pebbly, (till)

\* \* \*

## Test Hole 15, CW, 1964-65, No. 22

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 31, T. 118 N., R. 52 W.

Surface elevation: 1749.15

Static water elevation: 1740.15

0- 2 Topsoil, clay  
 2-12 Medium to very coarse sand and gravel, 3" mud loss  
 12-18 Yellow clay  
 18-33 Gray clay

\* \* \*

## Test Hole 16, CW, 1964-65, No. 34

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 31, T. 118 N., R. 52 W.

Surface elevation: 1753.27

Static water elevation: 1742.02

0- 1 Topsoil  
 1- 3 Sandy clay  
 3-28 Medium to very coarse sand and gravel, 6" mud loss  
 28-31 Gray clay  
 31-37 Medium to very coarse sand and gravel, 6" mud loss  
 37-48 Gray clay

\* \* \*

## Test Hole 17, CW, 1964-65, No. 33

Location: SE $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 31, T. 118 N., R. 52 W.

Surface elevation: 1741.06

Static water elevation: 1736.23

0- 1 Topsoil  
 1- 3 Sandy clay  
 3-20 Medium to very coarse sand and gravel, 6" mud loss  
 20-33 Gray, clay

\* \* \*

## Test Hole 18, SDGS, 1957, No. 21

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 31, T. 118 N., R. 52 W.

Surface elevation: 1747 feet

Static water elevation: 1735 feet

0- 7 Topsoil  
 7-12 Sand, tan; silt; water  
 12-18 Gravel, medium-brown; water  
 18-30 Sand, coarse; gravel, fine  
 30-40 Sand, coarse  
 40-45 Sand, medium to fine  
 45-65 Sand, fine

\* \* \*

Test Hole 19, CW, 1964-65, No. 37

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 32, T. 118 N., R. 52 W.

Surface elevation: 1753.71

Static water elevation: 1742.71

0- 1	Topsoil
1- 4	Yellow clay
4-20	Medium to coarse sand and gravel, 4" mud loss
20-33	Brown clay and gray clay

\* \* \*

Test Hole 20, SDGS, 1957, No. 50

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 32, T. 118 N., R. 52 W.

Surface elevation: 1747 feet

Static water elevation: 1740 feet

0- 3	Topsoil
3- 7	Gravel, medium; sand, coarse; water
7- 9	Sand, medium; gravel, fine
9-24	Sand, coarse
24-47	Sand, medium to fine
47-65	Sand, medium to fine

\* \* \*

Test Hole 21, CW, 1964-65, No. 31

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 32, T. 118 N., R. 52 W.

Surface elevation: 1753.71

Static water elevation: 1742.71

0- 1	Topsoil
1- 3	Sandy clay
3-18	Medium to very coarse sand and gravel, 7" mud loss
18-33	Yellow clay

\* \* \*

Test Hole 22, CW, 1964-65, No. 32

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 32, T. 118 N., R. 52 W.

Surface elevation: 1761.87

Static water elevation: 1747.87

0- 1	Topsoil
1- 4	Sandy clay
4-23	Medium to very coarse sand and gravel, 10" mud loss
23-33	Brown gray clay

\* \* \*

Observation Well 23, SDGS 1967-70

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 33, T. 118 N., R. 52 W.

Top of observation well: 1767 feet

Depth to water: 12.47 feet

0- 2	Topsoil
------	---------

## Observation Well No. 23—continued.

2-23 Sand and gravel  
 23-29 Clay, dark-gray; pebbly, (till)

\* \* \*

## Test Hole 24, SDGS, 1963, No. 20

Surface elevation: 1750 feet

Depth to water: not measured

0-17 Gravel, fine to medium; some sand  
 17-44 Clay, brown  
 44-49 Clay, brown; some sand  
 49-54 Clay, blue

\* \* \*

## Test Hole 25, SDGS, 1963, No. 21

Surface elevation: 1747 feet

Depth to water: 22 feet

0-29 Clay, red; sand  
 29-39 Sand, brown; clay  
 39-49 Sand; more clay  
 49-59 Clay, gray

\* \* \*

## Test Hole 26, SDGS, 1963, No. 15

Surface elevation: 1721 feet

Depth to water: 17 feet

0- 9 Clay, brown; sand  
 9-24 Till, blue  
 24-49 Till, brown

\* \* \*

## Observation Well 27, SDGS, 1967-70

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 3, T. 117 N., R. 53 W.

Top of observation well: 1749.9 feet

Depth to water: 18 feet

0- 2 Topsoil  
 2-28 Sand and gravel  
 28-49 Clay, gray-blue; pebbly, (till)

\* \* \*

## Observation Well 28, SDGS, 1967-70

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 2, T. 117 N., R. 53 W.

Top of observation well: 1728.58 feet

Depth to water: 8 feet

0- 1 Topsoil  
 1-12 Sand and gravel, coarse

## Observation Well No. 28--continued.

12-27 Gravel  
27-39 Clay, dark-brown; pebbly, (till)

\* \* \*

## Observation Well 29, WRC, No. WA2

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 2, T. 117 N., R. 53 W.

Static water level: 3 feet

0- 6 Topsoil  
6-39 Sand, gray, fine to coarse; some coal  
39-50 Clay till, dark-gray

\* \* \*

## Test Hole 30, SDGS, 1963, No. 23

Surface elevation: not measured

Depth to water: 10 feet

0-14 Sand and gravel; some clay  
14-19 Sand and gravel  
19-24 Sand and gravel; more clay  
24-29 Till, brown  
29-37 Till, blue

\* \* \*

## Test Hole 31, CW, 1964-65, No. 13

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 1, T. 117 N., R. 53 W.

Surface elevation: 1726.59

Static water elevation: 1722.26

0- 1 Topsoil  
1- 5 Gray clay  
5- 7 Medium to very coarse sand and gravel  
7- 8 Black clay  
8-13 Brown clay  
13-23 Medium to very coarse sand and gravel, boulders, 4" mud loss  
23-28 Gray clay, gravel streaks  
28-30 Medium to coarse sand and gravel, 1" mud loss  
30-45 Gray clay

\* \* \*

## Test Hole 32, CW, 1964-65, No. 35

Location: SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 6, T. 117 N., R. 52 W.

Surface elevation: 1730.66

Static water elevation: 1725.66

0- 1 Topsoil  
1- 8 Gray clay  
8-20 Fine to coarse cemented sand, 4" mud loss  
20-33 Gray clay

\* \* \*

Test Hole 33, CW, 1964-65, No. 36  
 Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 6, T. 117 N., R. 52 W.  
 Surface elevation: 1734.17  
 Static water elevation: 1732.67

0- 1	Topsoil
1- 3	Soft clay
3-10	Medium to very coarse sand and gravel, 4" mud loss
10-11	Gray clay, boulders
11-22	Medium to very coarse sand and gravel, 5" mud loss
22-32	Gray clay
32-38	Fine to coarse cemented sand and gravel, 4" mud loss
38-48	Gray clay

\* \* \*

Test Hole 34, SDGS, 1963, No. 78  
 Surface elevation: 1736 feet  
 Depth to water: 4 feet

0- 6	Topsoil and clay
6-19	Sand, medium; gravel, fine
19-59	Sand; gravel
59-64	Sand; gravel; more clay
64-74	Clay, brown

\* \* \*

Test Hole 35, CW, 1964-65, No. 20  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 6, T. 117 N., R. 52 W.  
 Surface elevation: 1738.23  
 Static water elevation: 1733.06

0- 1	Topsoil
1- 3	Gray clay
3-17	Fine to very coarse sand and gravel, boulders, 4" mud loss
17-20	Gray clay
20-63	Fine to coarse cemented sand and gravel, 6" mud loss
63-78	Gray clay

\* \* \*

Test Hole 36, CW, 1964-65, No. 6  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 6, T. 117 N., R. 52 W.  
 Surface elevation: 1733.29  
 Static water elevation: 1727.79

0- 1	Topsoil
1-10	Gray clay
10-15	Fine to medium sand
15-18	Fine to coarse sand and gravel, boulders, 7" mud loss
18-31	Fine sand
31-42	Gray clay, sand streaks
42-55	Fine to medium cemented sand
55-63	Gray clay

\* \* \*



## Test Hole 37, SDGS, 1963, No. 25

Surface elevation: not taken

Depth to water: 6 feet

0- 9	Sand, fine to coarse; some clay
9-29	Sand; some clay
29-44	Till, blue

\* \* \*

## Test Hole 38, CW, 1964-65, No. 39

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 6, T. 117 N., R. 52 W.

Surface elevation: 1744.57

Static water elevation: 1735.40

0- 1	Topsoil
1- 5	Yellow clay
5-15	Medium to coarse sand and gravel, 5" mud loss
15-32	Brown clay
32-37	Fine to coarse sand, 3" mud loss
37-38	Gray and brown clay

\* \* \*

## Test Hole 39, SDGS, 1967-70

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 5, T. 117 N., R. 52 W.

Surface elevation: 1744 feet

Depth to water: 5 feet

0 - 2	Topsoil, black, organic
2 - 4 $\frac{1}{2}$	Clay, gray, compact, dry
4 $\frac{1}{2}$ - 5 $\frac{1}{2}$	Sand, gray-brown, fine, moist; some pebbles
5 $\frac{1}{2}$ -18	Sand, brown, medium to coarse, wet
18 -30	Sand, light grayish-brown, fine to medium
30 -56	Sand, brown, very coarse to pea-size gravel, clean; some rocks
56 -67	Clay, gray, gravelly, (till)

\* \* \*

## Test Hole 40, SDGS, 1957

Location: SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 5, T. 117 N., R. 52 W.

Surface elevation: 1746 feet

Static water elevation: not measured

0- 4	Gravel
4-10	Gravel with silt

\* \* \*

## Test Hole 41, SDGS, 1957

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 7, T. 117 N., R. 53 W.

Surface elevation: 1758 feet

Static water elevation: 1718 feet

0- 9	Topsoil
9-11	Sand, medium

## Test Hole 41—continued.

11-27	Sand, medium; gravel
27-57	Silt, gray; sand, coarse
57-67	Silt, gray; sand, medium
67-71	Silt, gray; sand, fine
71-74	Clay, tan; rocks, (till)

\* \* \*

## Observation Well 42, SDGS, 1967-70

Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 9, T. 117 N., R. 53 W.

Height of pipe above the ground: 2 feet

Depth to water from the top of the pipe: 12.19 feet

0- 2	Topsoil
2-23	Sand and gravel
23-29	Clay, pebbly, (till)

\* \* \*

## Test Hole 43, SDGS, 1957, No. 28

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 9, T. 117 N., R. 53 W.

Surface elevation: 1726 feet

Static water elevation: 1717 feet

0- 2	Topsoil
2- 7	Sand, black; (sand with black silt)
7- 9	Sand, medium; gravel; silt
9-50	Gravel, fine; sand, medium; clay
50-65	Till

\* \* \*

## Test Hole 44, CW, 1964-65, No. 17

Location: NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 9, T. 117 N., R. 53 W.

Surface elevation: 1721.48

Static water elevation: 1715.63

0- 3	Road bed
3-13	Fine to very coarse sand and gravel, 3" mud loss
13-14	Gray clay
14-20	Fine to coarse sand and gravel, 3" mud loss
20-33	Gray clay

\* \* \*

## Test Hole 45, CW, 1964-65, No. 18

Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 10, T. 117 N., R. 53 W.

Surface elevation: 1721.68

Static water elevation: 1716.18

0- 5	Road bed (clay)
5-30	Fine to medium sand and gravel, 3" mud loss
30-40	Gray clay

\* \* \*

## Observation Well 46, SDGS, 1967-70

Location: NW¼NW¼NW¼NW¼ sec. 10, T. 117 N., R. 53 W.

Top of observation well: 1743.76 feet

Depth to water: 26 feet

0- 1	Topsoil
1- 7	Sand, coarse
7-24	Sand, brown, fine to coarse
24-31	Sand, coarse
31-39	Clay, olive-brown, pebbly, compact, (till)

\* \* \*

## Test Hole 47, CW, 1964-65, No. 9

Location: SE¼SE¼SE¼ sec. 10, T. 117 N., R. 53 W.

Surface elevation: 1718.94

Static water elevation: 1715.69

0- 1	Topsoil
1- 5	Gray clay
5-13	Medium to coarse sand and gravel, 4" mud loss
13-17	Gray clay, boulders
17-38	Medium to coarse sand and gravel, 4" mud loss
38-48	Gray clay

\* \* \*

## Test Hole 48, SDGS, 1963, No. 26

Surface elevation: 1724 feet (approximately)

Depth to water: 5 feet

0- 9	Clay, black, sandy
9-37	Gravel, fine to pea-size; hit rock, couldn't penetrate

\* \* \*

## Test Hole 49, CW, 1964-65, No. 23

Location: NW¼NE¼NW¼ sec. 11, T. 117 N., R. 53 W.

Surface elevation: 1724.86

Static water elevation: 1717.28

0- 1	Topsoil
1- 8	Gray clay
8-17	Medium to very coarse sand and gravel, 4" mud loss
17-20	Gray clay
20-33	Yellow clay

\* \* \*

## Test Hole 50, CW, 1964-65, No. 10

Location: SW¼SW¼NE¼ sec. 11, T. 117 N., R. 53 W.

Surface elevation: 1720.91

Static water elevation: 1716.24

0- 1	Topsoil
1- 8	Gray clay
8-28	Medium to coarse sand and gravel, 4" mud loss

## Test Hole 50--continued.

28-30 Gray and brown clay, boulders  
 30-43 Fine to coarse sand and gravel, 4" mud loss  
 43-48 Gray clay

\* \* \*

## Test Hole 51, CW, 1964-65, No. 11

Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 11, T. 117 N., R. 53 W.

Surface elevation: 1719.92

Static water elevation: 1715.50

0- 1 Topsoil  
 1- 7 Gray clay  
 7-28 Medium to very coarse sand and gravel, 8" mud loss  
 28-44 Fine to coarse sand and gravel  
 44-48 Gray clay

\* \* \*

## Observation Well 52, SDGS, 1967-70

Location: NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 11, T. 117 N., R. 53 W.

Top of observation well: 1721.04 feet

Depth to water: 4 feet

0- 1 Topsoil  
 1-20 Sand and gravel  
 20-29 Clay, dark-gray, pebbly, (till)

\* \* \*

## Test Hole 53, CW, 1964-65, No. 7

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 11, T. 117 N., R. 53 W.

Surface elevation: 1726.80

Static water elevation: 1720.38

0- 1 Road bed  
 1-10 Gray clay  
 10-20 Medium to very coarse sand and gravel, boulders, 6" mud loss  
 20-42 Fine to medium sand and gravel  
 42-48 Gray clay

\* \* \*

## Test Hole 54, SDGS, 1963, No. 27

Surface elevation: 1724 feet

Depth to water: 9 feet

0- 9 Clay, sandy  
 9-29 Sand; some clay  
 29-44 Till, blue

\* \* \*

## Test Hole 55, CW, 1964-65, No. 12

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 12, T. 117 N., R. 53 W.

## Test Hole 55—continued.

Surface elevation: 1722.01

Static water elevation: 1719.01

0- 1	Topsoil
1- 7	Gray clay
7-23	Medium to very coarse sand and gravel, 4" mud loss
23-33	Gray clay
33-34	Medium to coarse sand and gravel
34-38	Gray clay

\* \* \*

## Test Hole 56, CW, 1964-65, No. 2

Location: SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 12, T. 117 N., R. 53 W.

Surface elevation: 1724.93

Static water elevation: 1717.93

0- 1	Road bed
1- 7	Clay
7-23	Medium to very coarse sand and gravel, 6" mud loss
23-26	Gray clay, boulders
26-28	Medium to very coarse sand and gravel, 2" mud loss
28-38	Brown clay
38-48	Gray clay

\* \* \*

## Test Hole 57, CW, 1964-65, No. 3

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 12, T. 117 N., R. 53 W.

Surface elevation: 1727.34

Static water elevation: 1719.34

0- 1	Topsoil
1- 3	Gray clay
3-15	Medium to very coarse sand and gravel, boulders, 4" mud loss
15-33	Gray clay

\* \* \*

## Test Hole 58, SDGS, 1963, No. 28

Surface elevation: 1726 feet

Depth to water: 9 feet

0- 9	Sand; gravel; some clay
9-39	Sand; gravel
39-64	Till, brown

\* \* \*

## Test Hole 59, CW, 1964-65, No. 14

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 12, T. 117 N., R. 53 W.

Surface elevation: 1728.82

Static water elevation: 1720.57

0- 1	Topsoil
------	---------

## Test Hole 59--continued.

1- 3	Gray clay
3-22	Medium to very coarse sand and gravel, 4" mud loss
22-33	Gray clay

\* \* \*

## Observation Well 60, SDGS, 1967-70

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 12, T. 117 N., R. 53 W.

Height of pipe above the ground: 2 feet

Depth to water from the top of pipe: 4 feet

0- 2	Topsoil
2- 7	Clay, sandy
7-15	Sand, light-gray, fine
15-42	Sand, fine to coarse
42-57	Sand, coarse
57-69	Clay, dark-gray, (till)

\* \* \*

## Test Hole 61, CW, 1964-65

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 7, T. 117 N., R. 52 W.

Surface elevation: 1729.65

Static water elevation: 1722.15

0- 1	Topsoil
1- 3	Sandy clay
3-22	Medium to very coarse sand and gravel, boulders, 5" mud loss
22-33	Gray clay

\* \* \*

## Observation Well 62, SDGS, 1967-70

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 7, T. 117 N., R. 52 W.

Top of observation well: 1742.24 feet

Depth to water: 4 feet

0- 1	Sand, clean, brown, coarse
1- 4	Sand, medium-brown, clean; scattered pea-sized gravel
4-13	Gravel, brown, pea-sized
13-19	Sand, coarse
19-26	Gravel, sandy with high clay content
26-29	Till, gray, unoxidized

\* \* \*

## Test Hole 63, SDGS, 1967-70

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 18, T. 117 N., R. 53 W.

Depth to water: dry

0- 1	Topsoil
1- 4	Sand and gravel
4-22	Clay, brown, compact
22-39	Clay and sand

\* \* \*



## Test Hole 64, SDGS, 1967-70

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 18, T. 117 N., R. 53 W.

Depth to water: 9 feet

0- 2	Topsoil
2-12	Sand and gravel
12-29	Clay, dark-brown, pebbly, (till)

\* \* \*

## Test Hole 65, CW, 1933-34

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Surface elevation: 1719.4

Static water elevation: 1711.6

0- 1	Topsoil
1-12	Fine to coarse sand and gravel
12-16	Coarse sand
16-18	Clay

\* \* \*

## Test Hole 66, CW, 1964-65

Location: SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Surface elevation: 1721.47

Static water elevation: 1715.40

0- 3	Sandy topsoil
3-21	Fine to very coarse sand and gravel, 6" mud loss
21-23	Black silt
23-33	Gray clay

\* \* \*

## Test Hole 67, CW, 1964-65

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Surface elevation: 1720.17

Static water elevation: 1715.17

0- 1	Topsoil
1- 2	Sandy clay
2-15	Medium to very coarse sand and gravel, 4" mud loss
15-18	Medium to coarse sand and gravel
18-26	Medium to coarse sand, boulders
26-28	Soft gray clay
28-45	Medium to coarse sand and gravel, 4" mud loss
45-63	Gray clay

\* \* \*

## Test Hole 68, CW, 1964-65

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Surface elevation: 1720

Static water elevation: 1715

0- 1	Topsoil
------	---------

## Test Hole 68--continued.

1-17	Fine to coarse sand and gravel, sea shells, 6" mud loss
17-24	Fine to medium black sand
24-40	Gray clay
40-42	Fine to coarse sand
42-48	Gray clay

\* \* \*

## Test Hole 69, CW, 1964-65

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Surface elevation: 1729.17

Static water elevation: 1719.34

0- 1	Topsoil
1- 2	Sandy clay
2-20	Medium to very coarse sand and gravel, 4" mud loss
20-30	Gray clay
30-48	Brown clay

\* \* \*

## Test Hole 70, CW, 1964-65

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Surface elevation: 1719.05

Static water elevation: 1715.25

0- 1	Topsoil
1- 5	Gray clay
5-25	Medium to very coarse sand and gravel, boulders, 5" mud loss
25-33	Brown clay

\* \* \*

## Test Hole 71, CW, 1964-65

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Surface elevation: 1720.92

Static water elevation: 1717.09

0- 6	Clay
6-25	Medium to coarse sand and gravel, 4" mud loss
25-35	Gray clay

\* \* \*

## Test Hole 72, SDGS, 1963

Surface elevation: 1720 feet

Depth to water: 4 feet

0- 4	Sand, coarse; some clay
4-22	Sand, coarse
22-64	Clay, blue
64-74	Clay, brown

\* \* \*

## Observation Well 73, SDGS, 1967-70

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 14, T. 117 N., R. 53 W.

Top of observation well: 1724.46 feet

Depth to water: 8 feet

0- 1	Topsoil
1-13	Sand and gravel
13-24	Clay, olive-brown, (till)

\* \* \*

## Test Hole 74, CW, 1933-34

Location: SE $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 13, T. 117 N., R. 53 W.

Surface elevation: 1718.2

Static water elevation: dry hole

0-2	Topsoil
2-3	Sand
3-8	Clay

\* \* \*

## Test Hole 75, SDGS, 1963

Surface elevation: not taken

Depth to water: 9 feet

0- 4	Topsoil; unsorted sand and gravel
4-12	Clay, gray, moist
12-39	Clay, blue

\* \* \*

## Test Hole 76, CW, 1964-65

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 18, T. 117 N., R. 52 W.

Surface elevation: 1739.56

Static water elevation: dry hole

0- 1	Road bed
1- 4	Sandy clay
4- 5	Medium to coarse sand and gravel
5-23	Brown clay
23-33	Gray clay

\* \* \*

## Test Hole 77, SDGS, 1957

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 17, T. 117 N., R. 52 W.

Surface elevation: 1743 feet

Static water elevation: not measured

0 - 4	Topsoil
4 - 4 $\frac{1}{2}$	Gravel and clay
4 $\frac{1}{2}$ -25	Till

\* \* \*

Test Hole 78, SDGS, 1957  
 Location: SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 17, T. 117 N., R. 52 W.  
 Surface elevation: 1762 feet  
 Static water elevation: not measured

0-30      Till, yellow-brown

\* \* \*

Test Hole 79, CW, 1933-34, No. 48  
 Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 22, T. 117 N., R. 53 W.

0- 2      Topsoil  
 2-10      Clay  
 10-17      Fine to coarse sand and gravel  
 17-22      Clay  
 22-23      Fine to coarse sand and gravel  
 23-      Clay

\* \* \*

Test Hole 80, CW, 1933-34, No. 49  
 Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 22, T. 117 N., R. 53 W.

0- 4      Topsoil  
 4-16      Fine blue sand  
 16-      Clay

\* \* \*

Test Hole 81, CW, 1933-34, No. 50  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 22, T. 117 N., R. 53 W.

0- 3      Topsoil  
 3-14      Coarse yellow sand  
 14-      Clay

\* \* \*

Test Hole 82, SDGS, 1963, No. 32  
 Surface elevation: not taken  
 Depth to water: dry

0-34      Clay, brown

\* \* \*

Test Hole 83, SDGS, 1967-70  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.  
 Surface elevation: 1743 feet  
 Depth to water: 21 feet

0- 1      Topsoil  
 1- 6      Clay, sandy, dry  
 6-17      Sand and gravel, dry  
 17-39      Till

\* \* \*

Test Hole 84, CW, 1933-34, No. 30  
 Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.  
 Surface elevation: 1719.7  
 Static water elevation: 1712.4

0- 1	Topsoil
1- 8	Packed sand
8-15	Coarse sand
15-22	Fine to coarse sand and gravel
22-27	Coarse sand
27-38	Clay

\* \* \*

Test Hole 85, CW, 1933-34, No. 18  
 Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.  
 Surface elevation: 1719.5  
 Static water elevation: 1713.2

0- 3	Topsoil
3-10	Fine sand
10-20	Fine to coarse sand and gravel
20-26	Coarse sand
26-28	Clay

\* \* \*

Test Hole 86, CW, 1933-34, No. 26  
 Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.  
 Surface elevation: 1725.2  
 Static water elevation: not measured

0- 3	Topsoil
3-14	Packed sand
14-18	Clay

\* \* \*

Test Hole 87, CW, 1933-34, No. 24  
 Location: SE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.  
 Surface elevation: 1724.4  
 Static water elevation: not measured

0- 3	Topsoil
3-15	Fine to coarse sand and gravel
15-18	Clay

\* \* \*

Observation Well 88, SDGS, 1967-70  
 Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.  
 Top of observation well: 1732.61 feet  
 Depth to water: 14 feet

0- 1	Topsoil
1- 3	Clay, brown
3-28	Sand and gravel

## Observation Well 88—continued.

28-48 Clay, pebbly

\* \* \*

## Test Hole 89, CW, 1933-34, No. 25

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.

Surface elevation: 1724.2

Static water elevation: 1714.6

0- 3	Topsoil
3-16	Packed sand
16-18	Clay

\* \* \*

## Test Hole 90, SDGS, 1963

Surface elevation: 1730 feet

Depth to water: 14 feet

0-14	Clay, dark-brown; some sand
14-44	Clay, dark-brown
44-54	Clay, blue
54-74	Clay, brown

\* \* \*

## Test Hole 91, CW, 1933-34, No. 17

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 23, T. 117 N., R. 53 W.

Surface elevation: 1723.2

Static water elevation: 1715.3

0- 2	Topsoil
2- 8	Coarse sand
8-13	Fine to coarse sand and gravel
13-18	Clay

\* \* \*

## Observation Well 92, WRC, No. S-4

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 24, T. 117 N., R. 52 W.

Surface elevation:

Static water elevation: 4.6 feet

0- 3	Topsoil
3-24	Sand, coarse
24-40	Clay, blue

\* \* \*

## Test Hole 93, CW, 1933-34, No. 27

Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 24, T. 117 N., R. 53 W.

Surface elevation: 1725.3

Static water elevation: 1715.2

0- 1	Topsoil
------	---------



## Test Hole 93--continued.

1-17	Packed sand
17-18	Boulders
18-20	Clay

\* \* \*

## Test Hole 94, CW, 1933-34, No. 28

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 24, T. 117 N., R. 53 W.

Surface elevation: 1722.7

Static water elevation: not measured

0- 1	Topsoil
1- 7	Packed sand
7-18	Clay

\* \* \*

## Test Hole 95, CW, 1933-34, No. 23

Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 24, T. 117 N., R. 53 W.

Surface elevation: 1725.4

Static water elevation: 1713.4

0- 3	Topsoil
3-10	Packed sand
10-16	Coarse sand
16-18	Clay

\* \* \*

## Test Hole 96, SDGS, 1963, No. 33

Surface elevation: 1745 feet

Depth to water: 17 feet

0-29	Clay, brown; some sand
29-49	Sand; some clay
49-54	Till, brown

\* \* \*

## Observation Well 97, SDGS, 1967-70

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 27, T. 117 N., R. 53 W.

Top of observation well: 1732.78 feet

Depth to water: 8 feet

0- 2	Topsoil
2-12	Sand and gravel
12-24	Clay, grayish-tan, pebbly, (till)

\* \* \*

## Test Hole 98, CW, 1933-34, No. 53

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 3	Yellow sand
3-18	Blue sand

## Test Hole 98—continued.

18-25 Yellow sand  
25- Clay

\* \* \*

## Test Hole 99, CW, 1933-34, No. 51

Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 2 Topsoil  
2- 6 Clay  
6-27 Blue sand  
27- Clay

\* \* \*

## Test Hole 100, CW, 1933-34, No. 52

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 2 Topsoil  
2-22 Yellow sand  
22- Clay

\* \* \*

## Test Hole 101, CW, 1933-34, No. 56

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0-23 Yellow sand  
23-33 Blue sand  
33- Clay

\* \* \*

## Test Hole 102, CW, 1933-34, No. 56

Location: SE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 2 Topsoil  
2-25 Yellow sand  
25- Clay

\* \* \*

## Test Hole 103, CW, 1933-34, No. 55

Location: SW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 2 Topsoil  
2-30 Fine yellow sand  
30- Clay

\* \* \*

## Test Hole 104, CW, 1933-34, No. 57

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 2 Topsoil

## Test Hole 104—continued.

2- 8      White sand  
8-        Clay

\* \* \*

Test Hole 105, CW, 1933-34, No. 5  
Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.  
Surface elevation: 1719.3  
Static water elevation: not measured

0- 4      Topsoil  
4-11     Fine to coarse sand and gravel  
11-28    Clay

\* \* \*

Test Hole 106, CW, 1933-34, No. 39  
Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 3      Topsoil  
3-13     Fine yellow sand  
13-       Clay

\* \* \*

Test Hole 107, CW, 1933-34, No. 38  
Location: SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 2      Topsoil  
2-14     Fine yellow sand  
14-       Clay

\* \* \*

Test Hole 108, CW, 1933-34, No. 37  
Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 3      Topsoil  
3-23     Fine yellow sand  
23-       Clay

\* \* \*

Test Hole 109, CW, 1933-34, No. 36  
Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

0- 2      Topsoil  
2-25     Fine yellow sand and rock  
25-       Clay

\* \* \*

Test Hole 110, CW, 1933-34, No. 55  
Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.

## Test Hole 110--continued.

0- 3	Topsoil
3-34	Fine yellow sand and rock
34-	Clay

\* \* \*

Test Hole 111, CW, 1933-34, No. 4  
 Location: SE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 26, T. 117 N., R. 53 W.  
 Surface elevation: 1720.0  
 Static water elevation: 1714.0

0- 4	Topsoil
4- 9	Sand
9-28	Clay

\* \* \*

Test Hole 112, CW, 1964-65, No. 68  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1731.5  
 Static water elevation: 1724.5

0- 1	Topsoil
1- 2	Brown clay
2-13	Fine to coarse sand and gravel, 6" mud loss
13-33	Brown clay

\* \* \*

Test Hole 113, CW, 1933-34, No. 3  
 Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1717.8  
 Static water elevation: 1714.0

0- 4	Topsoil
4- 9	Sand
9-28	Clay

\* \* \*

Test Hole 114, CW, 1964-65, No. 64  
 Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1730.2  
 Static water elevation: 1718.9

0- 1	Topsoil
1- 2	Brown clay
2-19	Fine to coarse sand and gravel, 1' mud loss
19-33	Brown clay

\* \* \*

Test Hole 115, CW, 1933-34, No. 47  
 Location: SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

## Test Hole 115--continued.

0- 3 Topsoil  
 3-18 Coarse yellow sand  
 18- Clay

\* \* \*

Test Hole 116, CW, 1933-34, No. 42  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 3 Topsoil  
 3-17 Coarse yellow gravel  
 17- Clay

\* \* \*

Test Hole 117, CW, 1933-34, No. 58  
 Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 3 Topsoil  
 3-25 Yellow sand  
 25- Clay

\* \* \*

Test Hole 118, CW, 1933-34, No. 59  
 Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 3 Topsoil  
 3-13 Yellow sand  
 13- Clay

\* \* \*

Test Hole 119, CW, 1933-34, No. 60  
 Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 52 W.

0 - 2 Topsoil  
 2 -18 $\frac{1}{2}$  Yellow and blue sand  
 18 $\frac{1}{2}$ - Clay

\* \* \*

Test Hole 120, CW, 1933-34, No. 16  
 Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1721.3  
 Static water elevation: 1714.3

0- 2 Topsoil  
 2- 8 Coarse sand  
 8-15 Fine to coarse sand and gravel  
 15-19 Coarse sand  
 19-25 Clay

\* \* \*

Observation Well 121, SDGS, 1967-70  
 Location: SE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Top of observation well: 1723.49 feet  
 Depth to water: 6 feet

0- 2	Topsoil
2-17	Sand and gravel
17-24	Clay, dark-brown, pebbly, (till)

\* \* \*

Test Hole 122, CW, 1933-34, No. 14  
 Location: NE $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1720.9  
 Static water elevation: dry hole

0-2	Topsoil
2-5	Sand
5-8	Clay

\* \* \*

Test Hole 123, CW, 1933-34, No. 15  
 Location: NE $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1720.1  
 Static water elevation: 1713.6

0- 3	Topsoil
3- 7	Sand
7-16	Fine to coarse sand and gravel
16-18	Clay

\* \* \*

Test Hole 124, CW, 1933-34, No. 46  
 Location: NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 2	Topsoil
2-20	Yellow and blue sand, coarse gravel
20-	Clay

\* \* \*

Test Hole 125, CW, 1933-34, No. 45  
 Location: SE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 2	Topsoil
2-15	Yellow and blue sand
15-	Clay

\* \* \*

Test Hole 126, CW, 1933-34, No. 44  
 Location: NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 3	Topsoil
3-20	Yellow and blue sand

## Test Hole 126--continued.

20- Clay

\* \* \*

## Test Hole 127, CW, 1964-65, No. 50

Location: SE $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

Surface elevation: 1727.4

Static water elevation: 1719.4

0- 1 Sandy topsoil, brown silt streak ?  
 1-23 Fine to very coarse sand and gravel, 1" mud loss  
 23-33 Brown clay

\* \* \*

## Test Hole 128, CW, 1933-34, No. 41

Location: SE $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 2 Topsoil  
 2-32 Very fine yellow and blue sand, some gravel  
 32- Clay

\* \* \*

## Test Hole 129, CW, 1933-34, No. 43

Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

0- 2 Topsoil  
 2-23 Coarse yellow sand  
 23- Clay

\* \* \*

## Test Hole 130, CW, 1933-34, No. 13

Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

Surface elevation: 1718.4

Static water elevation: 1714.1

0- 2 Topsoil  
 2- 8 Fine sand  
 8-15 Fine to coarse sand and gravel  
 15-18 Clay

\* \* \*

## Test Hole 131, CW, 1933-34, No. 12

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.

Surface elevation: 1718.7

Static water elevation: 1714.6

0- 3 Topsoil  
 3-13 Fine to coarse sand and gravel  
 13-18 Clay

\* \* \*



Test Hole 132, CW, 1933-34, No. 11  
 Location: SW $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1718.3  
 Static water elevation: 1714.0

0- 3	Topsoil
3- 8	Fine to coarse sand and gravel
8-11	Fine sand
11-21	Fine to coarse sand and gravel
21-28	Clay

\* \* \*

Test Hole 133, CW, 1933-34, No. 20  
 Location: NE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1720.1  
 Static water elevation: 1713.6

0- 2	Topsoil
2-15	Fine to coarse sand and gravel, packed
15-18	Clay

\* \* \*

Test Hole 134, CW, 1964-65, No. 58  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1721.6  
 Static water elevation: 1713.6

0- 2	Topsoil
2-35	Fine to coarse sand and gravel, 1' 16" mud loss
35-48	Brown clay

\* \* \*

Test Hole 135, CW, 1933-34, No. 2  
 Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1717.4  
 Static water elevation: 1713.5

0- 3	Topsoil
3- 8	Fine sand
8-15	Fine to coarse sand and gravel
15-18	Fine sand
18-19	Boulders
19-23	Clay

\* \* \*

Test Hole 136, CW, 1933-34, No. 21  
 Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1719.4  
 Static water elevation: 1712.9

0- 2	Topsoil
2- 8	Fine to coarse sand and gravel
8-18	Coarse sand

## Test Hole 136--continued.

18-22	Gravel
22-26	Sand
26-28	Clay

\* \* \*

Test Hole 137, CW, 1933-34, No. 22  
 Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1722.0  
 Static water elevation: not measured

0- 2	Topsoil
2-15	Packed sand
15-20	Clay

\* \* \*

Test Hole 138, CW, 1933-34, No. 1  
 Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1717.3  
 Static water elevation: 1713.5

0- 3	Topsoil
3- 17	Fine to coarse sand and gravel
17-108	Clay

\* \* \*

Test Hole 139, CW, 1933-34, No. 19  
 Location: SW $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1718.0  
 Static water elevation: 1713.5

0- 3	Topsoil
3-13	Fine to coarse sand and gravel
13-16	Fine sand
16-18	Clay

\* \* \*

Test Hole 140, CW, 1933-34, No. 10  
 Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1725.7  
 Static water elevation: 1715.3

0- 2	Topsoil
2-12	Fine to coarse sand and gravel
12-23	Clay

\* \* \*

Test Hole 141, SDGS, 1963, No. 34  
 Surface elevation: 1721 feet  
 Depth to water: 4 feet

## Test Hole 141--continued.

0-17	Sand; clay, poorly sorted
17-39	Sand; some clay
39-59	Clay, gray, sandy
59-64	Clay, blue
64-69	Till, brown

\* \* \*

Test Hole 142, CW, 1933-34, No. 8  
 Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1712.8  
 Static water elevation: 1707.7

0- 2	Topsoil
2- 7	Fine to coarse sand and gravel
7-18	Clay

\* \* \*

Test Hole 143, SDGS, 1967-70  
 Location: SW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1720 feet  
 Depth to water: 3 feet

0- 2	Topsoil
2- 5	Sand, coarse
5-40	Clay, pebbly, (till)

\* \* \*

Test Hole 144, CW, 1964-65, No. 59  
 Location: NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1717.0  
 Static water elevation: dry hole

0- 1	Topsoil
1- 3	Fine to very coarse sand and gravel
3- 4	Boulders
4-18	Brown clay

\* \* \*

Test Hole 145, SDGS, 1967-70  
 Location: NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 25, T. 117 N., R. 53 W.  
 Surface elevation: 1718 feet  
 Depth to water: 3 feet

0- 1	Topsoil
1-42	Clay, pebbly, (till)

\* \* \*

Test Hole 146, CW, 1933-34, No. 7  
 Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 30, T. 117 N., R. 52 W.  
 Surface elevation: 1718.8

## Test Hole 146--continued.

Static water elevation: 1708.4

0- 2	Topsoil
2-11	Fine to coarse sand and gravel
11-28	Clay

\* \* \*

## Test Hole 147, CW, 1933-34, No. 6

Location: SE $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 30, T. 117 N., R. 52 W.

Surface elevation: 1721.4

Static water elevation: 1713.9

0- 2	Topsoil
2-26	Fine to coarse sand and gravel-packed
26-29	Clay
29-30	Boulders
30-33	Clay

\* \* \*

## Test Hole 148, SDGS, 1967-70

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 31, T. 117 N., R. 53 W.

Surface elevation: 1729 feet

Depth to water: 19 feet

0- 3	Roadbed
3- 7	Clay, dark-gray
7-19	Clay, dark-brown
19-24	Sand and gravel
24-34	Clay, dark-gray, pebbly, (till)

\* \* \*

## Test Hole 149, SDGS, 1967-70

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 33, T. 117 N., R. 53 W.

Surface elevation: 1722 feet

Depth to water: 6 feet

0- 2	Roadbed
2-11	Clay, dark-gray
11-17	Sand, fine to coarse; some gravel
17-47	Sand, coarse; gravel
47-55	Clay
55-63	Sand and gravel
63-71	Clay
71-73	Sand and gravel
73-84	Clay, dark-gray, pebbly, (till)

\* \* \*

## Test Hole 150, SDGS, 1957, No. 10

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 33, T. 117 N., R. 53 W.

Surface elevation: 1770 feet

Static water elevation: not measured

## Test Hole 150-continued.

0- 3      Topsoil and till  
3-20      Silt; some sand, (till)

\* \* \*

## Test Hole 151, SDGS, 1967-70

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 33, T. 117 N., R. 53 W.

Surface elevation: 1750 feet

Depth to water: dry

0- 2      Topsoil  
2-25      Sand, fine to coarse  
25-39      Clay, dark-brown, compact, pebbly, (till)

\* \* \*

## Test Hole 152, SDGS, 1967-70

Location: SW $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 33, T. 117 N., R. 53 W.

Surface elevation: 1740 feet

Depth to water: 22 feet

0- 2      Topsoil  
2-31      Sand, coarse; gravel  
31-49      Clay, dark-gray, compact, (till)

\* \* \*

## Test Hole 153, SDGS, 1957, No. 11

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 33, T. 117 N., R. 53 W.

Surface elevation: 1740? feet

Static water elevation: 1666 feet

0- 1      Topsoil  
1-20      Gravel; sand; silt mixture  
20-21      Pea gravel  
21-25      Silt and pea gravel  
25-27      Clay and sand, (dry)  
27-44      Dry silt and occasional sand grains  
44-55      Clay with sand grains, (water)

\* \* \*

## Test Hole 154, SDGS, 1967-70

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 34, T. 117 N., R. 53 W.

Surface elevation: 1746 feet

Depth to water: dry? (not measured)

0- 1      Topsoil  
1-14      Sand and gravel  
14-24      Clay, dark-brown, (till)

\* \* \*

## Test Hole 155, SDGS, 1963, No. 40

Surface elevation: 1746 feet

## Test Hole 155--continued.

Depth to water: 35 feet

0-19	Sand, brown; gravel; some clay
19-29	Till, brown
29-44	Till, blue
44-54	Clay, buff
54-59	Till, blue

\* \* \*

## Test Hole 156, SDGS, 1957, No. 49

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 34, T. 117 N., R. 53 W.

Surface elevation: 1752 feet

Static water elevation: 1743 feet

0- 9	Topsoil
9-10	Silt, tan; sand; water
10-23	Till, clay, blue

\* \* \*

## Test Hole 157, SDGS, 1963, No. 41

Surface elevation: 1739 feet

Depth to water: not measured

0- 4	Topsoil
4-74	Till, brown; poor cuttings

\* \* \*

## Test Hole 158, SDGS, 1957, No. 12

Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 35, T. 117 N., R. 53 W.

Surface elevation: 1751 feet

Static water elevation: 1735 feet

0- 9	Topsoil
9-12	Sand
12-55	Silt, tan; sand grains, (water)
55-65	Silt with sand

\* \* \*

## Test Hole 159, SDGS, 1963, No. 35

Surface elevation: 1775 feet

Depth to water: dry

0-74	Clay, dark
------	------------

\* \* \*

## Test Hole 160, SDGS, 1967-70

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 35, T. 117 N., R. 53 W.

Surface elevation: 1730 feet

Depth to water: dry

## Test Hole 160--continued.

0- 1	Topsoil
1- 3	Sand, coarse
3-15	Sand; some gravel
15-39	Clay, gravelly

\* \* \*

## Observation Well 161, SDGS, 1967-70

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 35, T. 117 N., R. 53 W.

Top of observation well: 1730.34 feet

Depth to water: 8 feet

0- 1	Topsoil
1- 6	Sand, brown, medium
6- 8	Sand, coarse
8-13	Sand, medium
13-15	Gravel, coarse
15-25	Clay, pebbly, (till)

\* \* \*

## Test Hole 162, SDGS, 1963, No. 39

Surface elevation: 1732 feet

Depth to water: 9 feet

0-10	Sand; gravel; becoming silty
10-14	Sand; gravel; saturated
14-34	Clay, sandy
34-49	Sand, fine, silty

\* \* \*

## Test Hole 163, SDGS, 1957, No. 13

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1717 feet

Static water elevation: 1709 feet

0- 2	Topsoil
2- 8	Sand, clean; medium
8-20	Sand; some silt
20-55	Clay, dark, hard, dry; occasional sand grains
55-65	Sand; much silt, (water)

\* \* \*

## Test Hole 164, CW, 1933-34, No. 33

Location: NE $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1733.3

Static water elevation: 1708.3

0- 4	Topsoil
4-23	Packed sand
23-28	Fine sand
28-30	Clay
30-34	Fine sand



## Test Hole 164--continued.

34-38 Clay

\* \* \*

## Test Hole 165, CW, 1964-65, No. 67

Location: NW $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1729.8

Static water elevation: dry hole

0- 1	Topsoil
1- 4	Brown clay
4-14	Fine to coarse sand and gravel, 6" mud loss
14-16	Boulders, gray clay
16-25	Fine to coarse sand, 3" mud loss
25-33	Brown clay

\* \* \*

## Test Hole 166, CW, 1964-65, No. 66

Location: SW $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1724.7

Static water elevation: 1717.6

0- 1	Fill
1- 2	Black dirt
2- 5	Brown clay
5-17	Fine to coarse sand and gravel, 1' mud loss
17-25	Boulders, gray clay

\* \* \*

## Test Hole 167, CW, 1964-65, No. 65

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1721.9

Static water elevation: 1718.4

0- 1	Road bed
1-12	Fine to coarse sand and gravel, 6" mud loss
12-18	Brown clay

\* \* \*

## Test Hole 168, CW, 1964-65, No. 62

Location: SE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1724.3

Static water elevation: 1713.6

0- 1	Topsoil
1-30	Fine to coarse sand and gravel, 1' mud loss
30-32	Boulders, gray clay
32-48	Brown clay

\* \* \*

## Test Hole 169, CW, 1964-65, No. 51

## Test Hole 169--continued.

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1717.8

Static water elevation: 1712.6

0- 1	Road bed
1- 4	Brown clay
4-14	Medium to very coarse sand and gravel, 6" mud loss
14-15	Black silt and boulders
15-33	Brown clay

\* \* \*

## Test Hole 170, CW, 1964-65, No. 70

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1721.8

Static water elevation: 1715.8

0- 2	Black dirt
2- 4	Brown clay
4-13	Fine to coarse sand and gravel, 6" mud loss
13-14	Brown silt
14-25	Fine to coarse sand and gravel, 1" mud loss
25-33	Boulders and brown clay

\* \* \*

## Test Hole 171, CW, 1964-65, No. 61

Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1722.1

Static water elevation: 1713.2

0- 1	Road fill
1- 2	Black dirt
2- 5	Brown clay
5-13	Fine to very coarse sand and gravel, 6" mud loss
13-16	Boulders, gray clay
16-33	Brown clay

\* \* \*

## Test Hole 172, CW, 1964-65, No. 69

Location: NW $\frac{1}{4}$ SW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: not measured

Static water elevation: not measured

0- 1	Topsoil
1-11	Fine to coarse sand and gravel, 6" mud loss
11-13	Brown clay
13-18	Fine to medium sand
18-33	Brown clay

\* \* \*

## Test Hole 173, CW, 1964-65, No. 60

Location: SE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

## Test Hole 173—continued.

Surface elevation: 1718.5

Static water elevation: 1712.7

0- 1	Road fill
1- 3	Black dirt
3- 5	Brown clay
5-17	Fine to coarse sand and gravel. 6" mud loss
17-33	Boulders, brown clay

\* \* \*

## Test Hole 174, CW, 1933-34, No. 32

Location: NE $\frac{1}{4}$ NW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1724.4

Static water elevation: not measured

0- 4	Topsoil
4-10	Coarse sand
10-23	Fine to coarse sand and gravel, packed
23-25	Clay

\* \* \*

## Test Hole 175, SDGS, 1963, No. 42

Surface elevation: 1717 feet

Depth to water: 4 feet

0- 4	Sand, medium
4-24	Sand, medium
24-34	Gravel, fine
34-44	No cuttings

\* \* \*

## Test Hole 176, CW, 1964-65, No. 57

Location: NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1717.4

Static water elevation: 1706.2

0- 2	Topsoil
2-21	Fine to very coarse sand and gravel
21-23	Boulders, mud loss 1'
23-33	Brown clay

\* \* \*

## Test Hole 177, CW, 1964-65, No. 71

Location: SW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.

Surface elevation: 1714.0

Static water elevation: 1711.1

0- 1	Topsoil
1-14	Fine to coarse sand and gravel. 6" mud loss
14-16	Gray clay
16-18	Brown clay

\* \* \*

Test Hole 178, CW, 1964-65, No. 49  
 Location: NE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 36, T. 117 N., R. 53 W.  
 Surface elevation: 1714.1  
 Static water elevation: 1707.1

0- 2	Sandy topsoil, gravel mixed
2-11	Fine to very coarse sand and gravel, 6" mud loss
11-33	Hard brown silty clay

\* \* \*

Test Hole 179, CW, 1964-65, No. 54  
 Location: SW $\frac{1}{4}$ NW $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 31, T. 117 N., R. 52 W.  
 Surface elevation: 1714.40  
 Static water elevation: 1708.15

0- 3	Fill
3-21	Fine to very coarse sand and gravel
21-24	Boulders
24-25	Black silt
25-33	Brown clay boulders

\* \* \*

Test Hole 180, CW, 1964-65, No. 53  
 Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$  sec. 31, T. 117 N., R. 52 W.  
 Surface elevation: 1714.65  
 Static water elevation: 1708.7

0- 2	Topsoil
2- 6	Brown clay
6-10	Fine to coarse sand and gravel, sea shells
10-11	Brown silt
11-25	Gray clay

\* \* \*

Test Hole 181, SDGS, 1963, No. 44  
 Surface elevation: 1727 feet  
 Depth to water: not measured

0-14	Gravel, poorly sorted; clay, brown
14-29	Gravel, coarse to fine; some clay
29-45	Gravel, poorly sorted; less clay
45-54	Gravel
54-74	Sand, fine; some clay
74-89	Clay, blue

\* \* \*

Test Hole 182, SDGS, 1963, No. 45  
 Surface elevation: 1724 feet  
 Depth to water: 19 feet

0-24	Sand; gravel; clay
24-44	Gravel, medium; some clay

## Test Hole 182--continued.

44-59 Gravel; some clay  
 59-69 Gravel, fine  
 69-74 Clay, dark-brown

\* \* \*

## Test Hole 183, SDGS, 1963, No. 49

Surface elevation: 1743 feet

Depth to water: not measured

0-14 Sand; gravel; clay; poorly sorted  
 14-29 Sand, fine, clean  
 29-44 Sand; some clay  
 44-69 Clay, brown; some sand  
 69-89 Till, blue

\* \* \*

## Test Hole 184, SDGS, 1963, No. 50

Surface elevation: 1725 feet

Depth to water: 34 feet

0- 4 Topsoil  
 4-36 Clay; sand; gravel, poorly sorted  
 36-79 Clay; sand and gravel  
 79-84 Clay, blue

\* \* \*

## Observation Well 185, SDGS, 1967-70

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 2, T. 116 N., R. 53 W.

Surface elevation: 1725 feet

Depth to water from the top of pipe: 16.6 feet

0- 2 Topsoil  
 2- 9 Sand and gravel  
 9-27 Sand, very fine, brown  
 27-39 Clay, brownish-gray, pebbly, (till)

\* \* \*

## Observation Well 186, SDGS, 1967-70

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 2, T. 116 N., R. 53 W.

Top of observation well: 1726.45 feet

Depth to water: 19 feet

0- 1 Topsoil  
 1-33 Sand, brown, fine  
 33-52 Gravel  
 52-55 Sand, coarse

\* \* \*

## Test Hole 187, SDGS, 1963, No. 51

Surface elevation: 1720 feet

## Test Hole 187--continued.

Depth to water: 19 feet

0- 9	Clay, brown
9-14	Sand; some clay
14-20	Clay, sandy
20-39	Clay, sandy
39-84	Sand, coarse, silty

\* \* \*

## Test Hole 188, SDGS, 1963, No. 52

Surface elevation: 1718 feet

Depth to water: not measured

0-24	Gravel, fine
24-84	Gravel; sand; high clay content
84-99	Clay, sandy

\* \* \*

## Observation Well 189, SDGS, 1967-70

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 6, T. 116 N., R. 52 W.

Surface elevation: 1712 feet (approximately)

Depth to water: 3 feet

0- 1	Topsoil
1- 2	Clay, sandy
2- 4	Gravel
4-42	Sand, coarse
42-46	Gravel
46-50	Clay, gray, (till)

\* \* \*

## Test Hole 190, CW, 1964-65, No. 55

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 6, T. 116 N., R. 52 W.

Surface elevation: 1713.0

Static water elevation: 1708.24

0- 3	Road bed
3-35	Fine to very coarse sand and gravel, boulders, 1" mud loss
35-39	Gray clay
39-45	Fine to coarse sand, cemented, boulders, 3" mud loss
45-68	Gray clay
68-77	Coarse sand and gravel
77-83	Gray clay and boulders

\* \* \*

## Test Hole 191, CW, 1964-65, No. 45

Location: NW $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 6, T. 116 N., R. 52 W.

Surface elevation: 1710.99

Static water elevation: 1706.39

0- 1	Topsoil
------	---------

## Test Hole 191--continued.

1- 5	Brown clay
5-15	Fine to very coarse sand and gravel, 1' mud loss
15-17	Brown clay
17-23	Fine to very coarse sand and gravel, 1' mud loss
23-27	Gray clay
27-35	Brown silty clay
35-40	Fine to coarse cemented sand, 3" mud loss
40-	Gray clay (hard)
-75	Very coarse sand and gravel, 6" mud loss
75-84	Gray clay with boulders

\* \* \*

## Test Hole 192, SDGS, 1957, No. 23

Location: NW $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 6, T. 116 N., R. 52 W.

Surface elevation: 1720 feet

Static water elevation: 1707 feet

0- 5	Topsoil
5-25	Gravel, pea-size
25-45	Coarse sand; water
45-	Rock and gravel

\* \* \*

## Test Hole 193, SDGS, 1957, No. 24

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 6, T. 116 N., R. 52 W.

Surface elevation: 1719 feet

Static water elevation: 1707 feet

0- 8	Topsoil
8-45	Sand and black silt
45-	Rocks

\* \* \*

## Observation Well 194, WRC, No. WA3

Location: SW $\frac{1}{4}$ SW $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 6, T. 116 N., R. 52 W.

Surface elevation:

Static water level: 10 feet

0- 2	Topsoil
2-10	Sand, brown, coarse, coarse gravel
10-50	Clay, sandy, some brown gravel

\* \* \*

## Test Hole 195, SDGS, 1963, No. 53

Surface elevation: 1720 feet

Depth to water: 9 feet

0- 9	Sand, poorly sorted, silty
9-34	Clay, buff, sandy
34-69	Till, dark-brown

\* \* \*



## Test Hole 196, SDGS, 1963, No. 43

Surface elevation: 1715 feet

Depth to water: 4 feet

0- 4	Topsoil
4- 29	Sand, dark, coarse; clay; gravel, poorly sorted
29-125	Clay, blue; some gravel
125-150	Clay, blue

\* \* \*

## Test Hole 197, CW, 1933-34, No. 34

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 5, T. 116 N., R. 52 W.

Surface elevation: 1714.9

Static water elevation: 1706.8

0- 3	Topsoil
3-16	Fine to coarse sand and gravel, packed
16-18	Clay

\* \* \*

## Test Hole 198, SDGS, 1957, No. 42

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 5, T. 116 N., R. 52 W.

Surface elevation: 1714 feet

Static water elevation: 1702 feet

0- 8	Topsoil
8-12	Gravel; sand, coarse
12-20	Sand, coarse; gravel, fine; water
20-22	Gravel, fine; sand, clean, coarse
22-32	Gravel, medium, clean, good for irrigation
32-42	Sand, clean, medium
42-54	Gravel, medium; silt, gray
54-60	Clay, blue; gravel, small, (till)

\* \* \*

## Test Hole 199, CW, 1964-65, No. 56

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 5, T. 116 N., R. 52 W.

Surface elevation: 1715.9

Static water elevation: 1708.19

0- 2	Black dirt
2- 5	Brown clay
5-23	Fine to coarse sand and gravel, 1' mud loss
23-33	Boulders and gray clay

\* \* \*

## Test Hole 200, SDGS, 1957, No. 47

Location: SW $\frac{1}{4}$ NW $\frac{1}{4}$  sec. 12, T. 116 N., R. 53 W.

Surface elevation: 1721 feet

Static water elevation: 1709 feet

0- 8	Topsoil
------	---------

## Test Hole 200--continued.

8- 12	Gravel, fine; sand, coarse; silt
12- 25	Sand, coarse; silt; water
25- 55	Silt; sand, medium; water
55- 93	Silt, gray; sand, medium
93-100	Clay, blue. (till)

\* \* \*

## Test Hole 201, SDGS, 1963, No. 59

Surface elevation: 1735 feet

Depth to water: 21 feet

0-19	Clay; some sand
19-39	Clay, brown
39-49	Till, blue

\* \* \*

## Test Hole 202, SDGS, 1963, No. 56

Surface elevation: 1726 feet

Depth to water: 14 feet

0-39	Sand, medium; clay increases downward
39-44	Clay, brown; some sand
44-54	Drills like till
54-69	Clay; little sand
69-74	Clay, blue

\* \* \*

## Test Hole 203, SDGS, 1963, No. 57

Surface elevation: 1715 feet

Depth to water: 19 feet

0-19	Topsoil and clay
19-24	Gravel, fine, silty
24-84	Till, brown
84-94	Clay, buff
94-98	Clay, blue

\* \* \*

## Test Hole 204, SDGS, 1957, No. 15

Location: SE $\frac{1}{4}$ SE $\frac{1}{4}$  sec. 14, T. 116 N., R. 53 W.

Surface elevation: 1763 feet

Static water elevation: not measured

0- 3	Topsoil
3-40	Silt; clay (dry); gravel, small and large stones intermixed, (till with quartz)

\* \* \*

## Test Hole 205, SDGS, 1957, No. 14

Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$  sec. 22, T. 116 N., R. 53 W.

## Test Hole 205--continued.

Surface elevation: 1749 feet

Static water elevation: 1740 feet

0- 4	Topsoil
4- 6	Silt and clay mixed with gravel
6-14	Sand; gravel, wet
14-19	Mostly silt; some sand; some gravel
19-38	Clay, tan; silt with some sand
38-49	Sand
49-65	Silt, tan; clay

\* \* \*

## APPENDIX C

Water-level measurement for July 30, 1970  
in the Lake Kampeska study area  
(For map location, see fig. 10.)

Observation well number and location	Water level in feet above sea level
11. SW $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 21, T. 52 W., R. 118 N.	1725.13
13. NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 22, T. 118 N., R. 52 W.	1725.79
14. SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 36, T. 118 N., R. 53 W.	1732.45
23. NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 33, T. 118 N., R. 52 W.	1754
28. SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 2, T. 117 N., R. 53 W.	1720.17
52. NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 11, T. 117 N., R. 53 W.	1716.71
62 NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 7, T. 117 N., R. 52 W.	1734.62
Lake Kampeska inlet-outlet on Highway 20 Bridge	1716.91
73. SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 14, T. 117 N., R. 53 W.	1717.06
97. NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 27, T. 117 N., R. 53 W.	1725.06
121. SE $\frac{1}{4}$ NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 25, T. 117 N., R. 53 W.	1719.63
161. SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 35, T. 117 N., R. 53 W.	1717.33
186. SE $\frac{1}{4}$ SE $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 2, T. 116 N., R. 53 W.	1710.70
Pelican Lake	1708

Some of the observation wells were destroyed by vehicles and construction of roads and are not included in this list.

# APPENDIX D

## Water levels for Lake Kameska from 1928 to 1945

Measurement in feet above mean sea level\*

Year	January	February	March	April	May	June	July	August	September	October	November	December
1928	1720.2	1720.5	1720.8	1720.5	1720.0	1719.5	1719.3	1719.2	1718.8	1718.7	1718.6	1718.5
1929	1718.5	1718.9	1721	1720.8	1720.3	1719.8	1719.1	1718.8	1718.4	1718.3	1718.3	1718.3
1930	1718.3	1718.5	1719.1	1719.1	1719.1	1719	1718.8	1718.3	1717.8	1717.5	1717.5	1717.5
1931	1717.5	1717.5	1717.3	1717.0	1718.7	1718.7	1718.6	1718.1	1717.5	1717.2	1717.1	1717.1
1932	1717.2	1717.2	1717.7	1717.9	1718.2	1718.3	1718.4	1718.4	1717.7	1717.5	1717.5	1717.5
1933	1717	1717	1717.2	1717	1716.1	1716.7	1716.5	1715.7	1715.5	1715	1714.7	1714.7
1934	1714.7	1714.7	1714.7	1715	1715.1	1715.3	1715.5	1715	1714.8	1714.2	1712.9	1712.5
1935	1712.9	1712.9	1714.5	1715	1715.7	1715.6	1715.1	1714.1	1713.5	1713.1	1712.9	1712.9
1936	1714		1714.1	1716.5	1720.6	1721.5	1720.8		1720.1	1719.7	1719.6	1719.6
1937	1712.9		1713.4	1721.1	1721.2	1720.8	1720.8	1720.6	1719.8	1719.7	1719.3	1719.2
1938	1719.6		1719.9									
1939												
1940												
1941												
1942												
1943												
1944												

No reliable data

The data were obtained from several graphs and numerical tables; available from S. D. G. S. files, Dept. of Game, Fish, and Parks, and *Watertown Public Opinion* (see references cited).

These are approximate elevations.

\*Measurements may be 2.53 feet higher than indicated elevations.

## APPENDIX E

## Water levels for Lake Kampeska from 1945 through 1970

(Measurements are in feet above mean sea level.)

## Taken at City Water Plant

(Figures are 2.53 feet higher than indicated elevations.)<sup>1</sup>

Year	January	February	March	April	May	June	July	August	September	October	November	December
1945	1719'	1718'11"	1718'10"	1719'4"	1719'4"	1720'7"	1719'11"	1719'3"	1719'	1718'9"	1718'8"	1718'8"
1946	1718'8"	1718'9"	1718'10"	1721'2"	1719'9"	1719'7"	1719'8"	1719'2"	1719'4"	1719'6"	1719'7"	1719'5"
1947	1719'	1719'	1719'1"	1719'8"	1720'10"	1719'8"	1719'2"	1719'1"	1719'	1718'9"	1718'8"	1718'6"
1948	1718'6"	1718'6"	1718'7"	1721'6"	1720'4"	1719'8"	1719'4"	1719'2"	1719'	1718'11"	1718'11"	1718'10"
1949	1718'10"	1718'10"	1719'9"	1719'9"	1719'6"	1719'4"	1718'10"	1718'5"	1718'3"	1718'	1717'8"	
1950	1718'	1718'1"	1719'4"	1720'	1720'1"	1719'1"	1719'1"	1719'1"	1718'8"	1718'9"	1718'6"	
1951	1718'6"	1718'6"	1720'4"	1721'1"	1719'11"	1719'11"	1719'11"	1719'10"	1719'8"	1719'5"	1719'6"	
1952	1719'7"	1719'9"	1719'8"	1721'10"	1719'11"	1719'7"	1719'10"	1719'4"	1718'11"	1718'7"	1718'5"	
1953	1718'5"	1718'6"	1719'10"	1720'1"	1720'	1720'5"	1720'8"	1720'3"	1719'6"	1719'4"	1719'2"	
1954	1718'11"	1718'11"	1719'9"	1720'3"	1720'2½"	1720'4"	1719'3½"	1718'10½"	1718'9¼"	1718'7½"	1718'7"	
1955	1718'7"	1718'8"	1719'2"	1719'6"	1719'4"	1719'2"	1719'2"	1718'10"	1718'7"	1718'3"	1718'1"	
1956	1718'2"	1718'2"	1718'4"	1719'2"	1719'7"	1719'9"	1719'8"	1720'	1719'6"	1719'3"	1719'3½"	
1957	1719'4"	1719'4"	1719'11"	1720'1/3"	1720'4"	1720'3½"	1719'9"	1719'2½"	1719'4"	1719'5½"	1719'8½"	
1958	1719'7½"	1719'7"	1719'8"	1720'1"	1719'10"	1719'7"	1719'4"	1718'10"	1718'5½"	1718'	1717'10½"	
1959	1717'11"	1718'8"	1718'½"	1718'2"	1718'2"	1718'2"	1717'9"	1717'3¼"	1716'9"	1716'7"	1716'6½"	
1960	1716'8¼"	1716'8"	1717'3-1/3"	1720'4¾"	1720'1½"	1720'1.3"	1719'8¼"	1719'2½"	1718'11"	1718'8½"	1718'6½"	
1961		1718'11"	1718'11"	1719'	1719'3½"	1719'5"	1719'1¼"	1718'7"	1718'5"	1718'3½"	1718'2"	
1962	1718'2"	1718'2"	1719'6"	1720'6"	1721'6"	1721'6"	1721'	1720'3"	1719'4"	1719'6"	1719'7"	
1963	1719'7"	1719'7"	1719'9"	1720'4"	1720'5"	1720'4"	1720'3"	1718'9"	1719'8"	1719'8"	1719'8"	
1964	1719'6"	1719'5"	1719'7"	1720'4"	1720'4"	1719'8"	1719'5"	1718'5"	1718'7"	1718'5"	1718'2"	
1965	1718'2"	1718'2"	1718'3"	1720'6"	1721'2"	1720'4"	1720'2"	1720'3"	1719'3"	1719'5"	1719'4"	
1966	1719'4"	1720'6"	1720'6"	1720'4"	1720'4"	1720'	1719'7"	1719'6"	1719'4"	1719'2"	1718'7"	
1967	1719'2"	1719'1"	1720'6"	1720'5"	1720'4"	1720'1"	1720'2"	1719'3"	1718'9"	1718'7"	1718'5"	
1968	1718'4"	1718'5"	1718'4"	1718'7"	1718'7"	1718'8"	1718'7"	1718'5"	1718'2"	1718'1"	1718'3"	
1969			1718'5"	*	1720'7"	1718'8"	1719'8"	1719'7"	1719'3"	1719'2"	1719'1"	
1970	1719'3"	1719'3"	1719'7"	1720'2"	1720'4"	1720'4"	1720'1"	1720'4"	1719'1"	1718'8"	1718'9"	

<sup>1</sup> John Babcock, personal communication, City of Watertown Engineer<sup>2</sup> Years 1962-1970 measured to tenths of a foot.

\*See attachment to appendix E.

## ATTACHMENT TO APPENDIX E

## Lake Levels

(Taken at Filtration Plant—Lake Kampeska)

April 1969

Date	Time	Lake Level *
April 5		1718.5
April 7		1718.5-1718.9
April 9	12:30 a.m.	1721.9
	2:30 a.m.	1722.1
	6:00 a.m.	1722.4
	3:30 p.m.	1723.2
	5:30 p.m.	1723.2
	7:30 p.m.	1723.3
	9:30 p.m.	1723.4
	11:30 p.m.	1723.5
April 10	1:30 a.m.	1723.6
	3:30 a.m.	1723.6
	5:30 a.m.	1723.6
	7:30 a.m.	1723.7
	9:30 a.m.	1723.7
	1:45 p.m.	1723.7
	4:30 p.m.	1723.7
	10:00 p.m.	1723.7
April 11	12:30 a.m.	1723.7
	3:30 a.m.	1723.7
	7:30 a.m.	1723.7
April 12	3:00 a.m.	1723.6
	6:00 a.m.	1723.5
	2:00 p.m.	1723.4
April 13	3:00 a.m.	1723.4
	5:30 a.m.	1723.3
	4:30 p.m.	1723.2
April 14	12:30 a.m.	1723.2
	5:30 a.m.	1723.1
April 15	12:00 a.m.	1723.0
	6:15 a.m.	1723.0
	4:30 p.m.	1722.8
April 16	8:15 a.m.	1722.6
April 17	10:30 a.m.	1722.4
April 18	12:30 a.m.	1722.3
	4:00 a.m.	1722.3
April 19	12:30 a.m.	1722.2
April 20	3:15 a.m.	1722.1
April 21	3:15 a.m.	1722.1
April 22	3:30 a.m.	1721.8
April 23	12:45 a.m.	1721.7
April 24	3:15 a.m.	1721.6
April 26	2:00 a.m.	1721.5
April 27	2:30 a.m.	1721.4
April 28	12:00 a.m.	1721.3
April 30		1721.2

\*Measurements are 2.53 feet higher than indicated elevations.



## APPENDIX F

## Yearly water consumption by the city of Watertown

Year	Output Filtration Plant (in cubic feet)	Output Wells (in cubic feet)	Total Output (in cubic feet) <sup>AF/yr.</sup> *
1944	48,755,600	7,793,600	56,549,200 1,298
1945	55,318,700	8,493,900	63,812,600 1,462
1946	38,013,200	29,910,700	67,923,900 1,555
1947	53,334,300	16,219,100	69,553,400 1,593
1948	55,467,700	17,431,700	72,899,400 1,668
1949	41,381,300	31,506,100	72,887,400 1,667
1950	47,900,700	16,427,000	64,327,700 1,472
1951	49,930,100	11,931,800	61,861,900 1,418
1952	52,079,200	17,910,700	69,989,900 1,602
1953	51,837,500	7,950,500	59,788,000 1,370
1954	53,110,100	4,893,600	58,003,700 1,330
1955	56,365,900	7,754,000	64,119,900 1,470
1956	54,855,300	8,846,600	63,710,900 1,460
1957	59,510,000	20,602,700	70,112,700 1,608
1958	58,203,400	20,269,100	78,472,500 1,797
1959	57,560,500	30,508,000	88,068,500 2,020
1960	60,231,000	16,975,000	77,206,000 1,768
1961	60,032,200	18,796,100	78,828,300 1,805
1962	57,501,700	11,462,700	68,964,400 1,579
1963	56,840,400	18,460,500	75,300,900 1,725
1964	58,467,400	34,550,800	93,018,200 2,130
1965	56,548,100	26,462,800	83,010,900 1,904
1966	55,615,900	33,771,400	89,387,300 2,045
1967	58,752,400	33,919,400	92,671,800 2,125
1968	53,962,100	35,576,900	89,539,000 2,050
1969	51,241,500	43,027,300	94,268,800 2,160
1970	56,312,300	32,909,400	89,221,700 2,040

\* Slide rule - 8/23/71 WB



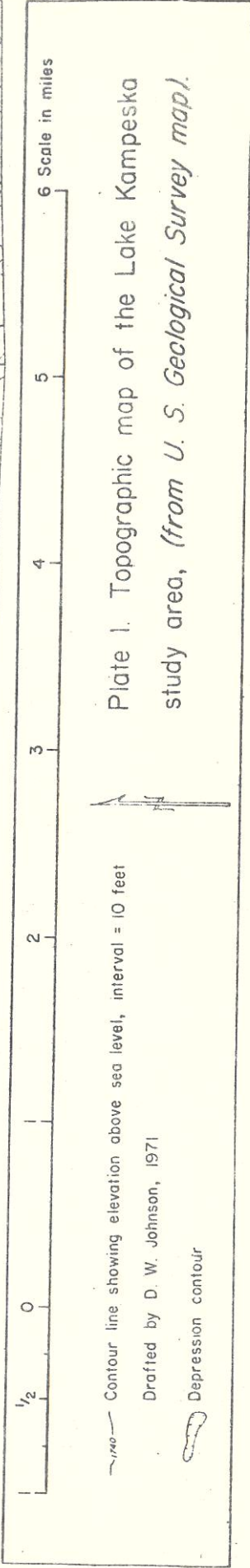
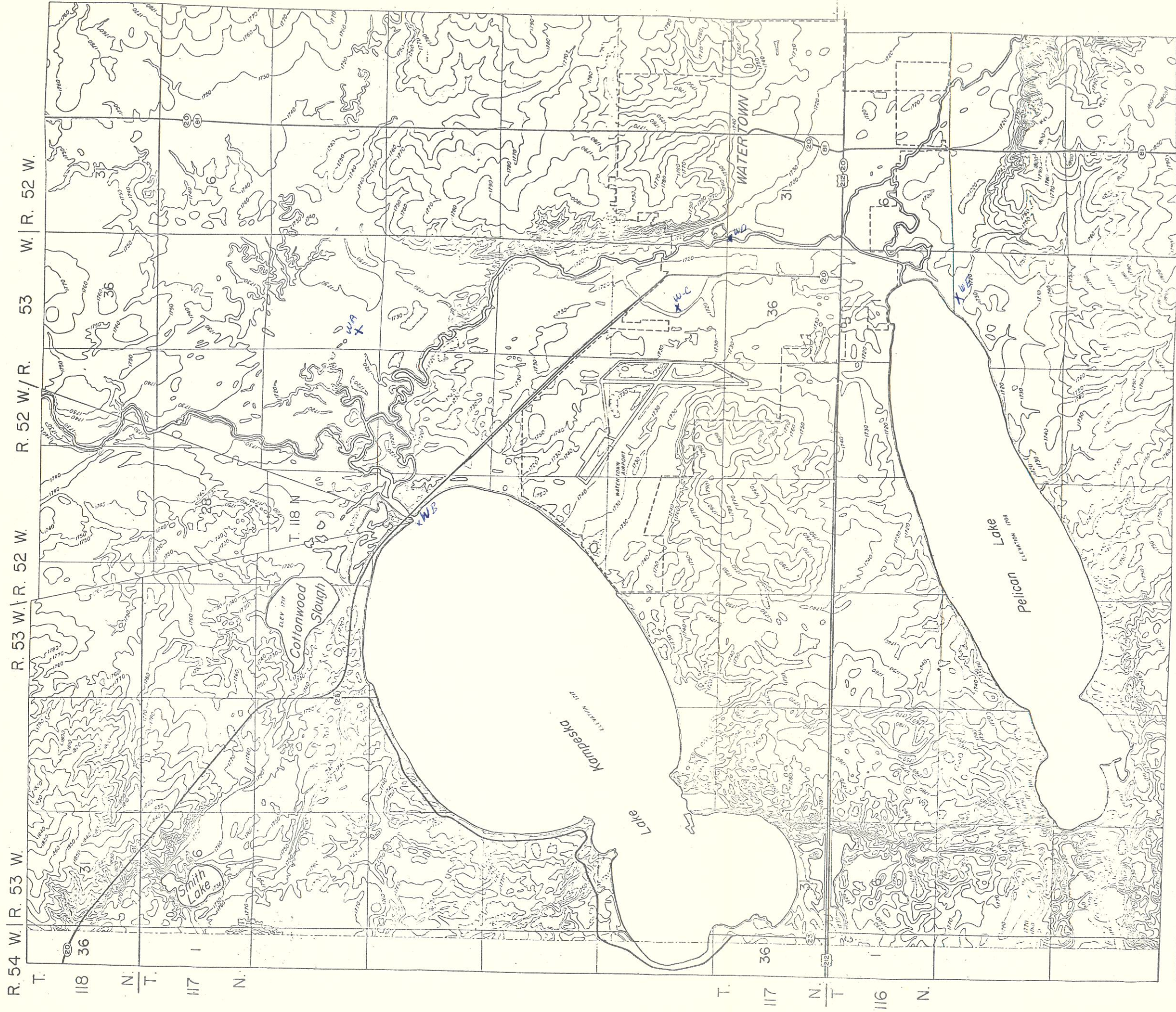


Plate 1. Topographic map of the Lake Kameska study area, (from U. S. Geological Survey map).

Drafted by D. W. Johnson, 1971